DESERT KNOWLEDGE CRC

Managing the impacts of feral camels in Australia: a new way of doing business

Edited by

GP Edwards
B Zeng
WK Saalfeld
P Vaarzon-Morel
M McGregor

Report 47

2008

Australian Government

CRC AUSTRALIA

DESERT KNOWLEDGE CRC

Managing the impacts of feral camels in Australia: a new way of doing business

Edited by

GP Edwards

B Zeng

WK Saalfeld

P Vaarzon-Morel

M McGregor

2008

Australian Government

CRC Australia

Desert Knowledge CRC

Contributing author information

Enquiries should be addressed to:

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Murray McGregor: Desert Knowledge Cooperative Research Centre and Curtin University of Technology, PO Box 3971, Alice Springs, Northern Territory 0871, Australia

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Petronella Vaarzon-Morel: Consulting anthropologist, PO Box 3561, Alice Springs, Northern Territory 0871, Australia

Keith Saalfeld: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia.

Desert Knowledge CRC Report Number 47

ISBN: 1 74158 093 5 (Print copy)

ISBN: 1 74158 094 3 (Online copy)

ISSN: 1832 6684

Citation

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

The Desert Knowledge Cooperative Research Centre is an unincorporated joint venture with 28 partners whose mission is to develop and disseminate an understanding of sustainable living in remote desert environments, deliver enduring regional economies and livelihoods based on Desert Knowledge, and create the networks to market this knowledge in other desert lands.

For additional information please contact

Desert Knowledge CRC
Publications Officer
PO Box 3971
Alice Springs NT 0871
Australia
Telephone +61 8 8959 6000 Fax +61 8 8959 6048
www.desertknowledgecrc.com.au

The project was funded by Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

ERRATA: July 2010. Note that changes have been made to figures on pages 340 and 341 in this pdf.

p.340: Contribution to greenhouse gas emissions and hence impact on global climate change: assessed in this report as ~~$3.73 million~~ $13.87 million per year, assuming each camel emits 0.97 t of CO_2 per year (see Drucker 2008a), a value of $15 per ton of CO_2 emitted (see Drucker 2008a) and a total population of 953 000 camels (Saalfeld & Edwards 2008).

p. 341: The negative economic impacts of feral camels (excluding carbon emissions) outweigh the positive economic impacts by a factor of about 18 (Table 12.1). The net economic impact is ~~-$14.39~~ -$24.53 million annually (assessed over the period July 2005 – June 2007 for the most part) taking greenhouse emissions into account and -$10.67 million annually without accounting for greenhouse emissions.

In Table 12.1: -$3.73 million becomes -$13.87 million and -$14.39 becomes -$24.53 million.

Contents

Chapter 1: Background to the project

GP Edwards

Contributing author information

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Contents

Tables

Figures and graphs

List of shortened forms

APY	A<u>n</u>angu Pitjantjatjara Yankunytjatjara
DKCRC	Desert Knowledge Cooperative Research Centre
NRETAS	Natural Resources, Environment, The Arts and Sport (NT Government Department)
NRM	Natural resource management

Acknowledgements

This report is Chapter 1 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

Thanks to Bo Raphael for useful comments on a draft of this chapter and to Benxiang Zeng for preparing the figure.

Chapter 1: Background to the project

1. Why manage feral camels?

Because they are established and widespread, feral camels are one of the 73 or so species of introduced vertebrates occurring on mainland Australia that do not meet the criteria to justify eradication effort. For such species, the management options are containment, control, or no management (*Australian Pest Animal Strategy* 2007). We need to manage feral camels in Australia because the deleterious impacts of the species on pastoral production, the environment, and on social and cultural values are evident at current population densities over many parts of the camel's range (see Edwards et al. 2008). Furthermore, the current estimated population of about one million feral camels is doubling every 8–10 years (Edwards et al. 2004, Saalfeld & Edwards 2008) and it is presumed that impacts will increase along with the population (Edwards et al. 2008).

2. Why a national approach?

Management of the impacts of pest animals should be informed by a risk management approach and be strategic in determining where management should occur, at what time, and what techniques should be used (*Australian Pest Animal Strategy* 2007). It requires coordination at the appropriate scale among all levels of government in partnership with industry, land managers, and the community (*Australian Pest Animal Strategy* 2007).

The current management of feral camels, being largely ad hoc (Edwards et al. 2004), fails to adequately meet any of these criteria.

If we are to develop a strategic, coordinated risk management approach to mitigating the impacts of feral camels, it must be done at the national scale because:

- There is a large population of camels occurring over a large area which includes parts of Western Australia (WA), South Australia (SA), Queensland (Qld), and the Northern Territory (NT) (see Saalfeld & Edwards 2008).
- Camels are very mobile animals that can move over large distances in relatively short time periods (see Saalfeld & Edwards 2008).
- Many camels occur in very remote areas that are sparsely populated by people (see Saalfeld & Edwards 2008, Saalfeld et al. 2008).
- There are differing perceptions on feral camels and their impacts (Zeng & Edwards 2008a, Zeng & Edwards 2008b, Vaarzon-Morel 2008).
- Camels are considered both a pest and a resource (Edwards et al. 2008), which can lead to conflicting goals between the various stakeholders in respect of their management.

3. First steps: the Camel Action Plan Workshop

In 2004, the NT Department of Infrastructure, Planning and Environment applied for funding through the National Feral Animal Control Program to conduct a workshop focusing on developing a coordinated and strategic program to manage the impacts of feral camels. The application was supported by the SA Department of Environment and Heritage, the Qld Department of Natural Resources and Mines, and the WA Department of Agriculture. The application was successful.

The workshop was held on 13–14 April 2005 and was attended by a small but representative group of stakeholders with an interest in the management of feral camels (including government land management agencies, relevant non-government organisations, and land managers).

There was general consensus among the workshop participants that the key to successfully managing the impacts of feral camels lay in the implementation of the following recommendations:

Recommendation 1. Development of an integrated national approach to feral camel management involving collaboration and promoting attitudinal changes. This would require coordination across various jurisdictions and stakeholder groups.

Recommendation 2. Identification and protection of key assets currently or likely to be affected by feral camels (species/sites/infrastructure).

Recommendation 3. Clarification of environmentally 'acceptable' camel population levels across a range of situations.

Recommendation 4. Clarification of how and where the camel 'industry' can contribute to feral camel management.

4. Cross-jurisdictional management of feral camels to protect NRM and cultural values project

4.1 Development of the project proposal

In February 2005 the Desert Knowledge Cooperative Research Centre (DKCRC) submitted a project proposal titled 'Cross-jurisdictional management of feral camels to protect NRM and cultural values' to the Australian Government. The project bid was successful, and funding was announced in June 2005. The contract between the DKCRC and the Australian Government was signed in February 2006.

4.2 Aims and objectives of the project

Edwards et al. (2004) noted that to date the management of feral camels has been ad hoc, with little impact on existing populations. It is this issue that this project aimed to address through a collaborative, cross-jurisdictional approach that would meet the following objectives:

1. Identify the issues surrounding the management options relating to the management of camels.
2. Prioritise these issues for their potential ability to deliver significant NRM outcomes, taking into account economic, environmental, and social (including cultural) criteria.
3. Develop focused applied research to address the issues identified.
4. Establish pilot field projects and monitoring and evaluation programs for existing field-based projects, to establish the impact of harvest and culling actions on camel populations and camel impacts on natural and cultural heritage.

4.3 Project administration and delivery

As a key partner in the DKCRC, the NT Department of Natural Resources, Environment, The Arts and Sport (NRETAS) offered to lead the project. A steering group was formed to oversee delivery of the project. The Steering Committee was established, and individuals were invited to become members of the committee on the based on the skills they brought to the project rather than a representative structure.

The Steering Committee is currently comprised of 12 members from different jurisdictions (Commonwealth, NT, SA, WA, and Qld), drawn from a range of different stakeholders (Government, NRM managers, Aboriginal communities, the pastoralist industry, the camel industry, and the DKCRC). The current membership of the Steering Committee is shown in Table 1.1. Within NRETAS, the project work was coordinated and implemented by the project leader, the project officer, and the project support officer (Figure 1.1). Components of the project were delivered through research teams external to NRETAS through contracts with external organisations arranged through the DKCRC (Figure 1.1).

Table 1.1: Past and present membership of the Steering Committee

Name	Title and Affiliation	Membership period
Andrew Drenen	Regional Land Management Officer, Central Land Council (CLC), NT	Since December 2005
Frank Keenan	Acting Manager (Land Protection Policy, BioSecurity Queensland), Department of Primary Industries and Fisheries, Qld	Since January 2008
Glenn Edwards (Project leader)	Principal Scientist (Biodiversity Conservation), Northern Territory Department of Natural Resources, Environment, The Arts and Sport (NRETAS)	Since December 2005
John Gavin (Chairman)	General Manager, South Australia Arid Lands Natural Resources Management Board, SA	Since December 2005
Lorraine Rosenberg	General Manager, Alinytjara Wilurara Natural Resources Management (AWNRM) Board, SA	Since December 2005
Murray McGregor	General Manager (Research), DKCRC	Since December 2005
Neil Burrows	Principal Scientist, Western Australia Department of Environment and Conservation, WA	Since December 2005
Peter Seidel	Executive Officer, Central Australian Camel Industry Association, NT	Since December 2005
Phil Gee	Senior Consultant (Animal & Plant Control – Large Feral Herbivores), Rural Solutions, SA	Since September 2007
Quentin Hart	Acting Program Leader (Biosecurity and Statistical Sciences), Bureau of Rural Sciences, ACT	Since December 2005
Robin Mills	Pastoralist, Warragarine Station, WA	Since March 2007
Tony Pople	Acting Manager (Emerging Environmental Pests, Invasive Plants and Animals, Biosecurity Queensland), Department of Primary Industries and Fisheries, Qld	September–December 2007
Troy Coe	Livestock and Pastoral Officer, APY Land Management Council	Since May 2008

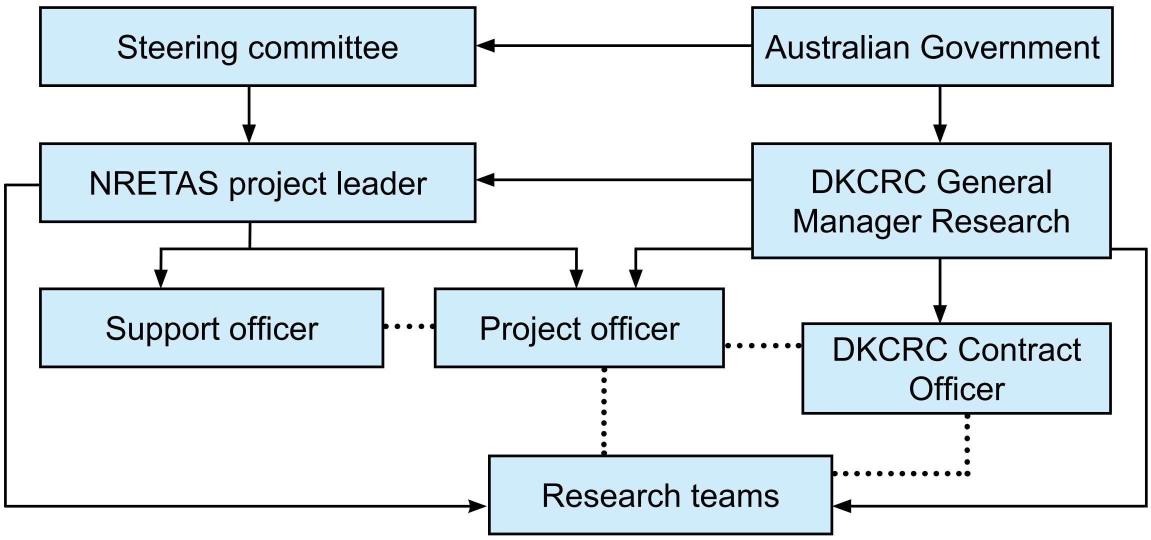


Figure 1.1: Schematic diagram showing how the project was administered and delivered

4.4 Components of the project

The research aims and objectives set for the project were achieved through a group of well-integrated sub-projects, based on a collaboration between different stakeholder groups, in a range of jurisdictions, working on a series of related projects across the country. The project had five core sub-projects:

1. Evaluation of key stakeholder perceptions: This work focused on Aboriginal, conservation, and pastoral land owners and managers within the camel's range.

2. Evaluation of the impacts of feral camels: This work adopted a triple bottom line approach in considering economic, environmental, and social (including cultural) criteria.
3. Evaluation of commercial approaches that could assist in the management of feral camels: This work considered aspects such as the live export of camels and the use of camels for pet meat and for human consumption.
4. Evaluation of the non-commercial approaches that are or could be used to manage feral camels: This work considered aspects such as aerial culling, ground culling, and fencing. A review of possible chemical, biological, and fertility control options for managing camels was also conducted by a research team based at the Invasive Animals Cooperative Research Centre.
5. Development of a framework for the cross-jurisdictional management of feral camels: In developing the framework, the following tasks were undertaken: (a) the compilation of spatial data relevant to the management of feral camels, and (b) development of a Multiple Criteria Decision Support system based on a Geographic Information System (GIS) for the cross-jurisdictional management of feral camels.

The following additional work was undertaken for the project:

1. A review of legislation to identify possible barriers to the cross-jurisdictional management of feral camels: Stephen Garnett, based at Charles Darwin University, led this research team.
2. Modelling of management options for management of feral camels in central Australia: Stephen McLeod, from New South Wales Department of Primary Industries, and Anthony Pople, from Queensland Department of Primary Industries and Fisheries, undertook this work.
3. An economic analysis of camel control in the central region of the Northern Territory: Adam Drucker, from Charles Darwin University, undertook this work.

6. Products of the project

This report brings together all of the elements of the research undertaken. The report has the following structure:

Chapter	Author
1. Background to the project	GP Edwards
2. Ecology of feral camels in Australia	WK Saalfeld and GP Edwards
3. Key stakeholder perceptions of feral camels: pastoralist survey	B Zeng and GP Edwards
4. Key stakeholder perceptions of feral camels: conservation manager survey	B Zeng and GP Edwards
5. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged)	P Vaarzon-Morel
6. Review of legislation and regulations relating to feral camel management (summary)	R Carey, M O'Donnell, G Ainsworth, S Garnett, H Haritos, G Williams, GP Edwards, M McGregor, and B Zeng
7. Evaluation of the impacts of feral camels	GP Edwards, B Zeng, and WK Saalfeld
8. Review of non-commercial control methods for feral camels in Australia	WK Saalfeld and B Zeng
9. Review of commercial options for management of feral camels	B Zeng and M McGregor
10. Economics of feral camel control in the central region of the Northern Territory (summary)	AG Drucker
11. A Multiple Criteria Decision Support Tool for feral camel management	WK Saalfeld, GP Edwards, B Zeng, and D Lamb
12. Synthesis and key recommendations	GP Edwards, M McGregor, B Zeng, WK Saalfeld, P Vaarzon-Morel, and M Duffy

In addition, the following research reports support the findings presented in this report:

McLeod SR and Pople AR. 2008. *Modelling management options for management of feral camels in central Australia*, DKCRC Research Report 48. Desert Knowledge CRC, Alice Springs.

Vaarzon-Morel P. 2008. *Key stakeholder perceptions of feral camels: Aboriginal community survey,* DKCRC Research Report 49. Desert Knowledge CRC, Alice Springs.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H and Williams G. 2008. *Review of legislation and regulations relating to feral camel management*, DKCRC Research Report 50. Desert Knowledge CRC, Alice Springs.

Lapidge SJ, Eason CT and Humphrys ST. 2008. *A review of chemical, biological and fertility control options for the camel in Australia*, DKCRC Research Report 51. Desert Knowledge CRC, Alice Springs.

Drucker AG. 2008. *Economics of camel control in the central region of the Northern Territory,* DKCRC Research Report 52. Desert Knowledge CRC, Alice Springs.

Lamb D and Saalfeld K. 2008. *A multiple criteria decision support framework for the management of feral camels*, DKCRC Research Report 53. Desert Knowledge CRC, Alice Springs.

The following report was produced to provide an overview of the project:

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

The following publication was produced by the project and used extensively during the evaluation of stakeholder perceptions, particularly in respect of Aboriginal stakeholders:

Tangentyere Landcare. 2006. *The Camel Book*, Reprinted by the DKCRC 'Cross-jurisdictional Management of Feral Camels' project, with support from the Australian Government.

5. References

Australian Pest Animal Strategy: a national strategy for the management of vertebrate pest animals in Australia. 2007. Natural Resources Ministerial Council, Canberra.

Edwards GP, Saalfeld K and Clifford B. 2004. Population trend of feral camels in the Northern Territory, Australia, *Wildlife Research* 31, 509–17.

Edwards GP, Zeng B and Saalfeld WK. 2008. Evaluation of the impacts of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 133–182. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK, Edwards GP, Zeng B and Lamb D. 2008. A Multiple Criteria Decision Support Tool for feral camel management. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 287–330. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008a. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008b. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Chapter 2: Ecology of feral camels in Australia

WK Saalfeld

GP Edwards

Contributing author information

Keith Saalfeld: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Contents

Tables

Figures and graphs

List of shortened forms

NRM	Natural resource management
GIS	Geographic information system
NLWRA	National Land and Water Resources Audit
ESRI	Environmental Systems Research Institute

Acknowledgements

This report is Chapter 2 of the final report for the project ‘Cross-jurisdictional management of feral camels to protect NRM and cultural values’. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

We would like to thank Professor Murray McGregor, Benxaing Zeng, and Phil Gee for their valuable input into what is happening with feral camel populations in Australia, and Dr Peter Whitehead for his detailed and frank criticism of the draft of this document. It has been improved considerably through his input.

Chapter 2: Ecology of feral camels in Australia

1. Summary

The camel played an important role in the development of central Australia in both the nineteenth and early twentieth centuries. The replacement of the camel by the motor vehicle in the early twentieth century resulted in large numbers of animals being released into the wild and the subsequent establishment of a feral population in arid Australia.

Monitoring of Australia's camel population was haphazard at best until the 1980s. Since that time, a number of systematic surveys of camel distribution and abundance have been carried out across substantial areas of the camel's distribution.

The current distribution of the camel covers much of arid Australia. Up to 50% of Australia's rangelands are reported as having camels present, as are most of the arid regions of Western Australia (WA), South Australia (SA), the Northern Territory (NT), and parts of Queensland (Qld).

The research reported here supports a current population estimate for the feral camel in Australia of approximately one million animals covering an area of some 3.3 million km^2 at an overall density of 0.29 camels/km^2. Densities vary, and the modelling of available data indicates that two substantial areas of high density are present, one centred on the Simpson Desert and the other on the Great Sandy Desert. The high density area covering the eastern part of the Great Sandy Desert has predicted densities in the range of 0.5 to greater than 2 animals/km^2 and that on the Simpson Desert in the range 0.5–1.0 animals/km^2.

Modelling of camel population dynamics gives population growth rates in the range of 7–8 % per year, reflecting intrinsic rates of increase in the range 0.074–0.079 (McLeod & Pople 2008). On the basis of these rates of increase, a population doubling time of about nine years is likely. Further, based on the current Australian camel population estimate, these rates indicate potential for increase at 80 000 camels per year and accelerating, due to the exponential nature of population growth and the belief that camels have not yet reached the carrying capacity of the land (McLeod & Pople 2008).

Camels appear to use most available habitat, with use reflecting seasonal influences related to food availability and breeding. Habitat types not used to any measured extent include mountain ranges and salt pans/lakes, although camels have been reported from both of these habitats. Camels use almost all available food sources with a clear suite of preferred species and are subject to limited mortality other than natural mortality associated with age.

Few of the resources needed by camels appear to be limiting at current population densities, with the possible exception of water. Increased water stress during hot dry summers is proposed as the causal factor for the encroachment of camels into remote central Australian communities in recent years. Camels were reported trying to obtain access to water by entering communities and damaging water-related infrastructure including bores, taps, and air conditioning units.

It would appear that without management camel populations have the potential to persist in large and growing numbers in already occupied sites and to expand into presently unoccupied or sparsely occupied areas.

1.1 Recommendations

- That efforts are made to achieve a better understanding of the factors influencing the movement patterns and population distribution of feral camels at the local to regional scale. This would allow static aerial survey data to be more accurately projected forwards and would facilitate the development of a dynamic model of feral camel density distribution.

- That the broadscale aerial survey database of feral camel distribution and abundance be expanded by implementing aerial survey in areas not previously covered in order to improve estimation of density distribution for feral camels.
- That a broadscale index-manipulate-index experiment related to broadscale aerial survey of feral camels be conducted to address the issue of environmental bias associated with current aerial survey estimates of feral camel population distribution and abundance.
- That a national database of feral camel aerial survey data be created incorporating all available aerial survey data related to feral camels from all jurisdictions, with data incorporated at the finest spatial scale available, and that this database be supported by all jurisdictions.
- That the national database be a core component of the development of a dynamic model of feral camel distribution and any other tools or models related to feral camel management, and that this imposes a requirement for complete and regular update of the database to ensure currency.

2. The establishment of feral camels in Australia

The one-humped dromedary (*Camelus dromedarius*) was first introduced to Australia in 1840 (McKnight 1969). Between 1880 and 1907 up to 20 000 camels were imported into Australia (McKnight 1969). Camels were well suited to working in remote dry areas and were used for riding, carting goods, and as draught animals in the early development of the arid interior of the continent (McKnight 1969). From the 1920s onwards the number of captive domestic camels declined steadily as the use of motor vehicles for freight haulage increased. This is clearly reflected in the reduction in registered camels between 1920, when register records give the number of captive camels as 12 649, and 1941, when there were fewer than 2300 registered camels (McKnight 1969).

The widespread establishment of feral camel populations in Australia can almost certainly be attributed to the wholesale abandonment of domestic camels during the 1920s and 1930s (McKnight 1969), and although some animals were destroyed, many were simply released into the bush. Exactly how many were released over this period we will never know. On the basis of the register records, Edwards et al. (2004) speculated that the number of camels released between 1920 and 1941 would have been between 5000 and 10 000.

Current feral camel population size and distribution is evaluated and discussed in section 4.1 below.

3. Aspects of camel biology and ecology

3.1 Habitat use

There are reasonable grounds to consider camels capable of using almost all available habitat types within the arid and semi-arid environment of Australia (Dörges & Heucke 1995). Dörges and Heucke (1995) undertook a detailed analysis of habitat selection by camels in a large paddock west of Alice Springs and identified a number of clear preferences in habitat selection based on a number of parameters. They identified six basic habitat types within the study area: saltmarsh/saltlake, open bushland, dense (closed) bushland, open plain, sandplain/dunes with sparse vegetation, and sandplains/dunes with dense vegetation. Camels used all of the habitats, but that usage was seasonally variable. The one exception to seasonality was open bushland, which Dörges and Heucke (1995) reported was the preferred habitat all year round, with no change in the proportion of usage between seasons. They attributed this preference to a rich and varied food supply regardless of season, open vegetation providing good observational awareness of surrounds, and the presence of shade trees in summer months. Of the five remaining habitat types, usage was highly variable (Dörges & Heucke 1995). After open bushland, Dörges and Heucke (1995) determined that sandplain/dunes with sparse vegetation was the next preferred habitat type, and sandplain/dunes with dense vegetation preferred to a lesser extent. Dense bushland was not a preferred habitat type except to mothers with new calves who used it specifically to provide cover. Neither open plain nor saltmarsh/saltlake habitat types were preferred habitats except in specific circumstances, and then for short periods of time (Dörges & Heucke 1995). Open plains were used extensively after rainfall due to an abundance of forbs and grasses that develop quickly compared with other habitats (Dörges & Heucke 1995) and the saltmarsh/saltlake habitat was used in winter when *Swainsona* and *Zygophyllum* species were growing.

Other than the work of Dörges and Heucke (1995, 2003), only limited research into habitat selection and preference has been undertaken on camels in Australia, with most habitat use information being derived incidental to other studies: aerial survey of population distribution and abundance (Short et al. 1988, Wurst & Saalfeld 1994, Axford et al. 2002, Edwards et al. 2004, Peeters et al. 2005, Lethbridge 2007) and movement studies (Grigg et al. 1995, Edwards et al. 2001, Lethbridge 2007), and reported in only the broadest of terms.

3.2 Food and water

Food selection by camels in Australia has been described by Barker (1964), McKnight (1969, 1976), Newman (1975, 1979), Dörges and Heucke (1995, 2003), and Peeters et al. (2005). The work of Dörges and Heucke (1995, 2003) is the most extensive and provides the greatest detail on food plant selection and preference of the camel in central Australia. Dörges and Heucke (1995) found that 83% of the available plant species were used by camels, but that the use was widely divergent in terms of food preference, with 50% of the food plant species contributing less than 1% of total intake and only 7% of the species contributing nearly 70% of actual food intake (Dörges & Heucke 1995). Forbs and small lignified plants comprised 63% of the species eaten, 19% were shrubs and trees and 18% grasses and ferns. While trees and shrubs comprised only 19% of the food species range selected by camels, they made up 52.9% of the volume of food consumed, with forbs comprising 42.5% of the remaining volume and grasses less than 5%. Camels used almost the entire available food supply, including species that are poisonous to cattle and horses, *Solanum, Swainsona, Zygophyllum, Nicotiana,* and *Indigofera* species (Dörges & Heucke 1995). The consumption of *Indigofera* species may be of concern to parties interested in using camels for pet meat as secondary poisoning is known to occur in dogs. Additionally, over 15% of the food plants consumed in the total diet of camels were halophytes, indicative of the camels' requirement for salt in their diet. Dörges and Heucke (1995) also reported camels feeding on crystalline salt in the form of saline soil.

Dörges and Heucke (2003) provided a list of the 342 observed food plants of camels in central Australia. Peeters et al. (2005) identified a smaller suite of species consumed by camels in the Great Victoria Desert in SA with a number of species in common with Dörges and Heucke (2003).

Dörges and Heucke (1995, 2003) identified three species whose conservation status they considered to be severely impacted by camel browsing: *Erythrina vespertilio, Acacia sessiliceps*, and *Santalum acuminatum*. All three species have important conservation and cultural values to Aboriginal people in central Australia, and of the three, *S. acuminatum* is believed to be most severely threatened by camel browsing (Woinarski et al. 2007, Peter Latz 2008, Ecological consultant, Alice Springs, pers. comm.). Camel impact on vegetation is considered in detail in Edwards et al. (2008).

Camels can go for considerable periods of time without access to free/surface water (Barker 1964, McKnight 1969, Wilson 1984, Dörges & Heucke 1995). This is a result of morphological and physiological adaptations that maximise water conservation and facilitate animals obtaining sufficient water from ingested food at those times of year when food is plentiful and/or high in moisture content (Dörges & Heucke 1995). Dörges and Heucke (1995) observed camels drinking at intervals of two to eight days in summer and longer in winter in central Australia.

Increased water stress during hot dry summers is proposed as the causal factor for the encroachment of camels into remote central Australian communities in recent years (see Edwards, Zeng, & Saalfeld 2008). Camels were reported entering communities to obtain access to water and damaging water related infrastructure including bores, taps, and air conditioning units.

3.3 Movements

Dörges and Heucke (1995), Grigg et al. (1995), Edwards et al. (2001) and Lethbridge (2007) have reported on range usage and movement in feral camels in arid Australia. Dörges and Heucke (1995) looked extensively at localised range usage by identified individual herd groupings in a large fenced paddock in central Australia. Dörges and Heucke (1995) demonstrated clear seasonal range usage patterns that were mainly dependent on social factors. During the summer, camel herds had relatively small 'home ranges', tended to have restricted movement within the study area, and tended not to interact. In winter, and particularly during rutting season (the period of heightened sexual activity in male camels), 'home ranges' were much larger, movements within the study were much more extensive, and interaction much more frequent (Dörges & Heucke 1995). 'Home ranges' of camels varied from as little as 10 km^2 in area up to 213 km^2 – the maximum size possible.

Satellite telemetry studies of feral camel movements in central Australia by Grigg et al. (1995), Edwards et al. (2001) and Lethbridge (2007) have shown that when not constrained, camels move over areas of thousands to tens of thousands of square kilometres. Grigg et al. (1995) obtained home ranges up to 7000 km^2 for camels in central Australia. Edwards et al. (2001) found that the areas used by feral camels in central Australia were variable in size, ranging from about 5000 km^2 in the Simpson Desert to about 450 km^2 in the northern parts of the Tanami Desert. On the basis of data collected over a short timespan, Lethbridge (2007) reported large movements and apparent migration and home range movement in camels in the Great Victoria and Gibson Deserts.

Edwards et al. (2001) found a strong negative correlation between long-term mean annual rainfall and the size of areas used by female camels. They reasoned that this pattern was related to habitat productivity, with camels having to move over greater areas to obtain sufficient forage as aridity increased. Additionally, camels need access to sources of water (Dörges & Heucke 1995), which are likely to be more widely dispersed in more arid areas (Edwards et al. 2001).

Of the individual camels monitored in the above satellite telemetry studies, only one was monitored long enough to determine with certainty that movement was occurring within an apparent home range (Edwards et al. 2001). For the remaining animals, the patterns of movement detected could fall into a number of categories including nomadic, migratory, or movement within a home range (Edwards et al. 2001).

Irrespective of whether movement is nomadic, migratory, or movement within a home range, the areas used are large (Edwards et al. 2001) and management to mitigate negative impacts will have to address the capacity of camel populations to use extensive areas of habitat covering many thousands of square kilometres.

3.4 Social organisation and behaviours

Social organisation of the camel in central Australia is characterised by non-territoriality and group formation (Dörges & Heucke 1995), with the formation of cow groups that are temporarily herded by a bull during rut and bachelor groups composed of younger bulls. Older bulls tend to live solitarily (Dörges & Heucke 1995). Cow groups are the basis of 'core groups' that are formed by the joining together of cows with calves of the same age. The core group can be joined by other adult cows without calves, young cows, and young bulls for varying periods of time (Dörges & Heucke 1995). The core group is stable for one and a half to two years, corresponding to the nursing phase of the calves, and stability is independent of the presence of a herding bull (Dörges & Heucke 1995).

At the beginning of rut the adult bulls compete for access to the cows. In central Australia rut is highly seasonal, with nearly all adult bulls being in rut at the start of winter (Dörges & Heucke 1995). Bulls take over a cow group and herd it for three to five months, depending on hormonal factors, bull condition, and competition with other bulls.

Dörges and Heucke (1995) observed that the majority of parturitions occurred between June and November, with cows approaching parturition segregating from the cow group and seeking seclusion in dense vegetation for parturition. Seclusion in dense vegetation is presumably sought for the protection of the newborn calf from predators and bull camels. This seclusion lasts for up to three weeks at which point the cow and calf join other cows with young calves (Dörges & Heucke 1995).

Infanticide was observed by Dörges and Heucke (1995) and is considered by them to be of particular importance to the reproductive strategy of feral camels in Australia and the first proof of a successful reproductive strategy of bulls in ungulates (Dörges & Heucke 1995). Rutting bulls show a distinct aggression toward newborn calves and they drive the cow from the calf after birth (Dörges & Heucke 1995) leading to the death of the calf. A fertile post-partum oestrus following the death of the calf increases the individual chance of reproduction for the bull (Dörges & Heucke 1995). While high infant mortality has been reported for camels elsewhere (Wilson [1984] reported levels up to 50%), specific socio-biological infanticide is not clearly documented for camels in their natural range. This potentially reflects the circumstance that outside of Australia there are almost no wild herds. Virtually all camels within their natural range are subject to domestication and intensive herd management (Wilson 1984) greatly reducing the capacity for socio-biological infanticide.

Dörges and Heucke (1995) associated infanticide with the immobility of calves immediately following birth and proposed that segregation of the cow prior to parturition was a mechanism to reduce infanticide.

Fighting between bulls occurs primarily during rut and between dominant bulls and bulls protecting the cow group they are herding (Wilson 1984, Dörges & Heucke 1995). Although fighting may result in lethal injuries, these are rare (Dörges & Heucke 1995).

3.5 Reproduction

Female camels reach sexual maturity at three to four years of age (Wilson 1984). Gestation period is variable depending upon location, with a range of 336–405 days reported by Wilson (1984) on the basis of numerous sources. Dörges and Heucke (1995) reported a gestation period of 370 ± 5 days. Dörges and Heucke (1995) observed a calving interval of 22.2 months on average, reduced to 14.4 months if the previous calf died. This calving interval is slightly less than that estimated by Wilson (1984) of two years on the basis of data from across the camels' natural range. The reproductive lifespan for female camels is at least 30 years (Wilson 1984, Dörges & Heucke 1995).

While male camels are capable of breeding all year round, they are unlikely to do so (Wilson 1984). Rut in central Australian camels appears to occur primarily throughout the winter months of May–October (Dörges & Heucke 1995). Wilson (1984) reports rut as being induced by environmental factors, although the exact interaction is unclear. Increased nutrition associated with specific seasons is advanced as one reason (Wilson 1984), but it is not apparent if this is a factor in central Australia.

For camels in central Australia, Dörges and Heucke (1995) report that births take place throughout the entire year, but that there is a distinct increase in the six months of June to November, with 93% of births in this period. Oestrus cycle in the female camel is of a type known as follicular wave, with coitus being required to induce ovulation (Wilson 1984). Camels are considered polyoestric but it has long been held that oestrus only occurs at certain times of the year (Wilson 1984). While seasonality in breeding does occur (Wilson 1984, Dörges & Heucke 1995), available information confirms that follicular wave activity occurs all year round (Wilson 1984), subject to considerable variability. In practical terms, the camel can be considered a seasonal breeder and this is the case in central Australia (Dörges & Heucke 1995).

Development of a population growth model for camels in central Australia by Dörges and Heucke (1995) was dependent on their obtaining accurate birth and mortality rate data on which to estimate the mean annual rate of increase. Birth rate is given by the proportion of reproductive females in the population divided by calving interval, with the proportion of reproductive females dependent upon average lifespan. Based on their observations, Dörges and Heucke (1995) obtained annual birth rates of 16–18.7% corresponding to average lifespan of 20–40 years. These estimated birth rates took into account an estimated calf mortality of 29% for newborns and calves <1 year old, and used a successful calving interval of 2.34 years.

3.6 Diseases and parasites

Disease and parasites do not have a major impact on feral camels in Australia. Quarantine procedures in place from the time of the earliest importation of camels have severely curtailed any introduction of the major diseases and epidemic pathogens impacting on camel populations in their natural range (McKnight 1969). Diseases that can affect camels, such as Brucellosis (*Brucella abortus*), Tuberculosis (*Mycobacterium tuberculosis*), camel-smallpox (*Orthopox virus cameli*), or camel Trypanosomiasis (*Trypanosoma evansi*), are not present in Australian camel populations (Williams 1992, Dörges & Heucke 1995, Brown 2004).

Similarly, parasite impacts on Australian camels appear to be minimal. Dörges and Heucke (1995) reported only a single death in their research study (in three and a half years) due to nematode infection. Scabies (*Sarcoptes scabei var cameli*) is reported as having a major impact on camel health in their natural range and is reported as infecting large numbers of camels in parts of central Australia, particularly the Simpson Desert and Amadeus Basin (Dörges & Heucke 1995). Williams (1992) reported that infection by *Corynebacterium pyogenes*, resulting in abscesses of the lymph nodes, was common in Australian camels, occurring in 90% of animals examined. Dörges and Heucke (1995) reported similar infection of several animals in their study without any apparent lethal effects. Other relatively harmless ectoparasites of camels in Australia are the camel bot fly (*Cephaloptina titillator*) and dermatophytes of the genus *Trichophyton* (Williams 1992, Dörges & Heucke 1995).

The near disease-free status of the Australian camel population has the potential to contribute to a greater average lifespan and hence higher population growth rate of the Australian camel population as compared with populations in their natural range. Additionally, the near disease-free status greatly enhances the suitability of Australian camel populations for commercial utilisation, particularly live export (Zeng & McGregor 2008).

3.7 Mortality

The average lifespan of camels appears variable, with a range of 20–50 years being reported. Dörges and Heucke (1995) quote Krumbiegel as giving an age of 50 years or more for camels held in zoological gardens. The average lifespan for Australian camels has been reported by Barker (1964) as 40 years and by McKinght (1969) as somewhat more than 30 years. The animals that these lifespans were reported for were working animals, hence an improved survivorship over wild animals could be reasonably assumed. Camels in Australia do not have any predators other than humans. The dingo (*Canis lupus dingo*) is the only potential predator, mostly on newborns and calves (Dörges & Heucke 1995).

As reported in section 3.6, disease has limited impact on the Australian camel population, and the majority of observers report that conditions for camels in central Australia are near ideal (Baker 1964, McKnight 1969, Dörges & Heucke 1995, Edwards et al. 2004). Consequently, average lifespan for free camel populations may approach that of captive animals, and a lifespan of up to 30 years was proposed for free ranging camels in Australia (Dörges & Heucke 1995).

Calculated total mortality rates obtained by Dörges and Heucke (1995) for camels in central Australia were 6.5–9% per year, depending on estimated lifespan. The 30-year lifespan for free-ranging camels proposed by Dörges and Heucke (1995) corresponds to an annual total mortality rate of

7.28%. However, Dörges and Heucke (1995) concluded that these mortality rates were likely to be underestimates due to optimal conditions throughout their study period. Sources of mortality reported by Dörges and Heucke (1995) were made up of:

1. newborn and calves <1 year old estimated at 29%, of which 58% was infanticide (section 3.4)
2. accidents and disease estimated at 3.95% per year
3. age-dependent mortality estimated at 2.5–5.0% per year for average lifespan of 40 years down to 20 years.

Accidents and disease included nematode infection, sepsis after injury, capture stress, snake bite, and death resulting from interaction with fences (Dörges & Heucke 1995).

4. Feral camel population and distribution

4.1 Camel distribution and abundance

Between 1940 and 1966 the Australian feral camel population was neither officially monitored nor managed, other than by the individual actions of pastoralists (McKnight 1969). McKnight (1969) guessed that there were 30 000 to 90 000 feral camels in 1940. This guess was wildly speculative and appears a gross overestimate even at the lower end of the range (Edwards et al. 2004). It was not until 1969 that the first genuine attempt was made to systematically estimate the number of feral camels in Australia. On the basis of an interview/questionnaire survey, McKnight (1969), estimated that there were 15 000–20 000 feral camels across outback Australia in 1966, with 40% in WA, 30% in the NT, 20% in SA, and the remaining 10% in Qld (Table 2.1). The first broadscale quantitative assessment of the number and distribution of feral camels in Australia was undertaken by Short et al. (1988), who used opportunistic camel sighting records made during a series of aerial surveys targeting kangaroos between 1980 and 1983 (Short et al. 1988). This produced a minimum Australian camel population estimate of 43 000 camels and a broad belt-like distribution of camels through central Australia from Broome in WA to the WA/NT/SA border, through southern NT and northern SA to the Qld border and in a few pockets in Qld (Short et al. 1988). While the population estimate of Short et al. (1988) was relatively imprecise – that is, it involved large error (Edwards et al. 2004) – they were able to provide a population breakdown by jurisdiction (Table 2.1).

Between 1984 and the present, a series of independent aerial surveys has been conducted at various locations to determine camel population size and distribution at sub-regional to regional scales (Table 2.1). Two of these surveys, Edwards et al. (2004) and Ward et al. (2006) attempted to scale up their individual survey specific estimates of density to provide an estimate of the Australia-wide population using the jurisdictional population breakdown of Short et al. (1988). Edwards et al. (2004) arrived at a minimum national population estimate of about 300 000 camels in 2001, while Ward et al. (2006) estimated there to be about 730 000 camels in 2006.

It is only recently that an attempt has been made to provide a systematic national snapshot of the distribution and abundance of the species. Between 2005 and the present, the Australian Government's National Land and Water Resources Audit (NLWRA) (http://nlwra.gov.au/) collected and mapped, at 1:250 000 scale, the distribution and abundance of a comprehensive range of invasive species, including the camel.

We used the NLWRA camel data, recent aerial survey data (Table 2.1), and information obtained during a survey of pastoralists on the presence of feral camels (Zeng & Edwards 2008) to map the current distribution of feral camels across Australia (Figure 2.1). Camels are distributed broadly across the Australian Rangelands, occupying almost 50% of their expanse, and covering a minimum area of 3.3 million km^2. Within this range, camel populations are known to be distributed heterogeneously (McKnight 1969, Short et al. 1988, Wurst & Saalfeld 1994, Axford et al. 2002, Edwards et al. 2004, Peeters et al. 2005, Lethbridge 2007; see also Table 2.1) and this was reflected in the recent NLWRA camel data as shown in Figure 2.2. Feral camel distribution is physically constrained in the south-east of the distribution by the Australian Wild Dog Fence, which restricts the spread of the camel into NSW and the south-east of SA (Figure 2.1).

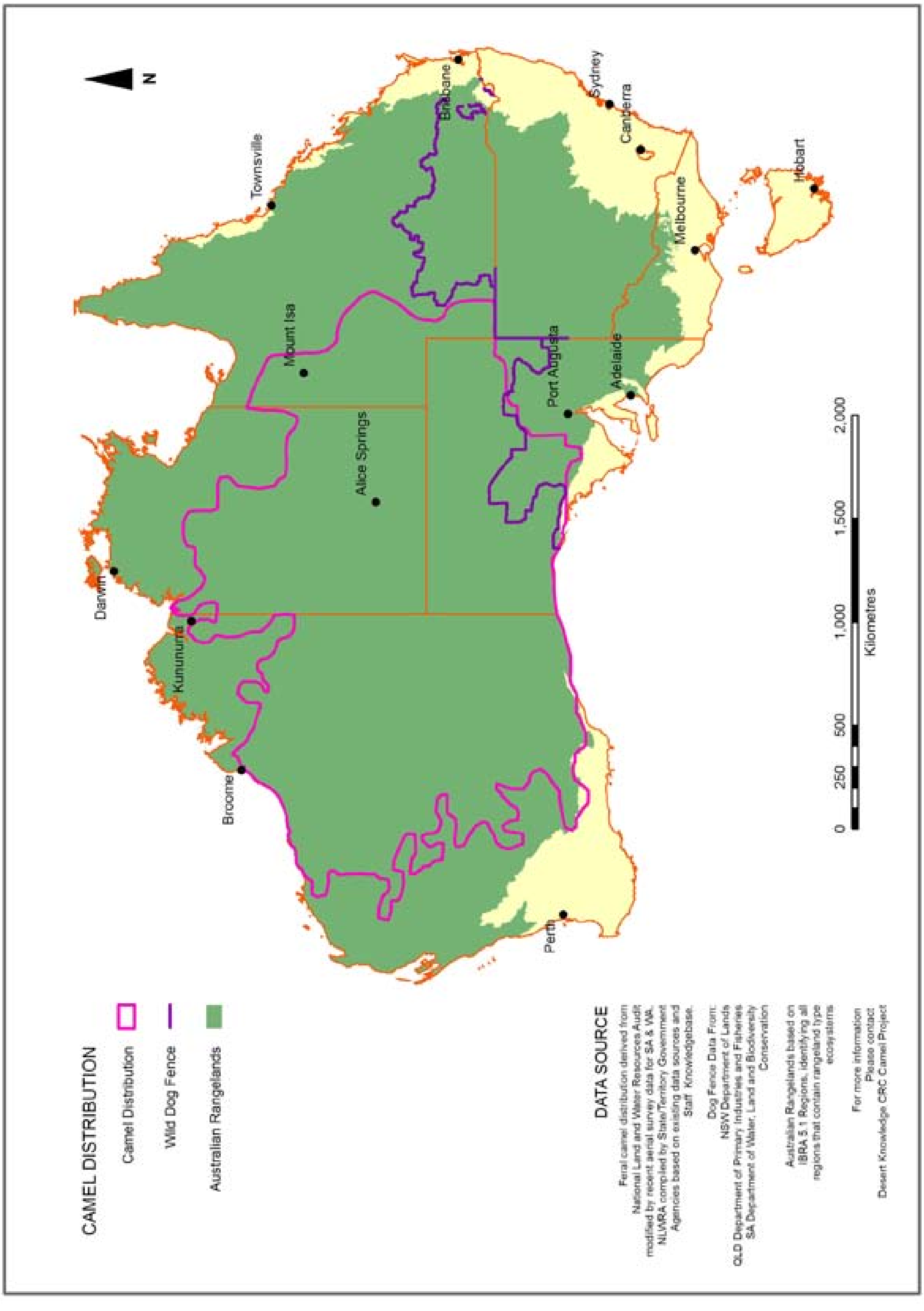


Figure 2.1: Australian rangelands and the current Australian camel distribution

Note: Data derived from the National Land and Water Resources Audit feral camel distribution, modified by recent aerial survey data (Ward et al. 2005, 2006, Lethbridge 2007) and feral camel reporting provided by a survey of pastoralists (Zeng & Edwards 2008).

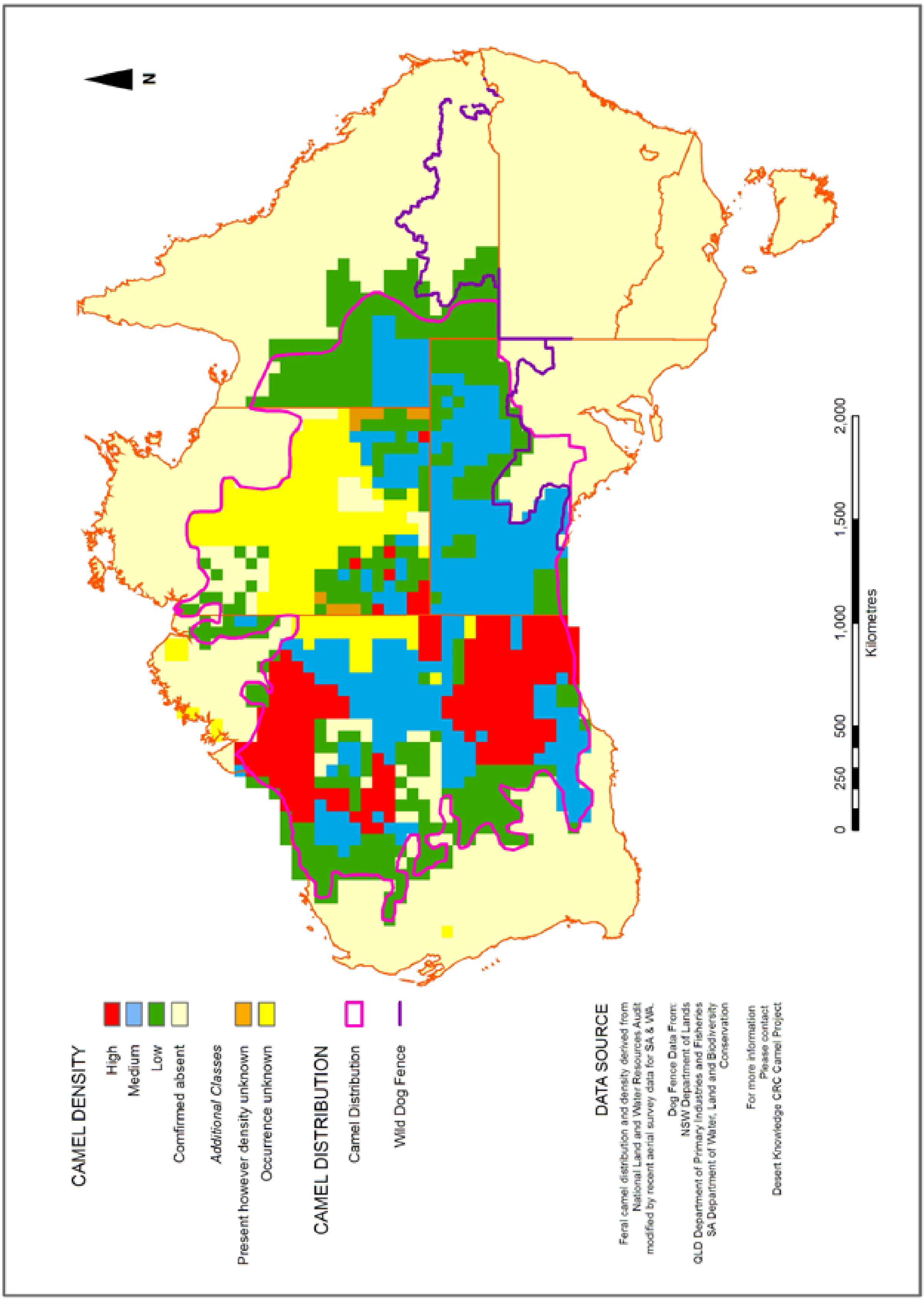


Figure 2.2: Current Australian camel distribution and density at 1:250 000 scale resolution

Note: Data derived from the National Land and Water Resources Audit feral camel distribution and density, modified by recent aerial survey data (Ward et al. 2005, 2006, Lethbridge 2007) and feral camel reporting provided by a survey of pastoralists (Zeng & Edwards 2008).

Table 2.1: Camel abundance and densities across jurisdictions between 1969 and the present

Jurisdiction and survey location	Year	Area (km²)	Estimate of abundance (± s.e.) percentages indicate percentage of estimated population in jurisdiction	Density (animals/km² ± s.e.)	Source
central Australia [a]	1966		15 000 to 20 000 [b]		McKnight 1969
WA			40%		
SA			20%		
NT			30%		
NSW			0%		
Qld			10%		
across Australia [c]	1980 –1983	5.8 million	43 000 [b]		Short et al. 1988
WA			50%		
SA			<23%		
NT			27%		
Vic			0%		
NSW			0%		
Qld			>0%		
NT [c]	1983	79 920	10 723 ± 5592	0.134 ± 0.070	Graham et al. 1986
NT [c]	1993	317 016	39 937 ± 5968	0.126 ± 0.019	Wurst & Saalfeld 1994
Simpson		171 227	18 863 ± 4692	0.109 ± 0.027	
Western desert		145 789	21 254 ± 3689	0.126 ± 0.019	
SA [c] (north-west)	2000	102 650	2605 ± 646 [b]	0.01 [b]	Last 2001
SA [c]	2001	55 164	12 155 ± 2182	0.22 ± 0.040	Axford et al. 2002
Simpson		45 764	10 754 ± 2105	0.235 ± 0.046	
Witjira		9400	1401 ± 573	0.149 ± 0.061	
NT [c]	2001	259 129	80 533 ± 7428	0.31 ± 0.03	Edwards et al. 2004
SA Great Victoria Desert [c]	2004	49 025	13 221 ± 2281	0.27 ± 0.05	Peeters et al. 2005
WA Great Victoria Desert [c]		14 487	3042 ± 579	0.21 ± 0.04	
WA western Little Sandy Desert [c]	2005	67 700	11 509 [d]	0.17 [d]	Ward et al. 2005
WA Rudall River National Park [c]	2006	78 500	20 400 [d]	0.26 [d]	Ward et al. 2006
SA [c]	2007	62 863	40 626 ± 6500 [e]	0.646 ± 0.103 [e]	Lethbridge 2007
WA [c]		65 156	54 579 ± 13 645 [e]	0.838 ± 0.210 [e]	
WA western Little Sandy desert [c]	2007	55 000	9860 [d]	0.17 [d]	Ward & Burrows 2007

[a] interview/questionnaire survey

[b] uncorrected for perception bias

[c] aerial survey

[d] standard errors not reported with aerial survey population estimates

[e] estimates derived using mark-recapture and multi-covariate distance sampling methods

Note: Data based on an interview/questionnaire survey and aerial surveys. Abundances and densities are for the area surveyed and are corrected for perception bias (in the sense of Edwards et al. 2004) unless otherwise indicated.

We attempted to use all of the available data on camel abundance at our disposal to estimate the current (2008) Australian camel population using three distinct procedures.

The first procedure used the estimated population sizes for most of the more recent aerial surveys from 2001 to 2007 (Axford et al. 2002, Peeters et al. 2005, Edwards et al. 2004, Ward et al. 2006, Lethbridge 2007, Ward & Burrows 2007). Note that data from Ward et al. (2005) were not used in this analysis because the survey area was the same as that used in the latter survey of Ward and Burrows (2007). Initial population estimates were projected forward to 2008 using the latest available annual rate of increase of 8% (McLeod & Pople 2008) and these estimates used to calculate a total population and density for the total survey area to 2008. These data are given in Table 2.2 and survey areas are shown in Figure 2.3. The assumption that the rate of increase across all parts of the surveyed range was equal is based on:

1. McLeod and Pople's (2008) determination that the NT population has been growing exponentially (up to 2001) and that this population is not yet approaching the carrying capacity of the land (McLeod & Pople 2008)
2. the fact that the area considered by McLeod and Pople (2008) covers 41% of the total surveyed area and includes a broad range of habitats.

Table 2.2: Projected camel population in 2008 for the most recent aerial surveys areas from 2001 to 2007

Survey location	Year of survey	Survey area (km^2)	Population estimate survey year	Population estimate 2008	Density 2008 (animals/km^2)
NT[a]	2001	259 129	80 533	138 019	0.53
SA[b]	2001	55 163	12 155	20 832	0.38
SA[c]	2004	49 025	13 221	17 987	0.37
WA[c]	2004	14 487	3042	4139	0.29
WA[d]	2006	78 500	21 073	24 580	0.31
WA[e]	2007	65 156	54 579	58 945	0.90
WA[f]	2007	55 000	9860	10 649	0.19
SA[e]	2007	62 863	40 626	43 876	0.70
Total Survey Area		**639 323**	**235 089**	**319 026**	**0.50**

[a] Edwards et al. 2004
[b] Axford et al. 2002
[c] Peeters et al. 2005
[d] Ward et al. 2006
[e] Lethbridge 2007
[f] Ward & Burrows 2007

Table 2.2 provides a 2008 population estimate of approximately 320 000 animals within the total area surveyed since 2001, at an overall density of 0.50 animals/km^2. The total area surveyed in Table 2.2 covers approximately 19% of the projected feral camel distribution in Australia (Figure 2.3). Scaling up the overall density for the surveyed area (0.50 animals/km^2) to the total distribution gives an estimate of 1.7 million camels across Australia in 2008.

If we accept the proposition that aerial surveys would have been targeted to those areas within the feral camel distribution that are perceived to have high densities, then the figure of 1.7 million camels is almost certainly a gross over-estimate of the total Australian feral camel population as it assumes a fixed density across the entire unsurveyed distribution.

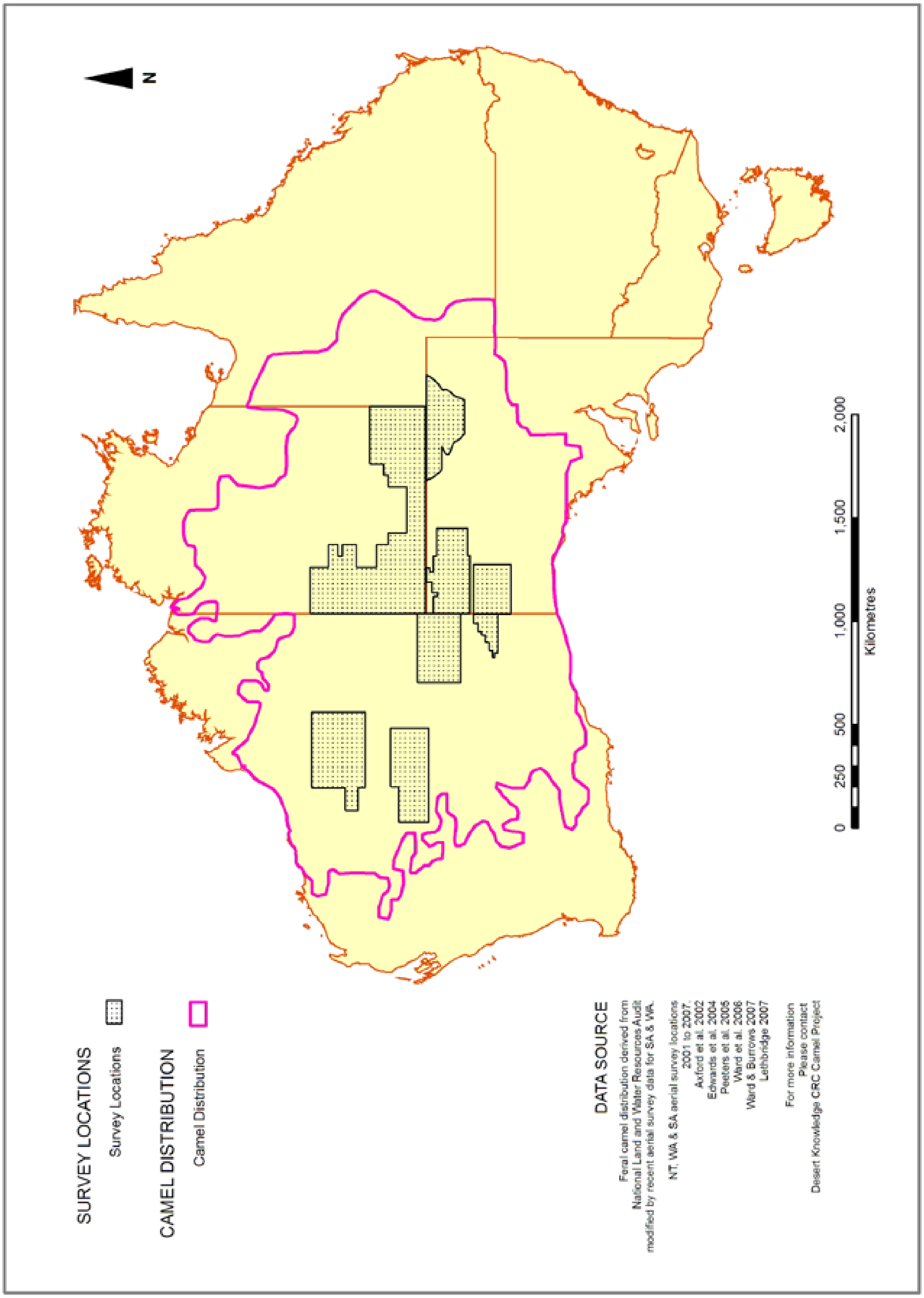


Figure 2.3: Locations of broadscale aerial surveys included in Table 2.3 of projected distribution that were used for the Krigging analysis

The second procedure used to estimate the Australian camel population was underpinned by the modified NLWRA camel density distribution from Figure 2.2. We calculated actual population estimates for each of the 0.5 degree cells in the NLWRA camel density distribution map by recoding the density classification for each cell. Recoding of each cell was based on the actual density ranges from aerial survey (Edwards et al. 2004) used to create the NT component of the NLWRA Australian camel density distribution map. The actual density values allocated to the different density classes from the NLWRA (Low, Medium, or High) are the mean estimated density for the same cells within the NT 2001 survey area (Edwards et al. 2004). Table 2.3 lists the NLWRA density classes and associated density range and mean density from the NT aerial survey.

Table 2.3: NLWRA density classes and associated density range and mean density

NLWRA density class	NT density range (animals/km^2)	NT mean density (animals/km^2)
Low	0 <= 0.25	0.04
Medium	0.25 <= 1.0	0.54
High	> 1.0	2.30

Note: From the 2001 NT aerial survey

Recoding each of the 0.5 degree cells in the NLWRA density distribution results in an overall Australian population estimate of 2 million camels at a density of 0.53 camels/km^2. Like the previous estimate (1.7 million), this estimate is considered to be an over-estimate. This estimate is also considered to be dubious in nature because there are obvious inconsistencies in the NLWRA density distribution due to the subjective manner in which density classifications were assigned to cells. This problem is evident in Figure 2.2 where there are clear cross-border differences in the density classifications of many adjacent cells that probably do not exist in reality. In addition, a higher proportion of cells in WA were coded high density in the NLWRA compared with the other jurisdictions (31% of cells within the camel distribution in WA were coded as high density, compared with 3% in the NT and none in either SA or Qld). As a result, WA was estimated to have a population of 1.6 million camels compared with estimates of only 216 000 for SA, 121 000 for the NT and 63 000 for Qld. These results for each jurisdiction are very different from those provided by Short et al. (1988) (see Table 2.1). In addition to the apparent over-estimation of high density in WA, there were large areas of 'no data available' coding reported for areas of WA and the NT in the NLWRA.

To address the issue of perceived over-inflation associated with the first and second procedures for estimating the Australian camel population above, a third procedure using only aerial survey data and GIS-based spatial analysis was used to extrapolate known survey densities across the entire distribution range. As with previous methods, known aerial survey densities were projected forward to 2008 using annual growth rate. An annual growth rate of 10% (Edwards et al. 2004) was used because the McLeod and Pople (2008) estimate was not available at the time of the analysis (see section 4.2). Survey data used were from Axford et al. (2002), Edwards et al. (2004), Ward et al. (2006), Ward and Burrows (2007), and Lethbridge (2007) as raw data were available for these surveys.

ArcGIS version 9.2 (ESRI 2006) Spatial Analyst extension was used to perform a surface interpolation analysis over the known aerial survey density distribution using the Krigging method. The Krigging method used was an ordinary Gaussian semivariogram with a cell size of 0.5 degrees and a variable search radius of 12 input points. The interpolated density distribution was limited to the current predicted range of the camel distribution in Australia as determined previously (Figure 2.1). A Gaussian semivariogram was used as it provides a normal distribution. A cell size of 0.5 degrees was used as this was the cell size that matched the resolution of the input data derived from the aerial surveys. A variable search radius of 12 input points was selected as providing a coverage area for each location exceeding a pastoral property and its neighbouring properties, covering a minimum of 30% of any single block of Aboriginal land and not exceeding the area of any single survey.

Figure 2.4 shows the density distribution of camels across the range of the camel in Australia derived from the Krigging interpolation of known aerial survey densities extrapolated forward to 2008. Densities vary, with two substantial areas of high density being present, one centred on the Simpson Desert and the other on the Great Sandy Desert. The high density area covering the eastern part of the Great Sandy Desert has predicted densities in the range of 0.5 to greater than 2 animals/km^2 and that on the Simpson Desert in the range 0.5–1.0 animals/km^2. No areas of habitat within the distribution range of the camel were excluded from the Krigging envelope as camels appear to use almost all available habitat types within the arid and semi-arid environment of Australia to some extent (Dörges & Heucke 1995). Two habitat types that might be expected to be least used by feral camels are mountain range and salt lake/pan habitat. While there is no quantitative data available for camel use of these habitats, camel tracks have been observed across many salt lakes during aerial surveys (Glenn Edwards, pers. obs.) and camel sign has been observed in accessible parts of range country (Glenn Edwards, pers. obs., David Hewitt 2008, Relief Manager, Punmu Community, Ngaanyatjarra lands WA, pers. comm.).

A population estimate of 780 000 feral camels for Australia at an overall density of 0.23 animals/km^2 was derived from the Krigging interpolation of known aerial survey densities. However, these population and density estimates are considered to be on the low side because the Krigging interpolation failed to interpolate to the full extent of the proposed current Australian camel distribution; that is, much of the periphery of the distribution where camels are known to occur was estimated to have zero camel density (Figure 2.4). This was particularly the case in the south-west and Kimberly areas of WA, the centre and north-east of the NT, and in south-west and south-east of SA and most of Qld. The lack of aerial survey data in these areas resulted in the Krigging interpolation underestimating density in these areas. This conclusion is supported by the preliminary results of a 2008 survey that recorded camels being at low density (0.03 camels/km^2 (uncorrected); approximately 0.045 camels/km^2 when corrected for perception bias (Bruce Ward 2008, WA Dept of Environment and Conservation, pers. comm.) in an area of the Nullarbor in WA for which the Krigging interpolation showed a density of zero for the most part.

As a means of partially addressing the problem of the Krigging interpolation failing to interpolate to the full extent of the camel distribution, all areas that Krigging reported as having 0–0.1 animals/km^2 density were set to the mean density for all non-zero cells on the periphery of the camel distribution, 0.075 animals/km^2. Applying this modified Krigging approach across the Australian camel distribution gave a population estimate of approximately one million camels (Table 2.4). This estimate is considered a better approximation of the actual population than that derived from the first two procedures described above because it is underpinned wholly by quantitative data and the Krigging procedure uses a declining Guassian function to model from the known densities to the edge of the distribution boundary rather than assuming uniform density equal to that of the mean of the surveyed areas across the entire unsurveyed distribution. Further means by which the Krigging interpolation may be improved are considered below.

Feral camel population estimates were calculated for each of the jurisdictions within the camel's range and for each of the major land tenure classifications on the basis of the modified Krigging interpolation (Tables 2.4, 2.5). The major tenure classifications used here and elsewhere in this report are: Aboriginal lands (includes Aboriginal freehold and leasehold land excluding Aboriginal pastoral land), pastoral lands (includes private, Aboriginal, and government pastoral leasehold), vacant Crown land and conservation/other land (includes all remaining lands). Figure 2.5 shows feral camel density contours overlaying major tenure classifications within the Australian camel distribution.

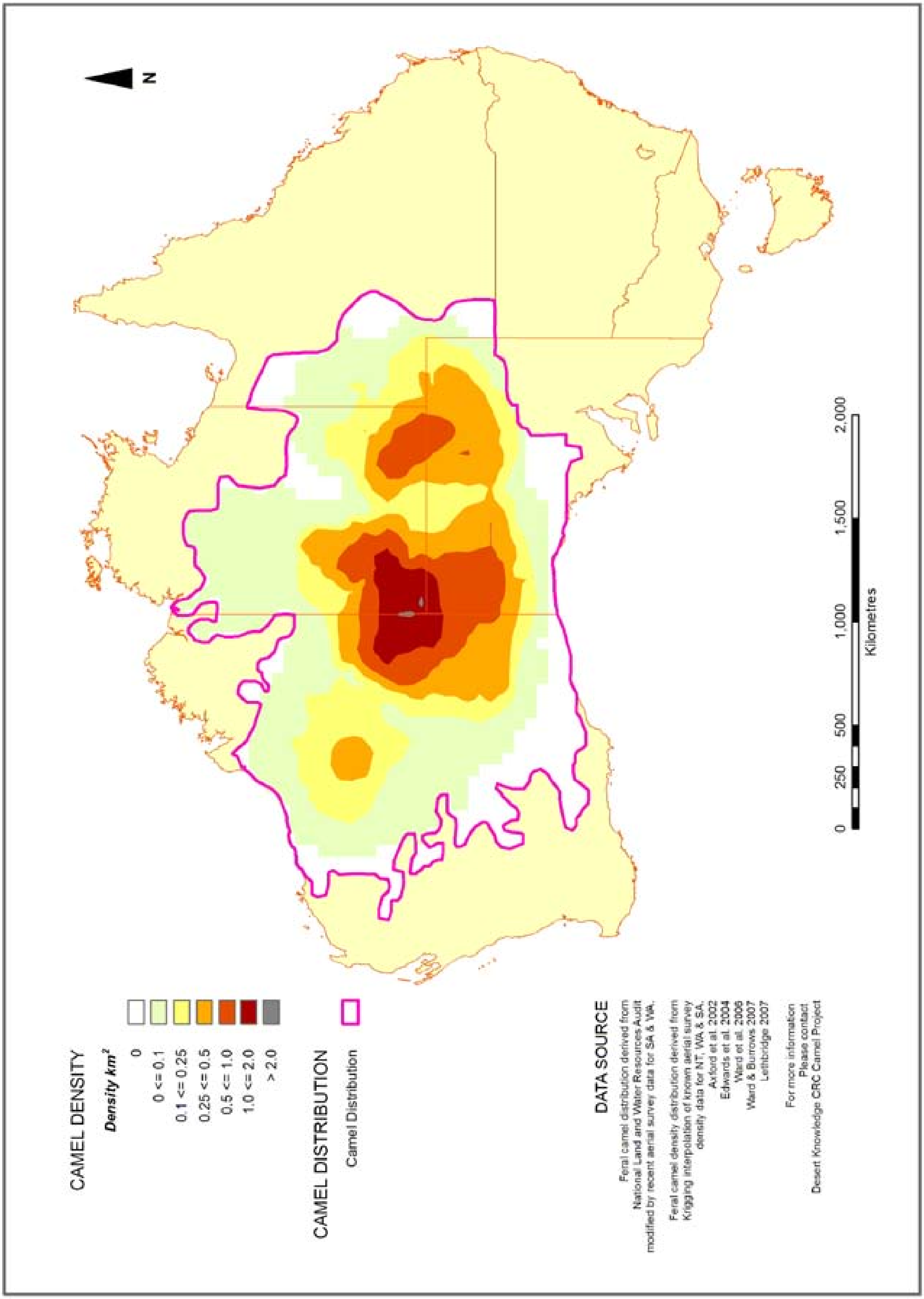


Figure 2.4: Density distribution of camels across the range of the camel in Australia

Note: Data derived from Krigging interpolation of known aerial survey densities extrapolated forward to 2008.

Table 2.4: Feral camel population estimates for each jurisdiction within the camel's range based on Krigging interpolation of known aerial survey population density distribution

Jurisdiction	Area within camel distribution (km^2)	Population estimate based on modified Krigging (above)	Density estimate (animals/km^2) based on modified Krigging (above)
WA	1 534 000	399 000	0.26
NT	875 000	341 000	0.39
SA	589 000	183 000	0.31
Qld	331 000	30 000	0.09
Total	3 329 000	953 000	0.29

Table 2.5: Feral camel population abundance and density for each of the major tenure classifications within the Australian camel distribution

Tenure classification	Area (km^2)	Population (%)	Density (animals/km^2)
Aboriginal	783 000	415 000 (43%)	0.53
Pastoral	1 399 000	210 000 (22%)	0.15
Vacant Crown land	813 000	236 000 (25%)	0.29
Conservation/Other	335 000	94 000 (10%)	0.28
Total	3 330 000	955 000 (100%)	0.29

All of the procedures used to estimate the current density distribution and abundance of feral camels in Australia have limitations that highlight the need for further monitoring of distribution and abundance. The greatest limitation, and equally applicable to each of the procedures, is the assumption of a static distribution with population increase in any area equal to known mean annual rate of increase. This is clearly not the case (McKnight 1969, 1976; Short et al. 1988; Wurst & Saalfeld 1994; Dörges & Heucke 1995, 2003; Grigg et al. 1995; Edwards et al. 2001; Edwards et al. 2004; Lethbridge 2007; Ward & Burrows 2007), with camel distribution being both spatially and temporally dynamic in response to a range of environmental parameters. Detailed modelling of the distributional dynamics of the feral camel in Australia across its range is yet to be undertaken (McLeod & Pople 2008).

The population estimates derived from the three procedures described above are all based on aerial survey data which contain a negative bias. The survey data on which they are based was corrected for perceptual (observer) bias (Marsh & Sinclair 1989, Edwards et al. 2004) but not for environmental (availability) bias (Marsh & Sinclair 1989, Edwards et al. 2004). While the extent of the environmental bias for camels is unknown, Short et al. (1988) estimated that the visibility of camels may be as low as 25%, and expert opinion is that the correction for environmental bias could be anything in the range of 1.5–2 times perceptual corrected counts (Glenn Edwards and Keith Saalfeld 2008, NT Department of Natural Resources, Environment and the Arts, pers. comm.; Phil Gee 2008, SA Rural Solutions, pers. comm.). For this reason, the estimates provided by the three procedures above are lower than they would be if wholly corrected data were used. It is for this reason that all three population estimates as they stand (ignoring the methodological problems discussed above) should be viewed as minimum estimates.

Application of a correction for environmental bias of 1.5–2 to the modified Krigging population estimate (one million camels) gives a potential maximum overall Australian camel population estimate in the range of 1.5 to 2.0 million camels. While a population of this size is considered a possibility, we recommend using the more conservative estimate of one million camels as the current estimate of the Australian camel population, at least until a more accurate estimate can be devised.

Expansion of the available broadscale aerial survey data set for feral camels to cover the void areas in the Krigging interpolation is proposed as the simplest means of increasing the accuracy of the Krigging derived density distribution of feral camels in Australia.

The requirement to obtain an estimate of environmental (availability) bias for feral camel aerial survey data in order to provide more accurate population estimates is clearly elucidated when various management options are considered. If the management strategy to be implemented is based on commercial utilisation and density estimates are negatively biased, areas suitable for commercial utilisation may be deemed unsuitable for the method. This contrasts dramatically with management actions based on non-commercial methods to achieve the management of feral animal impact on conservation, cultural or production values. These actions are generally centred on the reduction of feral animal populations to target densities at which impacts are considered to be managed or acceptable. Program costs and budgets are based on achieving set changes in population density, for example, reduction from 0.8 to 0.3 animals/km^2, using known cost models. If the starting densities on which these actions are based are underestimates but the target densities are actual densities, then program costs will be underestimated and actual target density may not be achieved, that is, desired management outcomes may not be realised within the budget allocated. The requirement for additional funding and time coupled with population recruitment means that final costs will be greater than anticipated. Of course, if the starting and target densities contain the same bias, there is no problem in this regard.

Obtaining an estimate of environmental (availability) bias would be best accomplished by means of a broadscale index-manipulate-index experiment that covered a range of camel habitats. This experiment would most appropriately take the form of a broadscale aerial survey to obtain an initial population density index, control operations to remove a known density of animals, and a final duplicate aerial survey to obtain a final population density index. The difference between initial and final density indices would equate to known density removal assuming negligible emigration or immigration, and permit determination of a generic, habitat independent estimate of environmental bias for broadscale aerial survey.

4.2 Camel population dynamics

Edwards et al. (2004) used available aerial survey population estimates to determine the intrinsic rate of increase and associated annual rate of increase and population doubling times for feral camels in central Australia. Edwards et al. (2004) obtained a mean annual exponential rate of increase between 1993 and 2001 of 0.093, giving an annual rate of increase of 10% per year and a population doubling time of eight years.

The mean annual exponential rate of increase obtained by Edwards et al. (2004) accords well with the earlier estimates for annual rate of increase and population doubling times for feral camels in Australia obtained by Dörges and Heucke (1995). Dörges and Heucke (1995) estimated the annual growth rate for the camel population in their study through detailed knowledge of annual birth and mortality rates. They found that annual growth rate was strongly dependant on average lifespan and calculated growth rate for a range of average lifespans. With average lifespan ranging from 20 to 40 years, Dörges and Heucke (1995) obtained annual growth rates in the range 0.071 to 0.123 and population doubling times of 10 years, reducing to six years. Edwards et al. (2004) mean annual exponential rate of increase of 0.093 corresponds to an average lifespan of slightly more than 25 years using the Dörges and Heucke (1995) population growth model.

Development of a detailed model of camel population dynamics in Australia has been undertaken as part of this project and is reported in McLeod and Pople (2008). McLeod and Pople (2008) estimated model parameters for three population models – exponential growth, logistic growth and theta-logistic growth. Using all population estimates available from 1966–2001, McLeod and Pople (2008) estimated that the exponential rate of increase of camels in the southern Northern Territory ranged from 0.074 to 0.079. These estimates are slightly lower then the estimate calculated by Edwards et al. (2004) based on population growth between 1993 and 2001.

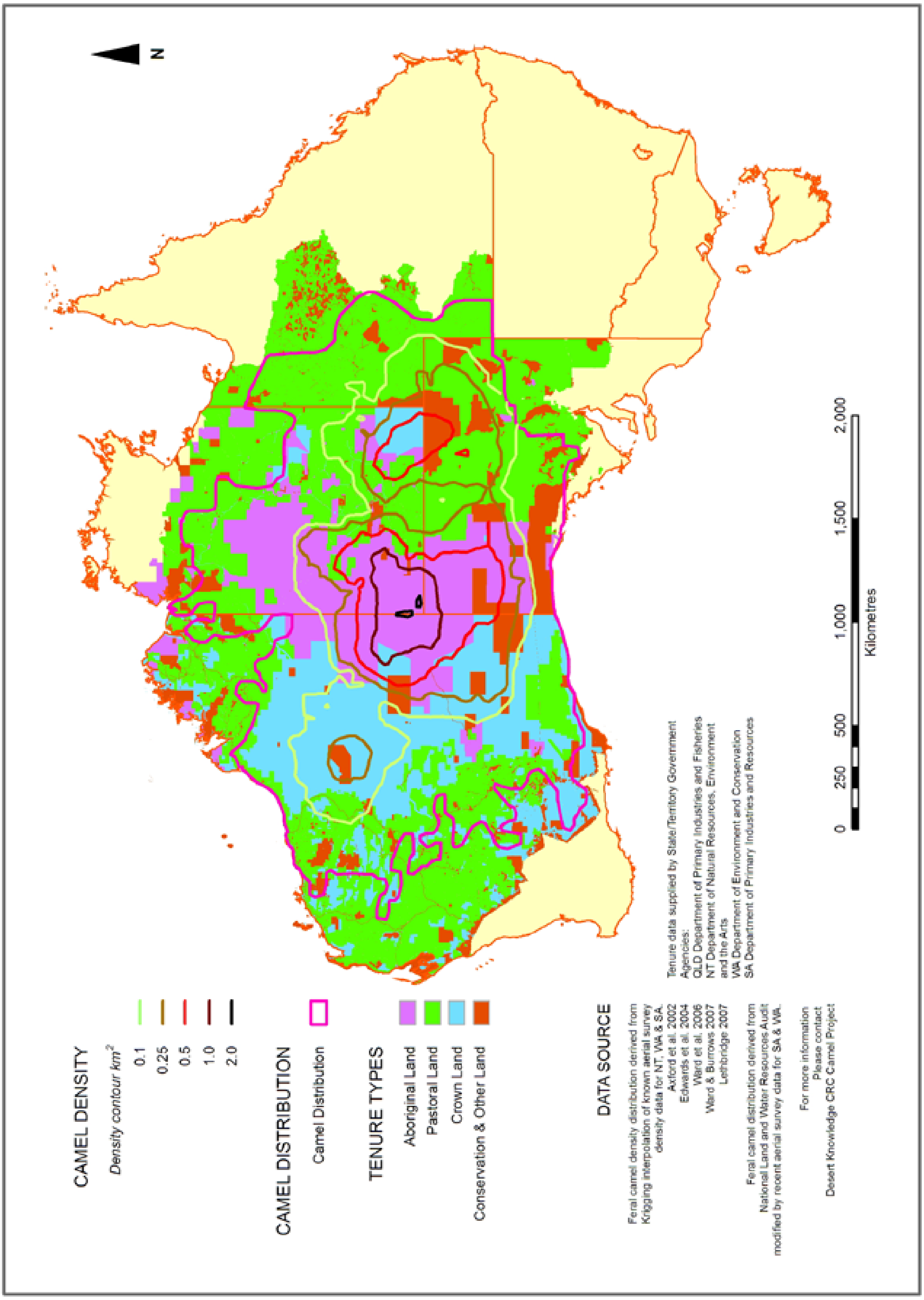


Figure 2.5: Tenure types within the Australian feral camel distribution with feral camel density contours overlain

Note: Contour interval is 0.1 camels/km².

5. Recommendations

- That efforts are made to achieve a better understanding of the factors influencing the movement patterns and population distribution of feral camels at the local to regional scale. This would allow static aerial survey data to be more accurately projected forwards and facilitate the development of a dynamic model of feral camel density distribution.
- That the broadscale aerial survey database of feral camel distribution and abundance be expanded through the implementation of aerial survey in areas not previously covered in order to improve estimation of density distribution for feral camels.
- That a broadscale index-manipulate-index experiment related to broadscale aerial survey of feral camels be conducted to address the issue of environmental bias associated with current aerial survey estimates of feral camel population distribution and abundance.
- That a national database of feral camel aerial survey data be created incorporating all available aerial survey data related to feral camels from all jurisdictions, with data incorporated at the finest spatial scale available, and that this database be supported by all jurisdictions.
- That the national database is a core component of the development of a dynamic model of feral camel distribution and any other tools or models related to feral camel management, and that this imposes a requirement for complete and regular update of the database to ensure currency.

6. References

Axford G, Holden C and Farroway L. 2002. *Aerial survey of camels and other large feral animals in the Simpson Desert region of South Australia*. Department for Environment and Heritage, South Australia.

Barker HM. 1964. *Camels and the Outback*. Pitman, Melbourne.

Brown A. 2004. *Camel – A review of diseases in central Australia,* DPIF Technical Bulletin no. 314, pp. 1–16. Northern Territory Department of Primary Industry, Fisheries and Mines, Darwin.

Dörges B and Heucke J. 1995. Ecology, social organisation and behaviour of the feral dromedary *Camelus dromedaries* (L. 1758) in central Australia, Unpublished Report (translated from two PhD theses, submitted 1995). University of Braunschweig, Braunschweig, Germany.

Dörges B and Heucke J. 2003. *Demonstration of ecologically sustainable management of camels on Aboriginal and pastoral land*, Final report on NHT project no. 200046. Natural Heritage Trust, Canberra, Australia.

Edwards GP, Eldridge SR, Wurst D, Berman DM and Garbin V. 2001. Movement patterns of female feral camels in central and northern Australia. *Wildlife Research,* vol. 28, 283–289.

Edwards GP, Saalfeld K and Clifford B. 2004. Population trend of camels in the Northern Territory, Australia. *Wildlife Research,* vol. 31, 509–511.

Edwards GP, Zeng B and Saalfeld WK. 2008. Evaluation of the impacts of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 133–182. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

ESRI (Environmental Systems Research Institute). 2006. ArcGIS Release 9.2, Environmental Systems Research Institute, Redlands, California, USA.

Graham A, Johnson K and Graham P. 1986. *An aerial survey of horses and other large animals in the Alice springs and gulf regions*, CCNT Technical Report no. 28. Conservation Commission of the Northern Territory, Alice Springs.

Grigg GC, Pople AR and Beard LA. 1995. Movements of feral camels in central Australia determined by satellite telemetry. *Journal of Arid Environments,* vol. 31, 459–469.

Last P. 2001. *Aerial survey for camels and other large vertebrate species on the Anangu Pitjantjatjara lands,* Report to the Department of Environment and Heritage. Department of Environment and Heritage, Canberra.

Lethbridge Mark R. 2007. *2007 camel survey of South Australia and Western Australia*, Draft Final Report. Flinders University, Adelaide.

Marsh H and Sinclair DF. 1989. Correcting for visibility bias in strip transect aerial surveys of aquatic fauna. *Journal of Wildlife Management,* vol. 53, no. 4, 1017–1024.

McLeod SR and Pople AR. 2008. *Modelling management options for management of feral camels in central Australia*, DKCRC Research Report 48. Desert Knowledge CRC, Alice Springs.

McKnight TL. 1969. *The camel in Australia*. Melbourne University Press, Melbourne.

McKnight TL. 1976. *Friendly vermin. A survey of feral livestock in Australia.* University of California Publications in Geography, vol. 21, University of California Press, California.

Newman DRM. 1975. The Camel – its potential as provider of protein in arid Australia, in *Proceedings III World Conference on Animal Production, Melbourne, Australia,* ed. Reid RL. Sydney University Press, Sydney, 95–101.

Newman DRM. 1979. The feeds and feeding habits of old and new world camels, in *The Camelid, an all purpose animal,* ed. Cockrill WR, vol. I, 1984 pp. 250–292, Scandinavian Institute for African Studies, Uppsala.

Peeters PJ, Jennings S, Carpenter RJ and Axford G. 2005. *Assessing the abundance and impacts of feral camels in the Great Victoria Desert*. A report to the Aboriginal Lands Integrated Natural Resource Management Group. Department for Environment and Heritage, South Australia.

Short J, Caughley G, Grice D and Brown B. 1988. The distribution and relative abundance of camels in Australia, *Journal of Arid Environments,* vol. 15, 91–97.

Ward BG, Ward CG and Liddelow GL. 2005. *Camel populations in central Western Australia determined from aerial surveys*, Draft Report. Department of Environment and Conservation, Western Australia.

Ward BG, Ward CG, Withnell N, Bishop C, Kay W, Everett M, Paterson W and Piirto G 2006, *Aerial survey conducted from Telfer Mine site of the Rudall river national Park and its surrounds to assess feral camel densities*, Draft Report. Department of Environment and Conservation, Western Australia.

Ward B and Burrows N. 2007. *Evaluating the effectiveness of an operation to cull feral camels in the Western Little Sandy Desert,* Unpublished Report. Department of Environment and Conservation, Western Australia.

Williams OJ. 1992. Investigation into the health and productivity of camels in central Australia, in *Abstracts of the First International Camel Symposium,* no. 122. Dubai, United Arad Emirates.

Wilson RT. 1984. *The Camel.* Longman, London and New York.

Woinarski J, Pavey C, Kerrigan R, Cowie I and Wards S (Eds). 2007. *Lost from our landscape: Threatened species of the Northern Territory*. Northern Territory Government, Darwin.

Wurst D and Saalfeld K 1994, *Aerial survey of feral camels and other large vertebrate species in the Alice Springs region of the Northern Territory,* Conservation Commission of the Northern Territory report to the Australian Nature Conservation Agency. Australian Nature Conservation Agency, Canberra.

Zeng B and Edwards GP. 2008. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Chapter 3: Key stakeholder perceptions of feral camels: pastoralist survey

B Zeng

GP Edwards

Contributing author information

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Contents

Tables

Figures and graphs

List of shortened forms

CLMA	Centralian Land Management Association
DKCRC	Desert Knowledge Cooperative Research Centre
NRM	Natural Resource Management
PLB	Pastoral Lands Board

Acknowledgements

This report is Chapter 3 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

We are grateful to Rural Solutions South Australia and the Centralian Land Management Association for their role in delivering the survey to pastoralists.

Support from government agencies in Western Australia, the Northern Territory, South Australia, and Queensland was important for the project.

Thanks go to Robin Mills and Phil Thomas for their help in identifying survey lists.

Thanks also to pastoralists involved in the survey for their engagement and cooperation.

Lyndee Matthews and Phil Gee provided useful comments on a draft of this report.

Chapter 3: Key stakeholder perceptions of feral camels: pastoralist survey

1. Summary

The perspectives of people involved in the pastoral industry on feral camels and their management were assessed through a questionnaire survey. The survey was designed to gauge:

- understanding about the distribution and abundance of feral camels
- perspective on camel impacts
- attitudes towards different camel management options.

Two hundred and nine properties responded to the survey. This represented about 18% of all pastoral properties within or on the margins of the camel range. The properties that responded to the survey covered 706 489 km^2, which is about 32% of the entire area of pastoral lands within or on the margins of the camel range (approximately 2.22 million km^2).

Camels occurred on the majority of the properties surveyed and more than 50% of pastoralists reported that the camel numbers were increasing.

Most pastoralists with camels on their properties claimed that camels caused damage. The value of this damage was estimated to be $7.15 million annually across all pastoral properties within or on the margins of the camel range, including $3.42 million for production losses (attributable to camels competing with stock for food and water, cattle escaping, etc.), $2.40 million for infrastructure damage (i.e. damage to fences, yards, and water equipment) and $1.33 million for management.

A small minority of pastoralists reported benefits attributable to feral camels. These benefits accrued from selling camels, eating camels, and using camels for NRM activities, including weed control. The value of the benefit that pastoralists realised from feral camels was estimated to be about $0.58 million annually across all pastoral properties within or on the margins of the camel range. Pastoralists are one of the most important harvesters of feral camels, accounting for about 20% of the total annual harvest for the period July 05 – June 07.

The vast majority of surveyed pastoralists indicated that camels needed to be controlled, and they favoured the methods of shooting to waste and harvesting to use camels. However, a small percentage is interested in pursuing alternative approaches, including exclusion fencing and Judas collaring. This indicates that pastoralists may be willing to engage in new techniques in conjunction with the preferred methods. Fewer than 11% of those surveyed indicated that they supported ‘strategic’ approaches to the control of camels and their impacts. This may indicate that pastoralists want immediate action rather than more talking about, planning to deal with, and monitoring of the problem. Pastoralists are indeed getting on with the job of managing the problem and are investing significant resources in doing so. More than 80% of pastoralists engaged in some form of activity to manage camels on their properties. Pastoralists engaged in all of the currently available methods for managing feral camels, with culling (shooting to waste) being the most widely used form of management. Most camel management is currently undertaken by station personnel. It is essential that the willingness and capacity of pastoralists to engage in the management of feral camels be harnessed when implementing a cross-jurisdictional approach to managing feral camel impacts.

While most pastoralists indicated that commercial use was a desirable way of managing camels and most generally supported the development of a stronger camel industry in Australia, only a few currently undertake management actions involving this approach. There is a lack of confidence in the current camel industry with particular concerns over its long-term viability because of unproved markets. The majority of pastoralists would have to upgrade their current infrastructure before they could engage more widely in the commercial use of camels.

Pastoralists currently engage with governments to secure assistance with culling operations. Most pastoralists indicated that they would welcome more assistance to manage feral camels on their land, particularly assistance with culling and the commercial use of camels.

Although the vast majority of pastoralists were engaged in managing camels and their impacts, most did not obtain relevant information that could help them in this task. This highlights the need for a communication strategy to disseminate information on camels, their impacts, and their management in culturally appropriate formats to all relevant stakeholders. This strategy should provide for two-way communication.

1.1 Conclusions

- Pastoralists are key stakeholders in the management of feral camels and their impacts.
- Pastoralists see a need to control camels and their impacts.
- Pastoralists currently play an active and important role in camel management and are willing to engage in collaborative management approaches.
- Pastoralists favour culling and commercial use to manage camel impacts but are comfortable using all of the available approaches and are willing to consider new ones.
- The annual monetary values of the positive and negative impacts of feral camels on pastoral properties within or on the margins of the camel range were estimated to be $0.58 million for positive impacts and $7.15 million for negative impacts and management (approximately $2.40 million for infrastructure damage, $3.42 for lost production, and $1.33 million for management).
- Most pastoralists did not obtain relevant information that could help them in the task of managing camels and their impacts.
- It is essential to engage with pastoralists in developing and implementing a cross-jurisdictional management framework for managing camels and their impacts.

1.2 Recommendations

- Develop a communication strategy to disseminate information on camels, their impacts, and their management in culturally appropriate formats to pastoralists and all other relevant stakeholders. This strategy should provide for two-way communication.
- Harness the willingness and capacity of pastoralists to engage in the management of feral camels when implementing a cross-jurisdictional management approach to feral camels.

2. Introduction

In Australia, feral camels are seen by people or associations of people in a number of different ways. Camels have a rich history in Australia, extending back to 1840 when the first camel was imported (McKnight 1969). Camels played an important role in opening up the outback and were used extensively for exploration, transportation, and construction up until the mid- to late 1920s (McKnight 1969). Many of the people involved with camels in this early period are historically as important as the camels themselves, particularly the Afghan cameleers, explorers like Burke and Wills, McKinlay, Warburton, and Giles, and pastoralists such as Thomas Elder (McKnight 1969, Brian 2005). Nowadays, camels are viewed as both a resource and a pest. Edwards et al. (2004) asserted that, at densities evident in 2001, feral camels had discernible negative economic, environmental, and social/cultural impacts, though at that time the scope of the impacts was not well documented. On the other hand, feral camels are currently being used for economic gain through enterprises such as pet meating and meat for human consumption (see Zeng & McGregor 2008). Camels are also used in the tourism sector, and through phenomena such as the Ghan train, are achieving iconic status as a symbol of the remote desert regions of Australia (Brian 2005).

Given this background, if we are to manage feral camels and their impacts across Australia it is important to understand the contemporary views of the different people, groups and organisations that have a stake in camels and their management – the so-called ‘stakeholders’. In the last decades of the twentieth century, the word ‘stakeholder’ has become commonly used to mean a person or organisation with a legitimate interest in a project (specific activity) or entity.

A stakeholder analysis can help to identify the interests of the various stakeholders who may affect or be affected by a specific activity; potential issues that could disrupt the activity; key people to target for the distribution of information; groups that should be encouraged to participate in different stages of the activity; issues to consider in the development of communication plans and stakeholder management strategies; and ways to manage critical issues and reduce potential negative repercussions of the activity (Braysher 1993, Babou 2008).

From the perspective of an activity such as Natural Resource Management (NRM), the stakeholders can be categorised as primary, secondary, opposition, and marginalised stakeholders (ConserveOnline 2006). Primary stakeholders include those who, because of power, authority, responsibility, or claims over the resource are central to any NRM initiative. As the outcome of any action will affect them directly, their participation is critical. Secondary stakeholders are those with an indirect interest in the outcome of the proposed activity. These stakeholders may need to be involved in collaborative processes, but their role is peripheral to that of primary stakeholders and they may need to be involved only periodically in the activity. Opposition stakeholders may have the capacity to adversely influence outcomes through the resources and influence they command. As they may negatively influence different aspects of NRM initiatives, particularly during the early stages, it is crucial to engage opposition stakeholders in open dialogue. Marginalised stakeholders, which often include women, Aboriginal peoples, and other impoverished and/or disenfranchised groups, may in fact be primary, secondary, or opposition stakeholders. Marginalised stakeholders may lack the recognition or capacity to participate in collaborative efforts on an equal basis. Particular effort must be made to ensure the participation of marginalised stakeholders in any proposed activity (ConserveOnline 2006).

Key stakeholders, who can belong to any of the four groups, are those stakeholders who have significant influence or importance in proposed initiatives or activities.

In the particular case of feral camel management, the stakeholders include:

- International society
- Government agencies (Australian, state/territory and local)
- NRM boards
- Government and non-government conservation agencies/organisations
- Peak bodies representing various interest groups
- Industries (pastoral, meat, tourism)
- Institutions (universities, think tanks, etc.)
- Aboriginal settlements
- Aboriginal traditional owners
- Non-Aboriginal settlements
- Pastoral landholders
- Animal welfare groups
- Animal rights groups
- Australian public.

This list is not exhaustive. Government, the pastoral industry, non-government conservation organisations, Aboriginal settlements, and Aboriginal traditional owners are primary as well as key stakeholders in feral camel management, as they manage or have claim over the lands where camels live and they are responsible for the management and use of resources on those lands. In order to develop a framework for the cross-jurisdictional management of feral camels, it was therefore critical to conduct a stakeholder analysis to understand the government policies, regulations and laws that impinge on feral animal management and to clarify and understand the perceptions of these key stakeholders. This chapter outlines a key stakeholder survey that aimed to document the perceptions of people involved in the pastoral industry in respect of feral camels and their management. Zeng and Edwards (2008) outline a key stakeholder survey that aimed to document the perceptions of managers of conservation reserves in respect of feral camels and their management. Vaarzon-Morel (2008) outlines a key stakeholder survey that aimed to document the perceptions of Aboriginal people in respect of feral camels and their management. Carey et al. (2008) review government policies, regulations and laws affecting the management of feral camels.

3. Methods

3.1 Survey method

The perspectives of people involved in the pastoral industry on feral camels and their management were assessed through a questionnaire survey. The survey was designed to gauge:

- understanding about the distribution and abundance of feral camels
- perspective on camel impacts
- attitudes towards different camel management options.

3.2 Questionnaire design

The way a questionnaire is presented to potential respondents affects the response rate, the speed at which responses are made, the number of approaches to be made in order to achieve the required sample size, and the cost and length of the questionnaire (Gorard 2003). There are three possible approaches: face-to-face, self-administered and technology-based (Gorard 2003). For the pastoralist survey, a combination of face-to-face and self-administered approaches was used.

A range of different types of questions and approaches can be used in questionnaires. These include requests for specific information, tick-box categories, multiple choice, scales, ranking procedures, grids or tables, and open-ended questions (Gorard 2003). The pastoralist survey integrated all of these types of questions and approaches in one questionnaire.

The approach taken to developing the questionnaire was to first develop a question tree (Hitchcock 2006; Grimm 2008). All of the questions used in the questionnaire came from the question list identified from the question tree, though some were combined and simplified. Using this approach, a draft questionnaire was constructed. It included some basic profile information such as property name, contacts, property size, and property jurisdiction.

Groups of professionals working in the NRM field (including the Steering Committee members: see Table 1.1 in Edwards 2008) and a small sample of pastoralists were then invited to 'answer' the draft questionnaire and provide feedback on the suitability of the questions. Following this, a final daft was developed for wider testing. The final draft was delivered to a small group (5–10) of selected pastoralists in the Northern Territory (NT) by the Centralian Land Management Association (CLMA) on a face-to-face basis to collect further feedback. The working version of the questionnaire (Appendix 3.1) was developed after considering this feedback.

An important consideration in designing the questionnaire was the time required for respondents to complete it. A completion time of 25–30 minutes was considered reasonable based on feedback from the test groups. In order to meet this constraint, the questionnaire was limited to 31 questions on a two-page form.

3.3 Sampling design

Our intention was to sample pastoral properties within or on the margins (within 150 km) of what was understood to be the distribution of feral camels in Australia in 2007 (refer to Saalfeld & Edwards 2008 for the current distribution). A list of properties believed to fit this criterion was compiled for each jurisdiction with camels (i.e. the NT, Western Australia [WA], South Australia [SA] and Queensland [Qld]). For SA, the property list was provided by Rural Solutions, SA. For WA the property list was determined using information provided by Robin Mills, a pastoralist and member of the Steering Committee, the WA Pastoral Lands Board (PLB), and the WA Department of Agriculture and Food (through Phil Thomas). For Qld, the property list was determined using information in existing pastoral land maps. For the NT, the property list was determined using information provided by the CLMA. The total list comprised 1189 properties (177 in the NT, 417 in WA, 159 in SA, and 436 in Qld). It was neither practical nor necessary to sample all of these properties. Rather, a representative sample of pastoral properties within or on the margin of the camel distribution was chosen for survey delivery. The scientific procedure suggested in Gorard (2003) was followed to determine the size of the sample needed to provide robust results: 'A good sample is representative of the wider population, large and with a high participation rate' (Gorard 2003, p. 88). A minimum sample of 200 was deemed sufficient and sampling was stratified by jurisdiction to improve its representativeness. The survey was delivered to a total of 280 properties with the objective of obtaining the minimum sample size of 200 properties. Properties were randomly chosen for survey from the compiled lists and we sampled proportionately more properties in NT, SA, and WA than in Qld because Qld has far fewer camels than the other jurisdictions (Saalfeld & Edwards 2008).

3.4 Survey delivery

Once the survey target properties had been identified, survey questionnaires were emailed to those properties with an email address. All target properties were then telephoned, and asked to verbally respond to the survey, with a clear indication that all information was to be passed on to the DKCRC to be used confidentially in the current project.

As the survey was a telephone survey, significant delays were experienced in obtaining some responses due to difficulties in contacting some pastoralists (who are often not at home for extended periods) and due to errors in contact numbers and contact names in some instances. In some cases repeat calls were made to individual pastoralists in order to solicit a response. In a small number of cases, stations were visited and the survey was conducted face to face.

In WA, SA, and Qld surveys were mainly delivered by Rural Solutions over February and early May 2008. In the NT, initial surveys were delivered by the CLMA in January – May 2007, and latter surveys were delivered by the Camel Project Officer (Benxiang Zeng) following withdrawal of the CLMA.

4. Data analysis

4.1 Data collection and collation

In most cases, the raw data were in the hand-written questionnaire forms recorded during telephone interviews or directly filled in by respondents. Some pastoralists respond by filling in the e-mail attached questionnaires electronically. The raw data were integrated into one datasheet using Microsoft Excel. The data were organised by jurisdiction.

The data set was collated and edited as necessary to facilitate appropriate analyses. Numerical data in non-standard units were converted to a standard unit (e.g. acres into km^2). Descriptive answers to questions requiring quantitative answers (e.g. 'not sure', 'minimal' and 'lots' to the question 'how much economic loss') were ignored. It was often the case that multiple answers were provided to open questions requiring 'comments'. For example, answers to question 19 (Other income related to camels, such as camel tourism) included 'weed management' and 'tourism'. In such cases, answers were collated by categorising the comments into different groups in order to transfer them to a series of 'yes/no' questions which allowed an easier count and analysis. For example, the answers 'weed management' and 'tourism' were accounted for by classifying them according to these questions: 'Do you derive income from tourism-related activities involving camels?' and 'Do you use camels for woody weed control?'.

4.2 Statistical analysis

Statistical procedures in Excel were used to provide summary statistics for the survey data which were amenable to this approach (Appendix 3.2). The sample sizes for different questions varied because not every question was answered by all respondents.

For 'yes/no' questions, the 'yes' scored '1' and 'no' scored '0' for the purpose of generating the summary statistics. In such cases, the total count of answers in tables in the results section refers to the number of 'yes' answers. For example, the total 'yes' count for question 1 ('Do you have feral camels on your land?') was 155 (Table 3.2). This means that 155 out of 209 respondents (this was the sample size) answered 'yes' and the rest answered 'no'.

Where questions required firstly a yes/no answer and then invited 'comments', some respondents made no comment while some respondents made one or more comments. For these questions, the total counts for all comments were sometimes lower and sometimes higher than the number of respondents to the yes/no question. Accordingly, in corresponding percentage calculations, the aggregation of every individual percentage was sometimes lower and sometimes higher than 100% (e.g. Tables 3.3 and 3.4).

4.3 Triangulation

Triangulation is an effective way of building trustworthiness into research design by increasing the reliability of the data and the improving the process of gathering it, and corroborating the data gathered from other sources (Tellis 1997; Decrop 2004). Triangulation can improve reliability of data interpretation if the representativeness of the sample is compromised by a poor response rate or poor quality of response. Four basic types of triangulation are identified by Denzin (1978):

- data triangulation, using a variety of data sources in the study
- method triangulation, using multiple methods to study a single problem, such as a combination of qualitative and quantitative methods
- investigator triangulation, using different researchers to explore the same data sets
- theoretical triangulation, using multiple perspectives to interpret a single set of data.

A triangulated research approach was used to interpret some of the information collected through the pastoralist survey (Tellis 1997). Three types of triangulation (data, method, and theoretical) were used in data analysis. The following example demonstrates this approach. Although information was obtained on pastoralists' perspectives on the camel industry through questions 22–30, it was not overly clear through responses to questions 23 and 25 whether or not individuals would like to be involved in a camel industry – many agreed that camels should be used but most had little experience in the industry and lacked confidence in the market. However, specific responses to question 24 indicated that most pastoralists supported external assistance for camel industry development. These two answers could triangulate to each other to give the result that most pastoralists would participate in a camel industry if it were viable and if they would benefit from that involvement.

4.4 Scaling up of results

On the basis of land area, we scaled up the estimates of the monetary value of the impacts of feral camels on pastoral properties that were surveyed to all pastoral properties within or on the margins of the camel distribution.

5. Results

Two hundred and nine properties successfully responded to the survey: 33 from the NT, 61 from SA, 100 from WA, and 15 from Qld (Table 3.1; Figure 3.1) giving an overall response rate of 74.6%. This represented about 18% of all pastoral properties within or on the margins of the camel range. The properties that responded to the survey covered 706 489 km^2, which is 32% of the entire area of pastoral lands within or on the margins of the camel range (approximately 2.22 million km^2). Complete summary statistics for the questionnaire are in Appendix 3.2.

Table 3.1: The number of properties surveyed within and on the margins of the camel distribution and the response rate

Jurisdiction	No. properties within camel distribution (approx).	No. properties surveyed	No. responses	Response (%)
All	1189	280	209	74.6
NT	177	55	33	60.0
SA	159	75	61	81.3
WA	417	130	100	76.9
Qld	436	20	15	75.0

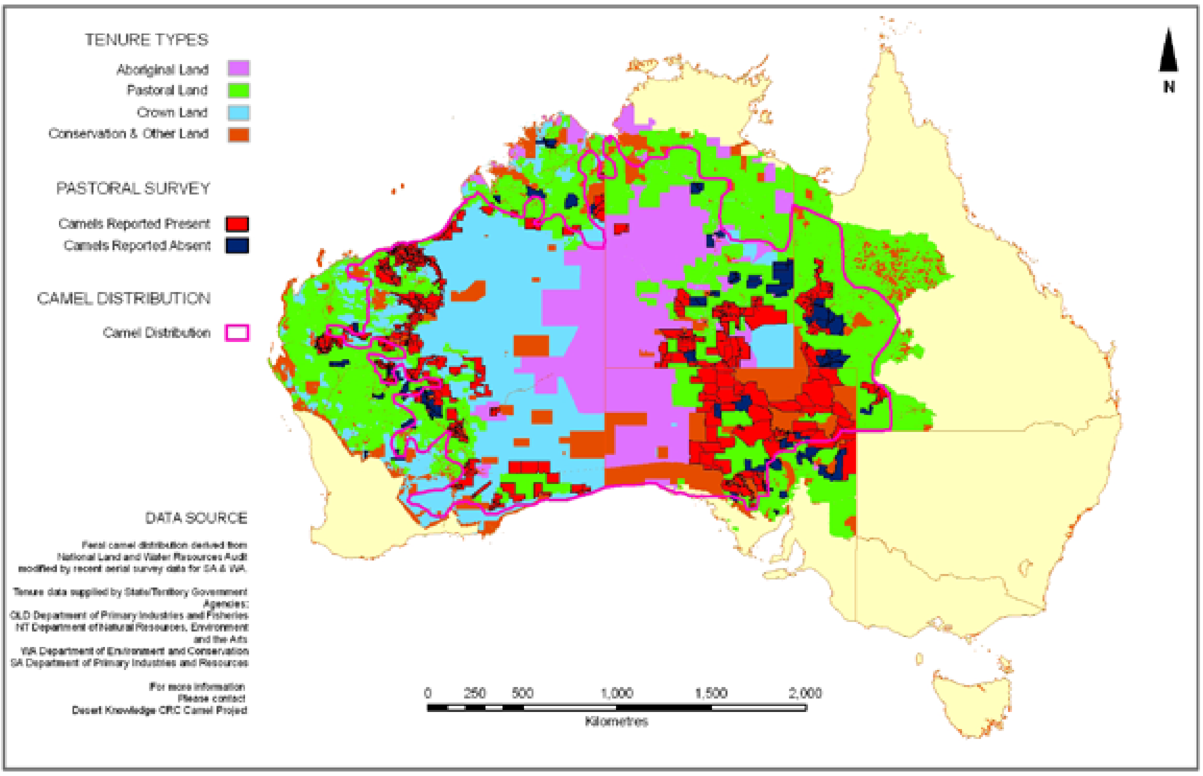


Figure 3.1: Map showing the camel distribution, land tenure, and the pastoral properties surveyed

Note: Red indicates that camels were reported present on a pastoral lease, blue indicates that camels were reported absent

5.1 Observation of camel presence

About 74% of pastoralists reported that they had had feral camels on their land and more than half (56%, i.e. 93/166) 'often' saw camels, compared with only 9% (15/166) who did not see camels at all in the previous two years (Table 3.2). About 50% of respondents observed that camel numbers were increasing on their properties (Table 3.2).

Table 3.2: Descriptive statistics for questions 1–3 on the presence and population trend of feral camels

Question	Response	Total (n)	%
1. Do you have feral camels on your land?	Yes/No*	155 (209)	74.2
2. Has the camel number been increasing?	Yes/No*	76 (151)	50.3
3. How often did you see feral camels on your land in the past 2 years (July 05 – June 07)?	Often	93 (166)	56.0
	Occasionally	58 (166)	34.9
	Never	15 (166)	9.0

Note: *Figures for 'yes' responses only. 'n' is sample size.

5.2 Perceptions of camel impacts

Both negative and positive impacts of feral camels on pastoral lands were reported.

5.2.1 Negative impacts in the broader landscape context

Nearly 82% (157/192) of pastoralists indicated that feral camels caused some problems in the broader landscape context (i.e. for country) (Table 3.3). Environmental impacts, including damage to vegetation, damage to water sources, soil trampling, biodiversity loss, and environmental degradation were ranked as the most important problem (28.0%, i.e. 44/157), while damage to infrastructure was ranked second (17.2%, i.e. 27/157). This perception was generally shared by pastoralists in all four jurisdictions. However, in the NT, pastoralists mentioned the impacts on environmental aspects more often than those in either SA, WA or Qld (NT: 81.3%, i.e.13/16; SA: 14.3%, i.e. 8/56; WA: 26.7%, i.e. 20/75; Qld: 30.0%, i.e.3/10) (Table 3.3).

Table 3.3: Descriptive statistics for question 20: 'Do you think that feral camels cause a problem for country?'

20. Do you think that feral camels cause a problem for country?					
Jurisdiction		Yes/No*	If Yes, specify.		
			Environmental impacts	Damage infrastructure/fences	Other impacts
All	Total	157	44	27	11
	% (n)	81.8 (192)	28.0 (157)	17.2 (157)	7.0 (157)
NT	Subtotal	16	13	2	1
	% (n)	76.2 (21)	81.3 (16)	12.5 (16)	6.3 (16)
SA	Subtotal	56	8	11	5
	% (n)	91.8 (61)	14.3 (56)	19.6 (56)	8.9 (56)
WA	Subtotal	75	20	12	3
	% (n)	78.9 (95)	26.7 (75)	16.0 (75)	4.0 (75)
Qld	Subtotal	10	3	2	2
	% (n)	66.7 (15)	30.0 (10)	20.0 (10)	20.0 (10)

Note: *Figures for yes responses only. n is sample size.

5.2.2 Negative impacts on pastoral properties

About 70% (109/155) of pastoralists who indicated that camels were present on their land also indicated that feral camels caused damage to their properties (Table 3.4). Of those who believed that feral camels caused damage, 86.2% (94/109) reported damage to fences and yards, 35.8% (39/109) reported damage to water sources, 26.6% (29/109) reported damage to grazing lands and 3.6% (4/109) reported other damage. These results were similar across the different jurisdictions.

Table 3.4: Descriptive statistics for question 4: Do feral camels cause any problems on your property?

Question	Response	Total (n)	%
4. Do feral camels cause any problems on your property?	Yes/No*	109 (155)	70.3
	Damage to fences/yards	94 (109)	86.2
	Damage to land	29 (109)	26.6
	Damage to rockholes/water points	39 (109)	35.8
	Other damage to sacred sites etc.	4 (109)	3.6

Note: * Figures for yes responses only. n is sample size.

Overall, only 32.3% (50/155) of pastoralists claimed that their livestock were negatively impacted by feral camels (Table 3.5). However, a much higher percentage of pastoralists in the NT reported a problem in this area (Table 3.5).

Table 3.5: Descriptive statistics for question 5: Do you think that feral camels cause a problem for your cattle/ livestock?

5. Do you think that feral camels cause a problem for your cattle/livestock?						
Jurisdiction		Yes/No*	If Yes, what problems?			
			Feed/water competition	Damage fence and cattle escape	Disturb and injure cattle	Others
All	Total	50	35	9	16	1
	% (n)	32.3 (155)	70.0 (50)	18.0 (50)	32.0 (50)	2.0 (50)
NT	Subtotal	14	8	5	6	0
	% (n)	70.0 (20)	57.1 (14)	35.7 (14)	42.9 (14)	0.0 (14)
SA	Subtotal	14	5	3	4	1
	% (n)	32.6 (43)	35.7 (14)	21.4 (14)	28.6 (14)	7.1 (14)
WA	Subtotal	20	20	1	6	0
	% (n)	24.1 (83)	100.0 (20)	5.0 (20)	30.0 (20)	0.0 (20)
Qld	Subtotal	2	2	0	0	0
	% (n)	22.2 (9)	100.0 (2)	0.0 (2)	0.0 (2)	0.0 (2)

Note: *Figures for 'yes' responses only. n is sample size.

Of the 32.3% (50/155) of pastoralists who claimed that their livestock were negatively impacted by feral camels, 70.0% (35/50) claimed that competition for feed and water was a problem, 32.0% (16/50) claimed that disturbance or injury of live stock was a problem, while 20.0% (10/50) claimed cattle escaping and other problems (Table 3.5).

5.2.3 Valuation of negative impacts on pastoral properties

Pastoralists were encouraged to estimate the economic impacts on their lands caused by camels over the previous two years (July 05 – June 07). The 73.4% (80/109) of pastoralists who believed that feral camels caused some problems on their land estimated that a total of $3.71 million of economic loss was caused by camels over the previous two years, including approximately $2.18 million for live stock production losses and approximately $1.53 million for infrastructure damage (Table 3.6). These figures equate to annualised figures of $1.86 million total impact, including $1.09 million for livestock production losses and $0.77 million for infrastructure damage.

Table 3.6: Descriptive statistics for questions 11–16 on valuation of negative impacts of camels over the previous two years (July 05 – June 07)

Question	Explanation/ Response	Total (n)	Mean or %
11. Damage to fences	$	1 331 900 (76)	17 525
12. Damage to yards	$	31 000 (7)	4429
13. Damage to water equipment	$	115 400 (17)	6788
14. Other damage	$	52 000 (3)	17 333
Total damage to infrastructure	$	1 530 300 (79)	19 371
15. Impacts of camels on grazing/livestock production	$	2 179 500 (20)	108 975
16. Extent of camel damage to grazing land	Severe	9 (140)	6.4%
	Some	56 (140)	40.0%
	None	75 (140)	53.6%
Who claimed the damage?	Yes/No*	109 (209)	52.2%
Who estimated the damage?	Yes/No*	80 (109)	73.4%
Total of claimed impact/damage in last 2 years	$	3 709 800 (80)	46 373

Note: *Figures for 'yes' responses only. 'n' is sample size.

Although pastoralists valued the camel's negative impact on live stock production much higher than the damage to infrastructure, only 32.3% of pastoralists claimed negative impacts on their live stock while 86.2% claimed damages to fences and yards (refer to Tables 3.5 and 3.4 respectively).

5.2.4 Positive impacts

Of the 209 pastoralists who responded to the survey, 10 (4.8%) derived some income from selling camels, 32 (15.3%) reported eating camels, and three (1.4%) reported deriving some other economic benefit from camels (e.g. some pastoralists in Qld are using feral camels for woody weed control) (Table 3.7).

Table 3.7: Descriptive statistics for questions 17–19 on valuation of positive impacts of feral camels over the previous two years (July 05 – June 07)

Question	Explanation	Total	Mean (n)
17. Selling camels	How many sold in last 2 years?	1431	143 (10)
	$ value approx	148 150	18 519 (8)
18. Eating camels	How many in last 2 years?	168	5 (32)
19. Other income related to camels	$ value approx	52 600	17 533 (3)

Note: 'n' is sample size.

As only 8 out of 10 who sold camels estimated the approximate economic value, the total value must be larger than the claimed $148 150 over two years. Given the average value for a camel was $200 (Note: this is the estimated farm gate value but not an abattoir value, which is much higher than this – see Zeng & McGregor 2008), the total economic value of selling camels by pastoralists would have been approximately $286 200 (i.e. $143 100 annually). The 168 camels that were eaten by pastoralists were worth an additional $33 600 (i.e. $16 800 annually). Therefore, the total annual benefit from selling and eating camels over the past two years would be $319 800 (or $159 900 annually). If we include other income related to camels (i.e. $52 600 in the last two years, or $26 300 annually), the valuation of positive impacts from camels estimated by surveyed pastoralists over the past two years was $372 400 (or $186 200 annually).

5.3 Attitudes to camel management

Almost all pastoralists (97.8%, i.e. 177/181) indicated that they would like feral camels to be controlled (Table 3.8) and 80.6% of respondents (125/155) undertook some form of activity to manage feral camels on their properties during the previous two years, such as aerial and ground shooting, hunting for food, mustering and selling, and fencing off of assets (Table 3.9). 57% (101/177) of respondents regarded shooting to waste (culling) as a viable way to control feral camels and their impacts (Table 3.8) while 84.0% (105/125) of respondents actually undertook shooting on their properties (Table 3.9). A few properties also undertook other actions such as mustering (10.4%, i.e. 13/125), hunting (13.6%, i.e. 17/125) and fencing off of assets (6.4%, i.e. 8/125) (Table 3.9).

While most pastoralists (66.1%, i.e. 117/177) indicated that commercial use of feral camels was a desirable way of managing camels (Table 3.8), only a few undertook management actions involving the commercial use of camels (Table 3.9, i.e. mustering and selling: 10.4%, i.e. 13/125; hunting for food: 13.6%, i.e. 17/125).

Table 3.8: Descriptive statistics for question 21–22 on attitudes to camel management

Question	Response	Total (n)	%
21. Do you think feral camels should be controlled?	Yes/No*	177 (181)	97.8
22. If yes, what actions do you think should be undertaken for effective feral camel control?	Shooting	101 (177)	57.1
	Commercial use	117 (177)	66.1
	Exclusion fencing	4 (177)	2.3
	Strategic approaches (ongoing elimination, corridor, monitoring)	20 (177)	11.3
	New techniques (e.g. Judas technique, biocontrol)	4 (177)	2.3

Note: *Figures for 'yes' responses only. 'n' is sample size.

Table 3.9: Descriptive statistics for question 6 on activities undertaken to manage camels over the previous two years (July 05 – June 07)

Question	Response	Total (n)	%
6. Did you undertake any activities to manage feral camels on your property during the last 2 years? If Yes, please specify.	Yes/No*	125 (155)	80.6
	Muster and sell	13 (125)	10.4
	Hunt for food	17 (125)	13.6
	Shoot to waste	105 (125)	84.0
	Fencing off	8 (125)	6.4
	Other	24 (125)	19.2

Note: *Figures for 'yes' responses only. 'n' is sample size.

Eighty of the 125 pastoral properties (i.e. 64.0%) that undertook some form of camel management provided an estimate of the cost of this management. The total cost was $844 075 over the previous two years or $422 038 annually (Table 3.10). The NT properties invested more in camel management per property than other jurisdictions, although this result was skewed by the high camel commercial harvest cost estimated by one station (i.e. $150 000 for mustering and freight of camels).

Table 3.10: Descriptive statistics for question 7 on money spent on camel management over the previous two years (July 05 – June 07) by jurisdiction

7. How much did you spend in camel management activities in last two years (July 05 – June 07)?										
Jurisdiction	**All**		**NT**		**SA**		**WA**		**Qld**	
	Total	Mean (n=80)	Total	Mean (n=15)	Total	Mean (n=30)	Total	Mean (n=33)	Total	Mean (n=2)
$	844 075	10 551	335 425	22 362	277 000	9233	227 150	6883	4500	2250

Note: 'n' is sample size.

Of the claimed $422 038 invested annually by pastoralists for camel management, 91.6% was input by pastoralists ($386 788) and the remaining 8.4% ($35 250) by government or NRM project funding for activities like culling (Table 3.11). In respect of the pastoralist input, 43.3% ($167 388) went to culling actions, including opportunistic ground shooting and aerial culling with governmental assistance in some cases, 23.8% ($92 000) went to commercial use and 32.9% ($127 400) went to other management, including fence and yard repair (Table 3.11).

Table 3.11: Descriptive statistics for questions 7 and 8 on money spent on camel management over the previous two years (July 05 – June 07)

Question			**Total ($)**	**n**	**Mean ($)**	**%**
7. Approximately how much money was spent on these activities in past 2 years (July 05 – June 07)?			844 075	80	10 551	-
Total management cost per year			422 038	80	5275	-
8. Who paid the cost?	Paid by pastoralist per year	Total	386 788	-	-	91.6
		Culling	167 388	-	-	43.3
		Commercial use	92 000	-	-	23.8
		Other (repair costs)	127 400	-	-	32.9
	Paid by governments or NRM projects per year	Total	35 250	-	-	8.4
		Culling	35 250	-	-	100.0

Note: 'n' is sample size.

Station staff were involved in 64.7% (99/153) of camel management undertaken on pastoral properties over the previous two years. Professional shooters and musterers were involved in 28.1% (43/153) of actions. The remaining activities involved government personnel in conjunction with NRM projects (7.2%, i.e. 11/153) (Table 3.12).

Table 3.12: Descriptive statistics for question 9 on who was involved in camel management over the previous two years (July 05 – June 07)

Question		Total (n)	%
9. Who was involved in these activities?	Station staff	99 (153)	64.7
	Governments/NRM broads	11 (153)	7.2
	Professional shooters/musterers	43 (153)	28.1

Note: 'n' is sample size.

Most pastoralists (70.1%, i.e. 101/144) indicated that they had not secured any information about feral camel management. Only 16.7% (24/144) obtained information from government sources while 13.2% (19/144) obtained information from other sources including NRM groups, industry associations and other non-government organisations (Table 3.13).

Table 3.13: Descriptive statistics for question 10 on sources of information about camel management over the previous two years (July 05 – June 07).

Question	Response	Total (n)	%
10. Where did you get information for your camel management?	None	101 (144)	70.1%
	Government	24 (144)	16.7%
	Other	19 (144)	13.2%

Note: 'n' is sample size.

Pastoralists generally indicated (78.5%, i.e. 142/181) that they would like to get support, including information sharing and financial assistance from governments or other groups to manage feral camels on their lands (Table 3.14). Most pastoralists indicated that they would like assistance with either commercially using camels and/or with culling/shooting (Table 3.14). About 8% (11/142) of pastoralists indicated that they would like to see broadscale strategic management of feral camels while about 9% (13/142) were in favour of direct financial support or compensation.

Table 3.14: Descriptive statistics for question 28 on willingness to participate in collaborative management of feral camels

28. Would you accept assistance (Government or other) to manage or control camels on your property?							
Region		Yes/No*	If Yes, what kinds of activities would you like?				
			Fencing/yard building	Help to use commercially	Culling/ shooting	Take actions for a strategic control	Direct financial support or compensation
All	Total	142	11	51	47	11	13
	% (n)	78.5 (181)	7.8 (142)	35.9 (142)	33.1 (142)	7.8 (142)	9.2 (142)
NT	Subtotal	8	0	3	5	3	1
	% (n)	44.4 (18)	0.0 (8)	37.5 (8)	62.5 (8)	37.5 (8)	12.5 (8)
SA	Subtotal	48	7	15	19	1	4
	% (n)	81.4 (59)	14.6 (48)	31.3 (48)	39.6 (48)	2.1 (48)	8.3 (48)
WA	Subtotal	74	4	32	20	6	3
	% (n)	82.2 (90)	5.4 (74)	43.2 (74)	27.0 (74)	8.1 (74)	4.1 (74)
Qld	Subtotal	12	0	1	3	1	5
	% (n)	85.7 (14)	0.0 (12)	8.3 (12)	25.0 (12)	8.3 (12)	41.7 (12)

Note: *Figures for 'yes' responses only. 'n' is sample size.

In the NT, only 44.4% (8/18) of pastoralists indicated that they needed assistance to manage feral camels on their land compared with >80% for the other jurisdictions.

5.4 Perceptions on the commercial use of feral camels (a camel industry)

The commercial use of feral camels is discussed in Zeng and McGregor (2008). Current activities include using feral camels for meat for human consumption and as pet meat, the export of live animals, production of camel milk and hides, and using camels for tourism.

Only 19.0% (36/189) of pastoralists indicated that they had been involved in a camel-related industry at some time or another (Table 3.15). Pastoralists generally supported a stronger camel industry in Australia to contribute to feral camel control (76.3% agreed or strongly agreed, 13.2% disagreed or strongly disagreed) (Table 3.15). However, only 42.9% (70/163) of pastoralists believed that a camel industry would be economically viable (Table 3.15).

Table 3.15: Descriptive statistics for questions 23–27 on attitudes towards the camel industry in Australia

Questions	Response	Total (n)	%
23. Have you ever been involved in camel industry?	Yes/No*	36 (189)	19.0
24. Do you agree that a camel industry must be encouraged and supported in Australia to achieve camel control?	Strongly agree	64 (190)	33.7
	Agree	81 (190)	42.6
	Not sure	20 (190)	10.5
	Disagree	15 (190)	7.9
	Strongly disagree	10 (190)	5.3
25. Do you think a camel industry will be economically viable?	Yes	70 (163)	42.9
	No	38 (163)	23.3
	Not sure	55 (163)	33.7
26. Do you have any fencing in place to hold feral camels that are mustered?	Yes/No*	33 (190)	17.4
27. Do you have any facilities to load camels on to trucks?	Yes/No*	69 (189)	36.5

Note: *Figures for 'yes' responses only. 'n' is sample size.

Only 17% of pastoralists believed that their fencing for cattle production could be used for mustering feral camels, while 37% of pastoralists thought they could use the current facilities for loading the harvested camels onto trucks.

5.5 Scaling up the monetary value of the positive and negative economic impacts to all pastoral properties within the camel range

Scaled-up estimates of the monetary value of the positive and negative impacts (including management costs) of feral camels on pastoral properties within or on the margins of the camel range over the past two years are $1.17 million and $14.30 million respectively (Table 3.16). This equates to annualised figures of $0.58 million for positive impacts and $7.15 million for negative impacts (approximately $2.40 million for infrastructure damage, $3.42 for lost production and $1.33 million for management). The figures for negative impacts are best viewed as minima because, during the pastoral survey, only about 73% of pastoralists who believed that feral camels caused some problems on their land actually estimated the value of the damage and only about 64% of pastoralists who undertook some form of camel management actually provided an estimate of the cost of this management.

Table 3.16: Scaled up estimates of the monetary value of the economic impacts of feral camels on pastoral properties within or on the margins of the camel distribution over the previous two years (July 05 – June 07)

	Impacts				
	Negative impacts				Positive impacts
	Infrastructure	Lost production	Management	Total	Total
Total impacts estimated for surveyed properties (July 05 – June 07) ($)	1 530 300	2 179 500	844 075	4 553 875	372 400
Total surveyed area (km²)	706 489	706 489	706 489	706 489	706 489
Impacts per sq. km ($/km²)	2.166	3.085	1.195	6.446	0.527
Total pastoral area within the camel range (km²)	2 218 960	2 218 960	2 218 960	2 218 960	2 218 960
Total impacts within the camel range (July 05 – June 07) ($ million)	4.81	6.85	2.65	14.30	1.17

Note: Management costs are those reported for work undertaken by station personnel.

6. Discussion and conclusions

Two hundred and nine properties responded to the survey. This represented about 18% of all pastoral properties within or on the margins of the camel range. The properties that responded to the survey covered 706 489 km^2, which is 32% of the entire area of pastoral lands within or on the margins of the camel range (approximately 2.22 million km^2).

Camels occurred on 74.2% of the properties surveyed and more than 50% or pastoralists reported that the number of camels was increasing. This latter statistic conforms with the results obtained from broadscale aerial surveys (Edwards et al. 2004).

About 70% of surveyed pastoralists claimed that camels caused damage to their properties. The monetary value of this damage (including management to mitigate it) was estimated to be $7.15 million annually across all pastoral properties within or on the margins of the camel range, including approximately $2.40 million for infrastructure damage (i.e. damage to fences, yards, and water equipment), $3.42 for lost production (attributable to camels competing with stock for food and water, cattle escaping, etc.) and $1.33 million for management. The figures for infrastructure damage and management are best viewed as minima because, during the pastoral survey, only about 73% of pastoralists who believed that feral camels caused some problems on their land actually estimated the value of the damage and only about 64% of pastoralists who undertook some form of camel management actually provided an estimate of the cost of this management. Of the two types of damage, infrastructure damage is considered the more tangible as assessments of damage are typically based on observed impacts (e.g. broken fences, damaged yards). In contrast, some aspects of lost production damage are perceived impacts which may or may not be real. For example, the extent that cattle and camels compete for food and water is yet to be ascertained. The overlap in the diets of cattle and camels that occurs from time to time (Dörges & Heucke 2003) does not in itself indicate that competition for food is occurring. One or both species must be harmed by the dietary overlap for it to be competition (Schoener 1983). The majority of pastoralists surveyed believed that camels caused damage to the environment.

A small minority of pastoralists (21%) reported benefits attributable to feral camels. These benefits were tangible benefits that accrued from selling camels, eating camels and using camels for NRM activities, including weed control. The monetary value of the benefit that pastoralists realised from feral camels was estimated to be about $0.58 million annually across all pastoral properties within or on the margins of the camel range. The survey data suggest that over the survey period, pastoralists accounted for about 20% of the total number of camels harvested (i.e. 1599 camels harvested out of a total harvest in 2006–2007 of about 8000 camels) (refer to Zeng & McGregor 2008).

The vast majority of pastoralists surveyed indicated that camels needed to be controlled and they favoured the methods of shooting to waste and harvesting to use camels. However, a small percentage is interested in pursuing alternative approaches, including exclusion fencing and Judas collaring. This indicates that pastoralists may be willing to engage in new techniques in conjunction with the preferred methods. Fewer than 11% of those surveyed indicated that they supported 'strategic' approaches to the control of camels and their impacts. This may indicate that pastoralists want immediate action rather than more talking about, planning to deal with, and monitoring of the problem. Pastoralists are indeed getting on with the job of managing the problem and are investing significant resources in doing so. More than 80% of pastoralists engaged in some form of activity to manage camels on their properties. Pastoralists engaged in all of the currently available methods for managing feral camels, with culling (shooting to waste) being the most widely used form of management. Most camel management is currently undertaken by station personnel. It is essential that the willingness and capacity of pastoralists to engage in the management of feral camels be harnessed when implementing a cross-jurisdictional approach to managing feral camel impacts.

While most pastoralists indicated that commercial use was a desirable way of managing camels, and most generally supported the development of a stronger camel industry in Australia, only a few currently undertake management actions involving this approach. The majority of pastoralists expressed a lack of confidence in the current camel industry and raised concerns over its long-term viability because of unproved markets. The majority of pastoralists expressed the view that they would have to upgrade their current infrastructure before they could engage in the commercial use of camels.

Pastoralists currently engage with governments to secure assistance with culling operations. Most pastoralists indicated that they would welcome more assistance to manage feral camels on their land, particularly assistance with culling and the commercial use of camels.

Although the vast majority of pastoralists were engaged in managing camels and their impacts, most did not obtain relevant information that could help them in this task. This highlights the need for a communication strategy to disseminate information on camels, their impacts and their management in culturally appropriate formats to all relevant stakeholders. This strategy should provide for two-way communication.

6.1 Conclusions

- Pastoralists are key stakeholders in the management of feral camels and their impacts.
- Pastoralists see a need to control camels and their impacts.
- Pastoralists currently play an active and important role in camel management and are willing to engage in collaborative management approaches.
- Pastoralists favour culling and commercial use to manage camel impacts but are comfortable using all of the available approaches and are willing to consider new ones.
- The annual monetary values of the positive and negative impacts of feral camels on pastoral properties within or on the margins of the camel range were estimated to be $0.58 million for positive impacts and $7.15 million for negative impacts and management (approximately $2.40 million for infrastructure damage, $3.42 for lost production, and $1.33 million for management).
- Most pastoralists did not obtain relevant information that could help them in the task of managing camels and their impacts.
- It is essential to engage with pastoralists in developing and implementing a cross-jurisdictional management framework for managing camels and their impacts.

6.2 Recommendations

- Develop a communication strategy to disseminate information on camels, their impacts and their management in culturally appropriate formats to pastoralists and all other relevant stakeholders. This strategy should provide for two-way communication.
- Harness the willingness and capacity of pastoralists to engage in the management of feral camels when implementing a cross-jurisdictional management approach to feral camels.

7. References

Babou S. 2008. *What is Stakeholder Analysis?* Available at: http://www.pmhut.com/what-is-stakeholder-analysis, Retrieved July 10, 2008.

Braysher M. 1993. *Managing vertebrate pests: principles and strategies.* Australian Government Publishing Service, Canberra.

Brian J. 2005. *Hoosh! Camels in Australia*, ABC Books, Sydney.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H, Williams G, Edwards GP, McGregor M and Zeng B. 2008. Review of legislation and regulations relating to feral camel management (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 125–132. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

ConserveOnline. 2006. *Ecoregional Assessments Standard 2: Engage Partners & Stakeholders*, Available at: http://conserveonline.org/workspaces/cbdgateway/era/standards/std_2, Retrieved July 10, 2008.

Decrop A. 2004. Trustworthiness in qualitative tourism research, in *Qualitative Research in Tourism: Ontologies, Epistemologies and Methodologies*, ed. J Phillimore and L Goodson, Routledge, London.

Denzin NK. 1978. *The research act: A theoretical introduction to sociological methods.* McGraw-Hill, New York.

Dörges B and Heucke J. 2003. *Demonstration of ecologically sustainable management of camels on Aboriginal and pastoral land*, Final report on project number 200046, Natural Heritage Trust (Online). Available at: http://www.camelsaust.com.au/NHTreport2003.doc

Edwards GP. 2008. Background to the project. In: GP Edwards et al. (Eds). *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 1–8. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Saalfeld K and Clifford B. 2004. Population trend of feral camels in the Northern Territory, Australia. *Wildlife Research* 31, 509–17.

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Gorard S. 2003. *Quantitative methods in social sciences: the role of numbers made easy.* Continuum, London.

Grimm D. 2008. Question Tree, Available at: http://www.dcn-cde.ca.gov/CRT/graph/Question/Tree.pdf, Retrieved July, 2008.

Hitchcock L. 2006. Integrating root cause analysis methodologies, 61st *Appita Annual Conference and Exhibition*, pp. 97–101, Gold Coast, Australia, Appita Inc., Carlton.

Mauffette-Leenders LA, Erskine J and Leenders MR. 1997. *Learning with cases*, University of Western Ontario, London.

McKnight, TL. 1969. *The camel in Australia*. Melbourne University Press, Melbourne.

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Schoener TW. 1983. Field experiments on interspecific competition. *American Naturalist* 122, pp. 240–285.

Tellis W. 1997. Application of a Case Study Methodology, *The Qualitative Report*, 3(3).

Vaarzon-Morel P. 2008. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), Managing the impacts of feral camels in Australia: a new way of doing business. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

8. Appendices

Appendix 3.1 Questionnaire template

Station/property name	
Location (including state)	
GPS location (if you know)	
Pastoral land size	
Contact number and Email	

(If you are responding on the digital form, please change the font to **Bold** to select the answer, (e.g. Yes to **Yes**).

If you are returning a hardcopy, please circle the correct response. e.g. Yes

1	Do you have feral camels on your land?	Yes	No (if No, go directly to Question 20)				
2	Is the number of feral camels on your land increasing?	Yes	No				
3	How often did you see feral camels on your land in the past 2 years (July 05-June 07)?	Often	Occasionally	Never			
4	Do feral camels cause any problems on your property?	No	Yes (please specify what problems):				
5	Do you think that feral camels cause a problem for your livestock?	No	Yes (please specify what problems):				
6	Did you undertake any activities to manage feral camel impacts on your property during the past 2 years (July 05-June 07)?	No	Muster and sell	Hunt for food	Shoot and lay to waste	Fence off	Other
7	Approximately how much money was spent on these activities?	$	For what?				
8	Who paid for the cost?						
9	Who was involved in these activities?						
10	Where did you get information for your camel management?	None	Government	Other (please specify):			

Estimate of damage caused by feral camels on your property

	Quantification of camel impacts July 05-June 07	Damage description (e.g. how many km of fencing repaired or replaced?)	Repair/replacement cost	Estimated related economic loss
11	Fences		$	N/A
12	Yards		$	N/A
13	Watering equipment		$	N/A
14	Other		$	Comment

Camel impacts on grazing land and livestock production

15	Impact of camels on livestock production		N/A	$
16	Extent of camel damage to grazing land	Severe damage	Some damage	No damage
	Benefit from camels			
17	Selling camels	How many:	Approx value $	
18	Eating camels	How many:		
19	Other income related to camels such as camel tourism	What:	Approx value $	

What is your general opinion regarding camel management?

20	Do you think that feral camels cause problems for country?	No	Yes (please comment):
21	Do you think feral camels should be controlled?	No	Yes (please comment):

22	What actions do you think we should undertake for effective feral camel control?		(please comment):				
23	Have you ever been involved in the camel industry?	No	Yes (please comment):				
24	Do you agree that a camel industry must be encouraged and supported in Australia to achieve camel control?		Strongly agree	Agree	Not sure	Disagree	Strongly disagree
25	Do you think a camel industry will be economically viable?		Yes/No (please comment):				
26	Do you have any fencing in place to hold feral camels that are mustered?	No	Yes (area and fencing type):				
27	Do you have any facilities to load camels on to trucks?	No	Yes (describe facility):				
28	Would you accept assistance (government or other) to manage or control camels on your property?	No	Yes (If Yes, what kind of assistance would you prefer?):				
30	Do you have any other comments about camel management issues?						
31	If you would like to be added on our mail list so that we can send you the updated information about the camel project, please provide your preferred e-mail address in the box below						

Thank you for your time in answering this questionnaire.

Appendix 3.2 Complete summary statistics for the questionnaire

For Yes/No questions, statistics are for the ‘Yes’ response only.

Questions	Answers	Sample size	Total		NT		SA		WA		Qld	
		n=	Total	Mean or %	Total	Mean or %	Total	Mean or %	Total	Mean or %	Total	Mean or %
Number of properties surveyed	No.		209		33		61		100		15	
Property size	sq. km	209	706489	3380	134877	4087	253584	4157	239909	2399	78120	5208
1. Do you have feral camels on your land?	Yes/No	209	155	74.2%	23	69.7%	43	70.5%	80	80.0%	9	60.0%
2. Has the camel number been increased?	Yes/No	151	76	50.3%	15	88.2%	10	23.8%	46	54.8%	5	62.5%
3. How often did you see feral camels on your land in the past 2 years?	Often	166	93	56.0%	21	87.5%	16	37.2%	50	59.5%	6	40.0%
	Occasionally	166	58	34.9%	3	12.5%	24	55.8%	28	33.3%	3	20.0%
	Never	166	15	9.0%	0	0.0%	3	7.0%	6	7.1%	6	40.0%
4. Do feral camels cause any problems on your property?	Yes/No	155	109	70.3%	18	85.7%	35	81.4%	50	61.0%	6	66.7%
	Damage to fences/ yards	109	94	86.2%	14	77.8%	32	91.4%	43	86.0%	5	83.3%
	Damage to land	109	29	26.6%	10	55.6%	3	8.6%	13	26.0%	3	50.0%
	Damage to rockholes/water points	109	39	35.8%	7	38.9%	6	17.1%	23	46.0%	3	50.0%
	Damage to sacred sites	109	2	1.8%	2	11.1%	0	0.0%	0	0.0%	0	0.0%
	Damage to bush tucker resources	109	2	1.8%	2	11.1%	0	0.0%	0	0.0%	0	0.0%
5. Do you think that feral camels cause a problem for your livestock?	Yes/No	155	50	32.3%	14	70.0%	14	32.6%	20	24.1%	2	22.2%
6. Did you undertake any activities to manage feral camels on your property during the last 2 years?	Yes/No	155	125	80.6%	19	95.0%	36	83.7%	65	78.3%	5	55.6%
	Muster and sell (M)	125	13	10.4%	3	15.8%	6	16.7%	0	0.0%	4	80.0%
	Hunt for food (H)	125	17	13.6%	2	10.5%	6	16.7%	7	10.8%	2	40.0%
	Shoot to waste (S)	125	105	84.0%	15	78.9%	33	91.7%	52	80.0%	5	100.0%
	Fencing off (F)	125	8	6.4%	5	26.3%	2	5.6%	1	1.5%	0	0.0%
	Others (What?) (O)	125	24	19.2%	0	0.0%	3	8.3%	21	32.3%	0	0.0%
7. Approximately how much money was spent on these management activities?	$	80	844075	10 551	335425	22362	277000	9233	227150	6883	4500	2250

Questions	Answers	Sample size	Total		NT		SA		WA		Qld	
		n=	Total	Mean or %	Total	Mean or %	Total	Mean or %	Total	Mean or %	Total	Mean or %
8. Who paid the cost?	Paid by pastoralist Total		773575		335425		224000		209650		4500	
	Culling		334774		75475		81250		175550		2500	
	Commercial use		184000		150000		2000		30000		2000	
	Others (mainly fixing cost)		254800		109950		140750		4100		0	
	Paid by governments or NRM projects: Total		70500		0		53000		17500		0	
	Culling		70500		0		53000		17500		0	
9. Who were involved in these activities?	Station staff	153	99	64.7%	16	100.0%	32	66.7%	47	58.0%	4	50.0%
	Governments/NRM boards	153	11	7.2%	0	0.0%	7	14.6%	4	4.9%	0	0.0%
	Professional shooters/musterers	153	43	28.1%	0	0.0%	9	18.8%	30	37.0%	4	50.0%
10. Where did you get information for your camel management?	None	144	101	70.1%	6	50.0%	21	50.0%	68	84.0%	6	66.7%
	Governments	144	24	16.7%	2	16.7%	13	31.0%	8	9.9%	1	11.1%
	Other	144	19	13.2%	4	33.3%	8	19.0%	5	6.2%	2	22.2%
11. Damage to fences	$	74	996500	13466	138000	23000	544600	16018	311900	9452	2000	2000
12. Damage to yards	$	7	31000	4429	12000	3000	14000	7000	5000	5000	0	0
13. Damage to water equipment	$	17	115400	6788	60000	30000	3000	1000	52400	4367	0	0
14. Other damage	$	3	52000	17333	52000	17333	0	0	0	0	0	0
Damage to infrastructures	$	79	1530300	19371	597400	66378	561600	16518	369300	10551	2000	2000
15. Impacts of camels on grazing/livestock production	$	20	2179500	108975	600000	150000	251500	41917	1328000	132800	0	0
16. Extent of camel damage to grazing land, Sev=Severe, So=Some, N=None	SEV	140	9	6.4%	1	7.7%	2	4.8%	5	6.6%	1	11.1%
	SO	140	56	40.0%	9	69.2%	15	35.7%	29	38.2%	3	33.3%
	NO	140	75	53.6%	3	23.1%	25	59.5%	42	55.3%	5	55.6%
Who claimed the damage?	Yes/No	209	109	52.2%	18	54.5%	35	57.4%	50	50.0%	6	40.0%
Who estimated the damage?	Yes/No	209	80	38.3%	9	27.3%	34	55.7%	36	36.0%	1	6.7%
Totally claimed Impact/ damage in last 2 years	$	80	3709800	46373	1197400	133044	813100	23915	1697300	47147	2000	2000
17. Selling camels in last 2 years	How many	10	1431	143	628	209	435	218	102	34	266	133
	$ value approx	8	148150	18519	127000	42333	7000	7000	14150	3538	0	0

Questions	Answers	Sample size	Total		NT		SA		WA		Qld	
		n=	Total	Mean or %	Total	Mean or %	Total	Mean or %	Total	Mean or %	Total	Mean or %
18. Eating camels in last 2 years	How many	32	168	5	15	4	123	7	16	2	14	5
19. Other income related to camels in last 2 years	$ value approx	3	52600	17533	600	600	0	0	52000	26000	0	0
20. Do you think feral camels cause problems for country?	Yes/No	192	157	81.8%	16	76.2%	56	91.8%	75	78.9%	10	66.7%
21. Do you think feral camels should be controlled?	Yes/No	181	177	97.8%	13	100.0%	60	98.4%	89	96.7%	15	100.0%
22. If Yes, what actions do you think we should undertake for effective feral camel control?	Shooting	177	101	57.1%	5	38.5%	38	63.3%	52	58.4%	6	40.0%
	Use them	177	117	66.1%	8	61.5%	40	66.7%	57	64.0%	12	80.0%
	Ongoing elimination	177	19	10.7%	4	30.8%	5	8.3%	10	11.2%	0	0.0%
	Bio-control	177	2	1.1%	0	0.0%	2	3.3%	0	0.0%	0	0.0%
	Exclusive fencing	177	4	2.3%	0	0.0%	0	0.0%	4	4.5%	0	0.0%
	Corridor and monitoring	177	1	0.6%	0	0.0%	1	1.7%	0	0.0%	0	0.0%
	Use Judas tech	177	2	1.1%	0	0.0%	0	0.0%	2	2.2%	0	0.0%
23. Have you ever been involved in camel industry?	Yes/No	189	36	19.0%	11	61.1%	14	23.0%	9	9.5%	2	13.3%
24. Do you agree that a camel industry must be encouraged & supported in Australia to achieve camel control?	Strongly agree	190	64	33.7%	11	55.0%	15	24.6%	32	34.0%	6	40.0%
	Agree	190	81	42.6%	6	30.0%	30	49.2%	36	38.3%	9	60.0%
	Not sure	190	20	10.5%	0	0.0%	11	18.0%	9	9.6%	0	0.0%
	Disagree	190	15	7.9%	2	10.0%	2	3.3%	11	11.7%	0	0.0%
	Strongly disagree	190	10	5.3%	1	5.0%	3	4.9%	6	6.4%	0	0.0%
25. Do you think a camel industry will be economically viable?	Yes	163	70	42.9%	1	50.0%	27	44.3%	31	36.5%	11	73.3%
	No	163	38	23.3%	1	50.0%	18	29.5%	19	22.4%	0	0.0%
	Not sure	163	55	33.7%	0	0.0%	16	26.2%	35	41.2%	4	26.7%
26. Do you have any fencing in place to hold feral camels that are mustered?	Yes/No	190	33	17.4%	5	23.8%	10	16.4%	12	12.9%	6	40.0%
27. Do you have any facilities to load camels on to trucks?	Yes/No	189	69	36.5%	11	55.0%	22	36.1%	31	33.3%	5	33.3%
28. Would you accept assistance (Govt. or other) to manage or control camels on your property?	Yes/No	181	142	78.5%	8	44.4%	48	81.4%	74	82.2%	12	85.7%

Chapter 4: Key stakeholder perceptions of feral camels: conservation manager survey

B Zeng

GP Edwards

Contributing author information

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Contents

Figures and graphs

Tables

List of shortened forms

NRM	Natural resource management
NRETAS	Natural Resources, Environment, The Arts and Sport (NT Government Department of)

Acknowledgements

This report is Chapter 4 of the final report for the project ‘Cross-jurisdictional management of feral camels to protect NRM and cultural values’. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

We are grateful to Rural Solutions South Australia for its role in delivering the survey to park/reserve managers.

Support from government agencies in Western Australia, the Northern Territory, South Australia and Queensland is acknowledged.

Thanks also to reserve[1] managers involved in the survey for their engagement and cooperation.

1 Note that the term ‘reserve’ is used in this report to cover reserves, parks, and properties.

Chapter 4: Key stakeholder perceptions of feral camels: conservation manager survey

1. Summary

Through a questionnaire survey, we assessed the perspectives about feral camels and their management of people involved in managing conservation lands. The survey was designed to gauge:

- understanding about the distribution and abundance of feral camels
- perspective on camel impacts
- attitudes towards different camel management options.

Thirteen park/reserve managers and regional managers representing seventy reserves/parks responded to the survey. These parks/reserves covered 250 629 km^2, which is about 40% of the entire area of conservation lands within or on the margins of the camel range (approximately 630 811 km^2).

Camels occurred on 51.4% of the properties surveyed. Camels were reported to be increasing on 88.9% of the properties with camels.

Camels were reported to cause damage on about 94% of the properties on which they were reported present. The monetary value of this damage and the cost of management to mitigate it was estimated to be $175 050 annually across all conservation lands within or on the margins of the camel range. All managers surveyed believed that camels caused damage to the broader environment. Three of the 70 properties surveyed reported benefits attributable to feral camels. These benefits were tangible benefits that accrued from selling camels and eating camels. The monetary value of the benefit that managers realised from feral camels was estimated to be about $34 379 annually across all conservation properties within or on the margins of the camel range, which was very small compared with the estimated negative impacts from camels. Managers reported that the major impacts of feral camels were on environmental and cultural values, the very values that reserves are endeavouring to protect. The monetary value of the negative impacts on these values was not costed in this analysis.

All managers surveyed indicated that camels needed to be controlled. More than 75% of managers who responded engaged in some form of activity to manage camels on their properties. Managers engaged in all of the currently available methods for managing feral camels, with culling (shooting to waste) being the most widely used form of management. A small but significant percentage of managers were interested in pursuing alternative approaches to management, including bounties and biological control. This indicates that conservation managers may be willing to engage in new techniques in conjunction with the preferred methods. However, fewer than 24% of those surveyed indicated that they supported 'strategic' approaches to the control of camels and their impacts. Park/reserve personnel, government personnel, and contract shooters/musterers were involved in the management of feral camels and their impacts on parks/reserves over the past two years. It is essential that the willingness and capacity of managers of conservation land to engage in the management of feral camels be harnessed when implementing a cross-jurisdictional approach to managing feral camel impacts.

While the majority of conservation land managers supported the development of a stronger camel industry in Australia, only a few currently undertake management actions involving this approach. The majority of conservation managers were either unsure or expressed a lack of confidence in the current camel industry. The majority of managers expressed the view that they would have to upgrade their current infrastructure before they could engage in the commercial use of camels.

Conservation managers currently engage with governments to obtain information about camels and camel management and to secure assistance with culling operations. All managers indicated that they would welcome more assistance to manage feral camels on their land, particularly assistance with culling and direct financial assistance.

1.1 Conclusions

- Conservation land managers are key stakeholders in the management of feral camels and their impacts.
- Conservation land managers see a need to control camels and their impacts.
- The annual monetary values of the positive and negative impacts of feral camels on conservation lands within or on the margins of the camel range were estimated to be $0.03 million for positive impacts and $0.18 million for negative impacts (approximately $0.08 million for infrastructure damage and $0.10 for management).
- Conservation land managers currently play an active and important role in camel management.
- Conservation land managers are comfortable using all of the available approaches to managing camels and their impacts.
- It is essential to engage with conservation land managers in developing and implementing a cross-jurisdictional management framework for managing camels and their impacts.

1.2 Recommendations

- Harness the willingness and capacity of conservation land managers to engage in the management of feral camels when implementing a cross-jurisdictional management approach to feral camels.

2. Introduction

Conservation organisations (both government and non-government) are important stakeholders in feral camel management (refer to Zeng & Edwards 2008). This chapter presents the results of a key stakeholder survey, which aimed to document the perceptions of those involved in conservation-based land management in respect of managing feral camels and their impacts.

3. Methods and data analysis

The survey was a questionnaire survey based on the one administered to pastoralists (see Zeng & Edwards 2008) with minor modifications to make it more suitable to conservation managers. This survey was delivered in a similar manner to the pastoralist survey. However, a supplementary survey was conducted in September 2008 to provide better geographical coverage. The same data analysis methods used with the pastoralist survey were applied in the conservation manager survey (refer to Zeng & Edwards 2008).

4. Results

Thirteen managers responded to the survey. The managers included both site managers and regional managers who manage a group of reserves/parks. They represented 70 nature reserves, conservation parks, timber reserves, forest reserves, and national parks within or on the margins of the camel distribution (Table 4.1; Figure 4.1). This included 50 reserves from Western Australia (WA), 12 from South Australia (SA), 5 from Queensland (Qld) and 3 from the Northern Territory (NT). These parks/reserves covered 250 629 km^2, which is about 40% of the entire area of conservation lands in or on the margins of the camel range (approximately 630 811 km^2) (Table 4.1). Complete summary statistics for the questionnaire are in Appendix 4.1.

4.1 Observation of camel presence

Feral camels were reported as present on about 51% of reserves. Camels were seen often on 66.7% (24/36) of these reserves over the previous two years (Table 4.2) and were observed to be increasing on about 89% of these reserves (Table 4.2).

Table 4.1: The number and area of conservation properties surveyed within and on the margins of the camel distribution

Jurisdiction	No. conservation properties surveyed (a)	Area of conservation properties surveyed (km²) (b)	No. conservation properties within camel distribution (approx.) (A)	Area of conservation properties within camel distribution (km²) (B)	% of conservation properties surveyed (a/A)	% of conservation areas surveyed (b/B)
All	70	250 629	N/A	630 811	N/A	39.7
WA	50	82 380	N/A	352 691	N/A	23.4
SA	12	141 909	37	215 313	32.4	65.9
Qld	5	21 341	42	31 235	11.9	68.3
NT	3	4999	22	31 572	13.6	15.8

Note: N/A= difficult to assess.

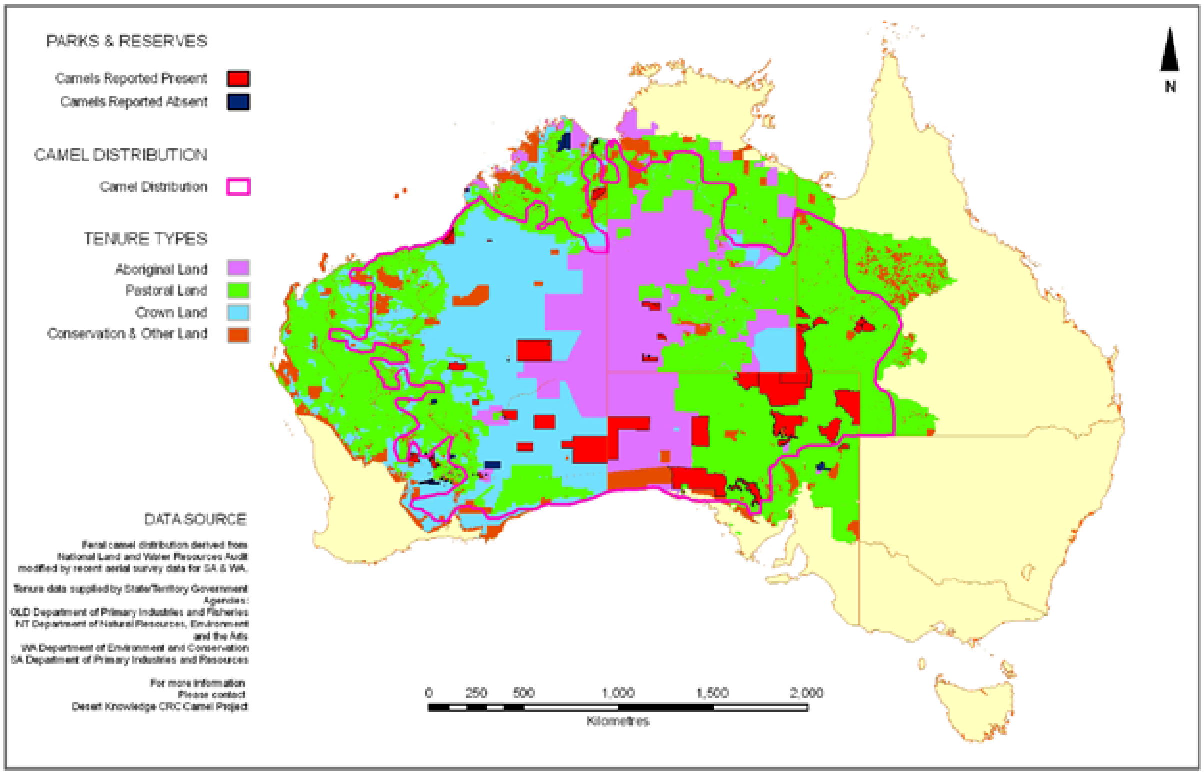


Figure 4.1: Map of parks/reserves surveyed

Table 4.2: Descriptive statistics for questions 1–3 on the presence and population trend of feral camels

Question	Response	Total (n)	%
1. Do you have feral camels on your land?	Yes/No*	36 (70)	51.4
2. Has the camel number been increasing?	Yes/No*	32 (36)	88.9
3. How often did you see feral camels on your land in the past two years (July 05–June 07)?	Often	24 (36)	66.7
	Occasionally	10 (36)	27.8
	Never	2 (36)	5.6

*Figures for 'yes' responses only.

Note: n is sample size.

4.2 Perceptions of camel impacts

Both negative and positive impacts of feral camels on conservation lands were reported.

4.2.1 Negative impacts in the broader landscape context

All managers agreed that feral camels caused some problems in the broader landscape (Table 4.3). Environmental impacts, including damage to vegetation, damage to water sources, biodiversity loss, and competition with native animals were ranked as the most important problems, while damage to cultural sites, infrastructure, and traffic hazards were regarded as lesser problems (Table 4.3).

Table 4.3: Descriptive statistics for question 20: Do you think that feral camels cause a problem for country?

Question	Response	Total (n)	%
20. Do you think that feral camels cause a problem for country?	Yes/No*	13 (13)	100.0
	Fences	3 (13)	23.1
	Vegetation	7 (13)	53.8
	Water sources	4 (13)	30.8
	Environmental damage/spread weeds/loss of biodiversity	5 (13)	38.5
	Competition with native animals	5 (13)	38.5
	Traffic hazard	1 (13)	7.7
	Cultural sites	2 (13)	15.4

*Figures for 'yes' responses only.
Note: n is sample size.

4.2.2 Negative impacts on conservation properties

Camels were reported to cause problems on 94.4% (34/36) of the reserves on which they were reported present (Table 4.4). Damage to vegetation was reported in 79.4% (27/34) of cases, damage to water sources in 64.7% (22/34) of cases, damage to sacred sites in 52.9% (18/34) of cases, damage to fencing in 29.4% (10/34) of cases, and other damage in 9% (3/34) of cases.

Table 4.4: Descriptive statistics for question 4: Do feral camels cause any problems on your property?

Question	Response	Total (n)	%
4. Do feral camels cause any problems on your property?	Yes/No*	34 (36)	94.4
	Damage to boundary fencing/dog fence	10 (34)	29.4
	Vegetation damage	27 (34)	79.4
	Damage to rockholes/water points	22 (34)	64.7
	Damage to sacred sites	18 (34)	52.9
	Damage to tourism	1 (34)	2.9
	Spreading weeds	2 (34)	5.9

*Figures for 'yes' responses only.
Note: n is sample size.

4.2.3 Valuation of negative impacts on conservation properties

Managers were encouraged to estimate the economic impacts on their lands caused by camels over the previous two years (July 05–June 07). Managers estimated that a total of $62 333 of economic loss was caused by camels over the previous two years (Table 4.5). This figure equates to annualised figures of $31 167 total impact.

Table 4.5: Descriptive statistics for questions 11–16 on valuation of negative impacts of feral camels over the previous two years (July 05–June 07)

Question	Explanation/Response	Total (n)	Mean or %
11. Damage to fences	$	30 333 (20)	1517
14. Other damage	$	32 000 (4)	8000
Total damage to infrastructure	$	62 333 (20)	3117
16. Extent of camel damage to vegetation	Severe damage	1 (35)	2.9%
	Some damage	30 (35)	85.7%
	No damage	4 (35)	11.4%

*Figures for 'yes' responses only.

Note: n is sample size.

4.2.4 Positive impacts

Three reserves derived some income from selling camels and three reported eating camels (Table 4.6).

Table 4.6: Descriptive statistics for questions 17–19 on valuation of positive impacts of feral camels over the previous two years (July 05–June 07)

Question	Explanation	Total	Mean (n)
17. Selling camels	How many sold in last 2 years	120	40 (3)
18. Eating camels	How many eaten in last 2 years	17	6 (3)
19. Other income related to camels	$ value approx	0	0 (0)

Note: n is sample size.

Given the average value for a camel was $200 (Note: it is the estimated farm gate value but not an abattoir value, which is much higher than this; see Zeng & McGregor 2008), the total economic value of selling camels by conservation properties would have been approximately $24 000 (i.e. $12 000 annually). The 17 camels that were eaten were worth an additional $3400 (i.e. $1700 annually). Therefore, the total positive impacts (benefit from selling and eating camels) would be $27 400 over the past two years (i.e. $13 700 annually).

4.3 Attitudes to camel management

All conservation managers indicated that they would like feral camels to be controlled (Table 4.7). Activity to manage feral camels was undertaken on 75.0% of reserves with camels present (27/36) during the previous two years (Table 4.8). Shooting to waste (culling) was the most widely advocated form of management (supported by 92.3% of managers) (Table 4.7), while 88.9% (24/27) of reserves with camels actually undertook shooting to manage camels and their impacts (Table 4.8). A few reserves also undertook other actions such as mustering (7.4%, i.e. 2/27), hunting (14.8%, i.e. 4/27), and fencing off of assets (14.8%, i.e. 4/27) (Table 4.8).

Table 4.7: Descriptive statistics for questions 21–22 on attitudes to camel management

Question	Response	Total (n)	%
21. Do you think feral camels should be controlled?	Yes/No*	13 (13)	100.0
22. If yes, what actions do you think should be undertaken for effective feral camel control?	Culling	12 (13)	92.3
	Muster/trap	8 (13)	61.5
	Fencing off	1 (13)	7.7
	Regional strategy	3 (13)	23.1
	Bio-control	1 (13)	7.7
	Public education	1 (13)	7.7
	Bounty	1 (13)	7.7

*Figures for 'yes' responses only.

Note: n is sample size.

Table 4.8: Descriptive statistics for question 6 on activities undertaken to manage camels over the previous two years (July 05–June 07)

Question	Response	Total (n)	%
6. Did you undertake any activities to manage feral camels on your property during the last 2 years? If Yes, please specify.	Yes/No*	27 (36)	75.0
	Muster and sell	2 (27)	7.4
	Hunt for food	4 (27)	14.8
	Shoot to waste	24 (27)	88.9
	Fencing off	4 (27)	14.8
	Others	16 (27)	59.3

* Figures for 'yes' responses only.

Note: n is sample size.

Twenty-four of the reserves that undertook some form of camel management provided an estimate of the cost of this management. The total cost was $234 300 over the previous two years, or $117 150 annually (Table 4.9).

Table 4.9: Descriptive statistics for questions 7 and 8 on money spent on camel management over the previous two years (July 05–June 07)

Question		Total ($)	n	Mean ($)	%
7. Approximately how much money was spent on these activities in the past 2 years (Jul05-Jun07)?		234 300	24	9763	-
Total management cost p.a.		117 150	24	4881	-
8. Who paid the cost?	Paid by conservation manager p.a.	38 425	24	1601	32.8
	Paid by governments or NRM projects p.a.	44 400	24	1850	37.9
	Paid by others p.a.	34 325	24	1430	29.3

Note: n is sample size.

Of the claimed $117 150 invested annually by conservation managers for camel management, 32.8% was input by park/reserve personnel ($38 425), nearly 38% by governments ($44 400) and the remaining 29.3% ($34 325) by contract shooters or musterers.

Park/reserve personnel were involved in 32.8% (19/58) of camel management undertaken on conservation properties; professional shooters and musterers were involved in 29.3% (17/58) of actions; and the remaining activities involved government personnel in conjunction with NRM projects (37.9%, i.e. 22/58) (Table 4.10).

Table 4.10: Descriptive statistics for question 9 on who was involved in camel management over the previous two years (July 05–June 07)

Question	Response	Total (n)	%
9. Who were involved in these activities?	Park/reserve staff	19 (58)	32.8
	Governments	22 (58)	37.9
	Professional shooters/musterers	17 (58)	29.3

Note: n is sample size.

Most conservation managers (53.8%, i.e. 7/13) indicated that they secured information about feral camel management from government sources, while 38.5% (5/13) obtained information from other sources (Table 4.11).

Table 4.11: Descriptive statistics for question 10 on sources of information about camel management over the previous two years (July 05–June 07)

Question	Response	Total (n)	%
10. Where did you get information for your camel management?	None	1 (13)	7.7
	Government	7 (13)	53.8
	Others	5 (13)	38.5

Note: n is sample size.

All conservation managers indicated that they would like to get support, including information sharing and financial assistance, from governments or other groups to manage feral camels on their lands (Table 4.12). Most managers indicated that they would like assistance with culling camels (Table 4.12). Only 9.1% (1/11) of managers indicated that they would like to see regional strategic management of feral camels, while about 36.4% (4/11) were in favour of direct financial support.

Table 4.12: Descriptive statistics for question 28 on willingness to participate in collaborative management of feral camels

Question	Response	Total (n)	%
28. Would you accept assistance (Govt or other) to manage or control camels on your property?	Yes/No*	11 (11)	100.0
	Planning/advice/recommendation for camel control	3 (11)	27.3
	Culling	9 (11)	81.8
	Financial assistance	4 (11)	36.4
	Outside control effort	1 (11)	9.1
	Marketing for use	1 (11)	9.1
	Regional efforts rather than focused on small land parcels	1 (11)	9.1
	Other general support	4 (11)	36.4

*Figures for 'yes' responses only.

Note: n is sample size.

4.4 Perceptions on the commercial use of feral camels (a camel industry)

The commercial use of feral camels is discussed in Zeng & McGregor (2008). Current activities include using feral camels for meat for human consumption and as pet meat, the export of live animals, production of camel milk and hides, and using camels for tourism.

Only 15.4% (2/13) of managers indicated that they had been involved in a camel-related industry at some time or another (Table 4.13). Managers generally supported a stronger camel industry in Australia to contribute to feral camel control (53.9% agreed or strongly agreed, 38.5% disagreed or strongly disagreed) (Table 4.13). Only 46.2% (6/13) of managers believed that a camel industry would be economically viable (Table 4.13).

Table 4.13: Descriptive statistics for questions 23–27 on attitudes towards the camel industry in Australia

Question	Response	Total (n)	%
23. Have you ever been involved in camel industry?	Yes/No*	2 (13)	15.4
24. Do you agree that a camel industry must be encouraged and supported in Australia to achieve camel control?	Strongly agree	2 (13)	15.4
	Agree	5 (13)	38.5
	Not sure	1 (13)	7.7
	Disagree	5 (13)	38.5
	Strongly disagree	0 (13)	0.0
25. Do you think a camel industry will be economically viable?	Yes	6 (13)	46.2
	No	4 (13)	30.8
	Not sure	3 (13)	23.1
26. Do you have any fencing in place to hold feral camels that are mustered?	Yes/No*	3 (44)	6.8
27. Do you have any facilities to load camels on to trucks?	Yes/No*	3 (44)	6.8

*Figures for 'yes' responses only.

Note: n is sample size.

Only 6.8% of conservation properties indicated that they had facilities that could be used for mustering feral camels and loading them onto trucks (Table 4.13).

4.5 Scaling up the monetary value of the positive and negative economic impacts to all conservation lands within the camel range

The data in sections 4.2.3, 4.2.4, and 4.3 were used to scale up monetary value of the positive and negative economic impacts of feral camels to all conservation lands within or on the margins of the camel range. Scaled-up estimates for the positive and negative impacts of feral camels over the past two years are $68 758 and $350 100 respectively (Table 4.14). The negative impacts were for infrastructure damage and management. This equates to annualised figures of $34 379 for positive impacts and $175 050 for negative impacts/management.

Table 4.14: Scaled up estimates of the monetary value of the economic impacts of feral camels

	Impacts			
	Negative impacts			Positive impacts
	Damage	Management	Total	
Total impacts estimated for surveyed properties Jul05-Jun07 ($)	62 333	76 850	139 183	27 400
Total surveyed area (km^2)	250 629	250 629	250 629	250 629
Impacts per sq. km ($/km^2)	0.249	0.307	0.555	0.109
Total conservation area within the camel distribution (km^2)	630 811	630 811	630 811	630 811
Total impacts within the camel distribution ($)	157 072	193 659	350 100	68 758

Note: Estimates for conservation reserves within or on the margins of the camel distribution over the previous two years (July 05–June 07). Management costs are those reported for work undertaken by park/reserve personnel.

5. Discussion and conclusions

Data were obtained for 70 conservation properties. The properties that responded to the survey covered 250 629 km^2, which is about 40% of the entire area of conservation lands in or on the margins of the camel range (approximately 630 811 km^2).

Camels occurred on 51.4% of the properties surveyed. Camels were reported to be increasing on 88.9% of the properties with camels. This latter statistic conforms with the results obtained from broadscale aerial surveys (Edwards et al. 2004).

Camels were reported to cause damage on about 94% of the properties on which they were reported present. The monetary value of this damage and the cost of management to mitigate it was estimated to be $175 050 annually across all conservation lands within or on the margins of the camel range. All managers surveyed believed that camels caused damage to the broader environment. Three of the 70 properties surveyed reported benefits attributable to feral camels. These benefits were tangible benefits that accrued from selling camels and eating camels. The monetary value of the benefit that managers realised from feral camels was estimated to be about $34 379 annually across all conservation properties within or on the margins of the camel range, which was very small compared with the estimated negative impacts from camels. Managers reported that the major impacts of feral camels were on environmental and cultural values, the very values that reserves are endeavouring to protect. The monetary value of the negative impacts on these values was not costed in this analysis.

All managers surveyed indicated that camels needed to be controlled. More than 75% of managers who responded engaged in some form of activity to manage camels on their properties. Managers engaged in all of the currently available methods for managing feral camels, with culling (shooting to waste) being the most widely used form of management. A small but significant percentage of managers were interested in pursuing alternative approaches to management, including bounties and biological control. This indicates that conservation managers may be willing to engage in new techniques in conjunction with the preferred methods. However, fewer than 24% of those surveyed indicated that they supported ‘strategic’ approaches to the control of camels and their impacts. Reserve personnel, government personnel, and contract shooters/musterers were involved in the management of feral camels and their impacts on reserves over the past two years. It is essential that the willingness and capacity of managers of conservation land to engage in the management of feral camels should be harnessed when implementing a cross-jurisdictional approach to managing feral camel impacts.

While the majority of conservation land managers supported the development of a stronger camel industry in Australia, only a few currently undertake management actions involving this approach. The majority of conservation managers were either unsure or expressed a lack of confidence in the current camel industry. The majority of managers expressed the view that they would have to upgrade their current infrastructure before they could engage in the commercial use of camels.

Conservation managers currently engage with governments to obtain information about camels and camel management and to secure assistance with culling operations. All managers indicated that they would welcome more assistance to manage feral camels on their land, particularly assistance with culling and direct financial assistance.

5.1 Conclusions

- Conservation land managers are key stakeholders in the management of feral camels and their impacts.
- Conservation land managers see a need to control camels and their impacts.
- The annual monetary values of the positive and negative impacts of feral camels on conservation lands within or on the margins of the camel range were estimated to be \$0.03 million for positive impacts and \$0.18 million for negative impacts (approximately \$0.08 million for infrastructure damage and \$0.10 for management).
- Conservation land managers currently play an active and important role in camel management.
- Conservation land managers are comfortable using all of the available approaches to managing camels and their impacts.
- It is essential to engage with conservation land managers in developing and implementing a cross-jurisdictional management framework for managing camels and their impacts.

5.2 Recommendations

- Harness the willingness and capacity of conservation land managers to engage in the management of feral camels when implementing a cross-jurisdictional management approach to feral camels.

6. References

Edwards GP, Saalfeld K and Clifford B 2004, 'Population trend of feral camels in the Northern Territory, Australia', *Wildlife Research* 31, pp. 509–17.

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

7. Appendix 4.1: Complete statistic results of the questionnaire

(For Yes/No questions, statistics are for the 'Yes' response only)

Question	Answers	Total	Sample size (n)	Mean or %
Number of managers surveyed	no.	13		
Number of reserves surveyed	no.	70		
Reserve size	sq. km	250 629	70	3580
1. Do you have feral camels on your land?	Yes/No	36	70	51.4%
2. Has the camel number been increased?	Yes/No	32	36	88.9%
3. How often did you see feral camels in your lands in the past two years?	Often	24	36	66.7%
	Occasionally	10	36	27.8%
	Never	2	36	5.6%
4. Do feral camels cause any problems on your property?	Yes/No	34	36	94.4%
	Damage to boundary fencing/dog fence	10	34	29.4%
	Vegetation damage	27	34	79.4%
	Damage to rockholes/water points	22	34	64.7%
	Damage to sacred sites	18	34	52.9%
	Damage to tourism	1	34	2.9%
	Spreading weeds	2	34	5.9%
6. Did you undertake any activities to reduce feral camel numbers and/or impacts?	Yes/No	27	36	75.0%
	Muster and sell	2	27	7.4%
	Hunt for food	4	27	14.8%
	Shoot to waste	24	27	88.9%
	Fencing off	4	27	14.8%
	Others	16	27	59.3%
7. Approximately how much money was spent on these activities in past 2 years? (July 05-June 07)	$	234 300	24	9763
9. Who were involved in these activities?	Reserve staff	19	58	32.8%
	Governments	22	58	37.9%
	Professional shooters/musterers	17	58	29.3%
10. Where did you get information for your camel management?	Nowhere	2	46	4.3%
	Government	26	46	56.5%
	Others	18	46	39.1%
11. Camel's damage to fences	$	30 333	20	1517
14. Other damages	$	32 000	4	8000
Damage to infrastructures	$	62 333	20	3117
16. Extent of camel damage to grazing lands/ vegetation	Severe damage	1	35	2.9%
	Some damage	30	35	85.7%
	No damage	4	35	11.4%
Who claimed the damage?	Yes/No	33	36	91.7%
Who estimated the impact?	Yes/No	20	33	60.6%
Total estimated impact/damage in last 2 years	$	62 333	20	3117
17. Selling camels in last 2 years	How many	120	3	40
18. Eating camels in last 2 years	How many	17	3	6

Question	Answers	Total	Sample size (n)	Mean or %
20. Do you think that feral camels cause a problem for country?	Yes/No	13	13	100.0%
	Fences	3	13	23.1%
	Vegetation	7	13	53.8%
	Water sources	4	13	30.8%
	Env. damage/spread weeds/loss of biodiversity	5	13	38.5%
	Competition with native animals	5	13	38.5%
	Traffic hazard	1	13	7.7%
	Cultural sites	2	13	15.4%
21. Do you think feral camels should be controlled?	Yes/No	13	13	100.0%
22. If Yes, what actions do you think we should undertake for effective feral camel control?	Culling	12	13	92.3%
	Muster/trap	8	13	61.5%
	Fencing off	1	13	7.7%
	Regional strategy	3	13	23.1%
	Bio-control	1	13	7.7%
	Public education	1	13	7.7%
	Bounty	1	13	7.7%
23. Have you ever been involved in selling camels or camel products or camel industry?	Yes/No	2	13	15.4%
24. Do you agree that a camel industry must be encouraged and supported in Australia to achieve camel control?	Strongly agree	2	13	15.4%
	Agree	5	13	38.5%
	Not sure	1	13	7.7%
	Disagree	5	13	38.5%
	Strongly disagree	0	13	0.0%
25. Do you think a camel industry will be economically viable? Why?	Yes	6	13	46.2%
	No	4	13	30.8%
	Not sure	3	13	23.1%
26. Do you have any fencing in place to hold feral camels that are mustered?	Yes/No	3	44	6.8%
27. Do you have any facilities to load camels onto trucks?	Yes/No	3	44	6.8%
28. Would you accept assistance (government or other) to manage or control camels on your park/reserve?	Yes/No	11	11	100.0%
	Planning/advice/recommendation for camel control	3	11	27.3%
	Culling	9	11	81.8%
	Financial assistance	4	11	36.4%
	Outside control effort	1	11	9.1%
	Marketing for use	1	11	9.1%
	Regional efforts rather than focused on small land parcels	1	11	9.1%
	Other general support	4	11	36.4%

Chapter 5: Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged)

P Vaarzon-Morel

Contributing author information

Petronella Vaarzon-Morel: Consulting anthropologist, PO Box 3561, Alice Springs, Northern Territory 0871, Australia

Contents

List of shortened forms

APY	Anangu Pitjantjatjara Yankunytjatjara
ARRI	Aboriginal Rural Resources Initiative
CLC	Central Land Council
IPA	Indigenous Protected Area
NCR	Natural and Cultural Resources
NRM	Natural Resource Management

Tables

Figures and graphs

Acknowledgements

This report is Chapter 5 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

This chapter is an abridged version of a report written for the project (see Vaarzon-Morel 2008). The report discusses in greater depth many issues referred to in this chapter and contains more detailed descriptive material and examples of interviewees' responses.

I want to acknowledge and thank the following contributors to this report:

The Aboriginal communities, survey participants, and Nintiringtjaku workers with whom I worked on this project: Kate Lawrence and Waltja Tjutangku Palyapayi Aboriginal Association; Gordon Sanders (Ngaanyatjarra Council); Tom Holyoake (Youth Worker, Kintore); Thalie Partridge (Threatened Species Officer, Anangu Pitjantjatjara Yankunytjatjara Land Management); Ian Conway (Kings Creek Station); Don Rowlands (Ranger, Parks and Wildlife, Queensland, and Wangkanguru traditional owner of lower Simpson Desert); Kerrynne Liddle (Malpa [mentor] for Project Manager and workers Kuka Kanyini); Peter Bartlett (Earth-Bound Consultants); David Brooks and Diana James (independent anthropologists). For comments on drafts of this report I am grateful to Jocelyn Davies (Principal Research Scientist – Geographer, CSIRO Sustainable Ecosystems, Alice Springs, Desert Knowledge Cooperative Research Centre). The support of my colleagues Glenn Edwards, Benxiang Zeng, and Keith Saalfeld is much appreciated.

Chapter 5: Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged)

1. Summary

As part of the survey of stakeholder perspectives on camel management, a survey was conducted on Aboriginal community perspectives on feral camels, their impacts, and management. The objective was:

- to identify the range of perspectives among selected Aboriginal communities
- to enable an effective participatory camel management strategy to be developed
- to promote education on camel issues.

The research was carried out using qualitative methods involving two case studies and a wide-ranging survey. The main data collection method was face-to-face semi-structured interviews. Questions used as the basis for the interviews addressed people's:

- perceptions of feral camels and their presence
- perspectives on the impacts of feral camels (including environmental, socio-cultural, and economic dimensions)
- involvement in, and attitudes towards, different camel management options.

The methods drew upon community-based participatory research principles, with local people assisting in the research process. *The Camel Book,* produced by Tangentyere Landcare, was used to give community members information about camel numbers, impacts, and management options.

Although there was a stronger focus on communities in areas known to have large camel populations, the survey has achieved a reasonably wide coverage of the Aboriginal communities within the feral camel range. Approximately 5.6% of Aboriginal communities within the camel range were surveyed, giving an estimated survey sample of 22.6% of the population within the camel range. In total, 27 communities were surveyed. It is estimated that approximately 490 Aboriginal people participated in discussions concerning the project. One hundred and fifty eight-formal interviews were conducted with individuals and small groups of people.

Interviewees from all communities surveyed reported that they had feral camels in the region surrounding their communities, with most perceiving that camel numbers were increasing. However, different areas had varying perceptions of the camel population: several communities reported only occasional sightings, indicating that camel numbers in their areas were low. Camels enter almost to half of the communities surveyed; they were sighted near cattle and horse troughs, tanks, taps and water points, local airstrips, waste disposal plants, and buildings. The responses of many Aboriginal people reveal their close observations and intimate knowledge of country.

In areas of high camel density many Aboriginal people indicated that feral camels negatively impact the broader landscape environment. Feral camel impacts on natural and cultural resources were the most significant issue of concern. Many people were concerned about camels 'messing up' or damaging naturally occurring water sources such as rockholes, soakages, and other wetlands. Feral camels were said to pollute and deplete water and degrade the surrounding area, as well as dying in and near water sources. People's concerns about camel impacts were multi-faceted and encompassed religious as well as aesthetic, practical, and physical dimensions. Many interviewees in areas of high camel density commented that whereas once they would freely have camped near water sources and used them, they are now much less likely to do so because of feral camels. These matters were not of particular concern to people in communities on the edge of the feral camel range or in communities surrounded by cattle stations where culling had occurred.

In areas where camels numbers were high, roughly half of the interviewees were concerned about feral camels stomping, eating, and/or otherwise destroying some types of bush tucker; for example, quandongs (*Santalum acuminatum*). Some interviewees also mentioned that camels sometimes disturb game and can get in the way of the hunter and his prey. Some people were concerned about camel impacts on other culturally significant resources such as Jukurrpa (Dreaming) trees, trees that provide shade for animals, bean trees (*Erythrina vespertilio*), bush medicine plants, and native tobacco (*Nicotiana* spp.). However, not all Aboriginal people shared these perceptions. Most people who were concerned about camel impacts on bush tucker indicated that the problems were associated with large numbers of camels and were greater during dry periods. In terms of impacts on vegetation, interviewees in communities surrounded by cattle stations sometimes compared camels favourably to cattle.

Concern about the risk camels posed to people's safety ranked second to concerns about negative impacts on culturally significant resources. Fear or wariness of camels is beginning to impact people's use of country. In nine areas of high camel density more than half of the interviewees indicated that camels affected their exploitation and enjoyment of country, particularly when camels were in large numbers or during the mating season when bull camels were present. Other key issues were road safety and camels wandering onto airstrips. One third of interviewees perceived that feral camels affected native animals by competing for water and food and/or scaring animals away. Others thought that camels did not interfere with other animals. In roughly half the communities, people observed that feral camels damaged fences, though this was not a matter of great concern where the fences were not their responsibility. In roughly a third of the communities, people associated with outstations claimed that feral camels were damaging the outstations. Feral camel damage to community infrastructure (including buildings, associated hardware, and airstrips) was reported in eight communities.

Most Aboriginal interviewees found it difficult to estimate the economic impacts on their community and country that camels had caused in the last two years. It is not that people are not concerned about impacts, but rather that they are not used to applying a dollar value to culturally significant resources and experiences, nor indeed to objects in the built environment. However, changes wrought by feral camels on the Aboriginal cultural environment have the potential to create significant and cumulative losses that may not be obvious to outsiders. These losses could include changes in patterns of exploitation and customary use of country, damage to rockholes and other culturally significant sites, a decline in bush food, medicine, tobacco and other culturally valued resources, and loss of opportunity to teach younger generations about such things.

A large number of Aboriginal people perceive that feral camels are a resource that could be used. Positive benefits associated with camels include income from jobs involving mustering, pet meat operations, the sale of camels, tourism enterprises such as camel farms and safaris, meat for human and pet consumption, and products such as camel wool. Other positive aspects ascribed to feral camels include the enjoyment derived from the use of feral camels as family pets, and the excitement and pleasure many people feel in seeing feral camels (although they also may be wary of them). In addition to the positive impacts already listed, many interviewees have strong historical associations with camels and feel empathy for them.

Importantly, it is not just income that is valued in relation to camel work but also the opportunity for meaningful and productive activity that camels can provide. To date, the number of interviewees who have benefited economically from feral camels is not large; however, the widespread and varying engagement Aboriginal people have with camels is impressive. In a few communities youth involvement in the capturing and butchering of camels provides meaningful activity, which is claimed to help prevent substance misuse. It also results in an ongoing, if small scale, local supply of cheap and healthy meat. Camel meat is gaining a reputation among Aboriginal people as a health food and the number of people who eat it is increasing, although there are still people in many communities who are unaccustomed and/or opposed to eating it. A minority of people have participated in camel mustering and selling activities, with the scale of operations ranging from sales of a few camels to much larger activities. Some Aboriginal people have been involved in the camel tourist industry.

Many interviewees thought that feral camel numbers and impacts need to be managed, particularly where camel numbers were high. In only two communities, both outstations, were interviewees comfortable with the idea of culling. Interviewees in four communities were prepared to consider aerial culling, provided that it was the only option and it was undertaken away from roads and communities. Three of these communities were in WA where people had observed a pet meat operation. However, the interviewee sample size in these communities was small and further consultations may reveal a different attitude. What is significant is that there are people who accept culling as a viable option, and that Aboriginal attitudes are not homogenous. Some other interviewees said that they would accept culling if the carcasses were buried or burnt. In general people were worried about the sight of dead camel bodies, associated disease and smell, and an increase in the dingo population.

For the majority of Aboriginal people the preferred camel management strategy was live removal. However, most wanted local people to be involved in live removal projects and expected that the workers and local community would derive income from the activities. Significantly, even among many Aboriginal people who do not like to eat camel meat, the killing of feral camels to obtain meat for pet and human consumption is widely accepted. The majority of people thought that it was a desirable way to manage camels, particularly if it occurred as part of a commercial operation. Opposition to this option was found in communities that had little experience of eating camel meat and where camel numbers were still relatively low.

Although many people have skills that could be used in camel management programs, they lack the resources and infrastructure to undertake such programs. Feral camel management was largely restricted to hunting for food, the fencing of culturally significant resources, and the fencing of property. While some individuals had been involved in mustering and selling camels in the recent past, this activity was undertaken for European pastoralists.

There was widespread interest in receiving more support than is presently available to manage camels in association with the protection and management of natural and cultural resources on Aboriginal land. Many interviewees specifically mentioned the need for more paid positions to protect sacred rockholes and other culturally significant resources, with some stating they wanted more ranger type work. A minority were interested in developing independent camel tourist operations.

Most Aboriginal people indicated that they lacked access to information about feral camel management. For the most part the information they were able to obtain was said to be from non-government organisations such as Central Land Council and land care groups in the Northern Territory, A<u>n</u>angu Pitjantjatjara Yankunytjatjara Land Management in South Australia, and Ngaanyatjarra Council in Western Australia. Many people indicated that they wanted more detailed information about a wider range of issues, including opportunities for commercial use and employment in feral camel management as well as impacts being experienced in areas of high camel density. They felt that they could not make properly informed decisions about feral camel management without such information. People asked for feedback on this camel project. Given that traditional Aboriginal society had an oral tradition, and that many people today are not functionally literate and speak English as a second language, it is important to ensure that information is made available in accessible and culturally meaningful forms.

1.1 Conclusion

- Aboriginal people are key stakeholders in the management of feral camels and their impacts.
- Many Aboriginal people, particularly those who live in high density camel areas, see a need to harvest feral camels and control their impacts.

- A few Aboriginal people are currently involved in camel management. However, a small number have broad experience working with camels and have relevant skills and knowledge, which they are keen to use in feral camel management programs on Aboriginal land. It is important to both recognise and build on this knowledge and interest base when developing and implementing feral camel management plans.
- Aboriginal people lack the necessary support and resources to play a greater role in feral camel management.
- Generally Aboriginal people lack detailed and accessible information about feral camel management issues. They therefore cannot make fully informed decisions about management options and ways to develop and implement management programs and activities. They are keen to obtain more information on these matters, as well as associated training.
- Most of the Aboriginal people interviewed were not comfortable with killing animals to waste (culling). However, the Aboriginal 'community' is not homogenous. There are diverse perspectives emerging in response to transformations being brought about by feral camels on Aboriginal land.
- The research shows that people with greater camel management experience tend to have different attitudes to others. At the present time, the range of camel management approaches is not generally available to Aboriginal communities.
- Aboriginal people are interested and willing to engage in collaborative management programs. However, interest varies within communities and among communities throughout the feral camel range. It is also predicated on the meaningful engagement of Aboriginal people in the programs and the creation of opportunities, support and investment in areas such as jobs, income, resources, and training.
- It is essential that government agencies engage with Aboriginal people, communities, and organisations representing Aboriginal land interests in developing and implementing a cross-jurisdictional management framework for managing feral camels and their impacts.

1.2 Recommendations

- Provide Aboriginal people with accessible and relevant information on camel management issues.
- Provide community survey participants with feedback on the findings of this camel project in the form of meetings and workshops.
- Facilitate the sharing of knowledge and information among the different stakeholder groups within a two-way learning framework.
- Undertake coordinated follow-up consultations to determine appropriate and acceptable feral management strategies for the different Aboriginal communities. Consultations involving people with customary interest in land and involving other community members to be undertaken and coordinated by representative bodies charged with managing Aboriginal land.
- Provide Aboriginal people and communities interested in feral camel management projects with support and assistance in the form of information, resources, training, and capacity building. This should include support for Aboriginal groups who want to operate independent 'flexible capture' programs.
- Harness the willingness and capacity of Aboriginal people to engage in feral camel management as well as their intimate knowledge about camel impacts and presence when developing and implementing a cross-jurisdictional management approach by undertaking appropriate consultations and providing necessary support and opportunities for collaborative engagement.
- Base the selection and support of camel management options on Aboriginal needs associated with the integrated management of natural and cultural resources as well as on economic criteria.

2. Introduction

As part of the survey of stakeholder perspectives on camel management, a survey was conducted on Aboriginal community perspectives on feral camels, their impacts, and management. The project was conceived as a partnership approach involving Waltja Tjutangku Palyapayi Aboriginal Corporation (Waltja) and Desert Knowledge CRC. Petronella Vaarzon-Morel, a consulting anthropologist with extensive fieldwork experience in Aboriginal communities, was engaged to deliver the surveys. The objective was:

- to identify the range of perspectives among selected Aboriginal communities
- to enable an effective participatory camel management strategy to be developed
- to promote education on camel issues.

3. Method

In order to obtain a meaningful sample of Aboriginal community perspectives a face-to-face survey was undertaken with Aboriginal stakeholders in communities located across the feral camel range. The research was carried out using qualitative methods involving two case studies and a wide-ranging survey. The methods drew upon community-based participatory research principles, with local people assisting in the research process. *The Camel Book,* produced by Tangentyere Landcare in 2006 and reprinted by DKCRC 'Cross-jurisdictional management of feral camels' project, with support from the Australian Government, was used to give community members information about camel numbers, impacts, and management options. Waltja provided administrative assistance for the Aboriginal community surveys, organising visits to communities and arranging local research facilitators (who Waltja referred to as Nintiringtjaku workers).

The case studies

The objective of the case studies was to survey a wide group of people of varying ages in order to evaluate differences in perspectives within communities as well as between communities. The main data collection method for the case studies was face-to-face semi-structured interviews with approximately 20 adults who comprised a cross-section of the community, including older, middle-aged and young men and women. The questionnaire used as the basis for the interviews addressed people's:

- perceptions of feral camels and their presence
- perspectives on the impacts of feral camels (including environmental, socio-cultural and economic dimensions)
- involvement in, and attitudes towards, different camel management options.

The wide ranging survey

The objective of the wide-ranging survey was primarily to canvas stakeholders' key views so that differences between communities could be identified. Given the time constraints on the research, it was envisaged that the data collection and sampling methods would be less comprehensive than those adopted in the case study. In the wide-ranging survey, it was intended to hold informal two-way discussions involving two groups of 10–15 people as well as community leaders. The discussions were to be focused on a more limited set of questions than those used in the case studies. In the event, it was not always possible to arrange discussions in this way, so semi-structured interviews using questionnaires were conducted with smaller groups and individuals in combination with two-way discussions. This resulted in richer and more extensive data than originally envisaged.

3.1 Selection of survey areas

In total, discussions were held in 27 communities (see Figure 5.1), five of which were located in South Australia (SA), eight in Western Australia (WA) and 14 in the Northern Territory (NT). In addition, discussions were held in Alice Springs and/or by phone with Aboriginal and non-Aboriginal people associated with a number of Aboriginal communities that were not visited. It is estimated that approximately 490 Aboriginal people participated in discussions concerning the project, of which approximately 255 people were involved in formal interviews.

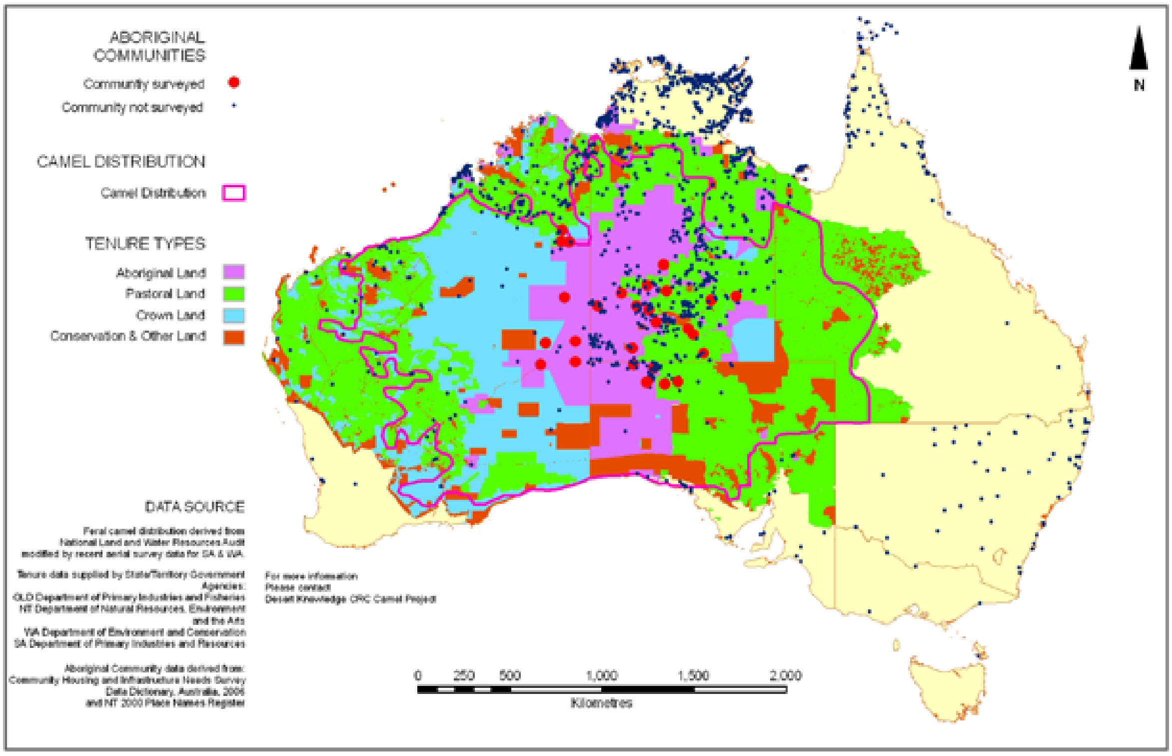


Figure 5.1: Location of Aboriginal communities surveyed

Ecological, social, cultural, and material factors were considered in the process of selecting the communities to be surveyed. As it was not possible to survey all the Aboriginal communities within the feral camel range, it was decided to limit the survey to the states and territories where feral camels numbers were most dense. This meant that Aboriginal communities in SA, WA and NT were included but not communities in Queensland (Qld) and New South Wales (NSW). Other criteria used in selecting communities included the need for a broad representation of different cultural and language groups across the feral camel range, including areas known to have high densities of camels with significant impacts on the environment and areas that have a lower camel density. Thus communities were selected whose members were affiliated with the following language and culture areas: Arandic communities (Eastern Arrernte, Anmatyerr, Alyawarr); Western Desert (Pintupi, Luritja, Pitjantjatjara, Yankunytjatjara, Ngaanyatjarra, Ngaatjatjarra); Warlpiri; Kukatja, Ngarti, Walmajarri, Tjaru and Tjurabalan. Communities in areas where there were reported to be few or no camels – for example, Tennant Creek – were not included in the survey. In addition, Central Land Council (hereafter CLC) requested that the survey not be extended to Docker River where they were implementing camel management plans. It was thought that yet another person asking questions about feral camel issues at this time would complicate the process. As a result the survey’s findings do not reflect views held in a community where extensive consultation and education on feral camel management issues has occurred.

Taking into account these considerations, in consultation with project leader Glenn Edwards and project officer Benxiang Zeng I drew up a list of potential communities to be surveyed. Among the Aboriginal communities selected were those surrounded by Aboriginal freehold land, those surrounded by pastoral leases and those surrounded by Aboriginal freehold land but on which there were cattle operations. For the most part, larger Aboriginal communities were selected; however, some homelands or outstations were also included in the survey.

The next step involved Waltja obtaining permits from relevant land management organisations such as CLC, Ngaanyatjarra Council, and Anangu Pitjantjatjara Land Management (hereafter APY). These organisations approached Aboriginal people in the selected communities to gauge their willingness and consent to participate in the feral camel research. Inevitably, the selection process meant that some communities whose members had extensive experience with camels – for example, Fregon – were not included in the survey.

3.2 Characteristics of the survey population

The project team's experience in the region has shown that pastoralists tend to be primarily concerned with issues that affect livestock production and their cattle operation. Most (but not all) Aboriginal stakeholders in the survey region do not share the same concerns, however. In the main, the primary focus that Aboriginal stakeholders have on the environment is the management of natural and cultural resources, which for Aboriginal people are intimately related.

Most Aboriginal stakeholders in the region being surveyed have little or no experience with the approaches used in quantitative research. While many Aboriginal people in the survey region are multilingual, English is often a second or third (or indeed, fourth) language. Many people, in particular those older than 40, are not functionally literate or numerate, and many others may have only received a rudimentary form of western education. In order to obtain meaningful information it was important both for the research approach to be qualitative and for the interviews to be open ended. The different cultural assumptions that westerners and Aboriginal people hold about the world, and about ways of categorising things within it, meant that a close-ended survey of the type used for pastoralists was not an appropriate method of inquiry. However, for the purposes of comparison and analysis, the research needed to be focused on similar themes to those explored in the pastoralist survey. Thus a questionnaire was used to provide structure to the interview process and to ensure, as far as possible, consistency in the coverage of questions with different interviewees. The use of a standardised open-ended interview approach enabled the interviewees to discuss issues of concern, while at the same time I was able to explore their cultural understandings, attitudes, and perceptions.

3.3 The survey questions

The development of the questionnaire involved a three-stage process. The initial questionnaire form was designed by Benxiang Zeng to address similar themes to those in the survey that was delivered to pastoralists (camel presence, impacts, and management) (see Zeng & Edwards 2008: Appendix 3.1), but with modifications arising from the significant differences between the two stakeholder groups. The second stage involved me making the questionnaire more user friendly for Aboriginal people. The third stage involved me trialing the modified questionnaire in Titjikala and Apatula/Finke. One set of questions that proved highly problematic concerned 'valuation of negative impacts'. Most Aboriginal interviewees found it difficult to estimate the economic impacts that camels have had on their community and country in the last two years. As a result, questions on this issue were not strongly pursued with interviewees. I also changed the order of some questions and added additional questions concerning people's country affiliations and their past experience with camels. This information helped me to contextualise the interviewees' other answers and understand their perspectives and underlying assumptions. A copy of the questionnaire is attached as Appendix 5.1.

3.4 Survey delivery and sharing of information

Waltja provided administrative assistance for the Aboriginal community surveys, organising my visits to communities and arranging local research facilitators (Nintiringtjaku workers). The timing of the visits depended on a number of factors such as the availability of key informants and local Waltja Nintiringtjaku workers to participate in the research, availability of accommodation, and my fieldwork timetable.

The role of the local research facilitators was to identify key informants and focus groups within the community, to introduce the principal researcher to potential participants in the survey process, and to facilitate the conditions for the interviews and two-way discussions about camel issues and people's perspectives on camels. Prior to each interview I explained to every interviewee involved the purpose of the research and how the information would be used. In addition, an information sheet was provided to interested people. I explained that as indicated in the original ethics proposal for the project, the names of interviewees would not be used in the report unless specifically requested. Informed consent was obtained from key interviewees. Where they were available, Waltja workers helped interpret the survey questions. Invariably, in the course of discussing issues raised by the survey questionnaire, people indicated that they wanted further information. This provided a good opportunity to discuss matters raised in *The Camel Book*, including growth in camel numbers, impacts, and management options.

Prior to me undertaking interviews Benxiang Zeng conducted interviews in WA at Warakurna, Warburton, Papulankutja (Blackstone), and Kanpa. As well Miriana Jambrecina, Uluṟu–Kata Tjuṯa National Park, Natural and Cultural Resources (NCR) Manager, conducted an interview with a focus group at Mutitjulu, and anthropologist Dianna James conducted an interview at Fregon with the Robin family from Walalkara. The Zeng and Jambrecina interviews took place before I had revised the questionnaire and as a result some questions were not directly addressed, for example: 'Do you think they need to control camel numbers?' I also interviewed by phone Jeannie Robyn, Project Manager for Kuka Kanyini Walalkara, who was in Adelaide at the time. In addition, I spoke by phone to Don Rowlands, Ranger, Simpson Desert Conservation Park concerning his perceptions of camel numbers and issues in the south-eastern Simpson Desert area.

3.5 Selection of interviewees

The survey of each Aboriginal community involved a number of interviewees. This is an important difference from the pastoralist survey, where one person spoke for one pastoral unit. Given the constraints on the research, the realities of Aboriginal community life and the varying interest levels of the participants, it was logistically impossible to ensure that the same age range and number of interviewees participated in each community survey.

Another factor that had to be considered was that within Aboriginal communities people have different statuses, roles, and responsibilities in relation to land or country. According to Aboriginal cultural protocols and customary law, it is senior people with recognised traditional rights, responsibilities, and interests in a particular country or estate who have the right to speak for it (see Myers 1998; Sutton 2003). These people include both 'owners' and 'managers' (see for example Pawu-Kurlpurlurnu 2008:10–17). In the Aboriginal land tenure system there are likely to be multiple estates and owners and managers of estates in any one region surrounding a community. At the same time, people who have lived in an area for a long time but are not traditional owners also have interests that must be taken into account. It was important to know a person's status vis-a-vis country and whether an individual was familiar with an area and had lived in the community for a period of time or was a recent arrival. The local Nintiringjaku workers and community council members were helpful in this regard, as were interviewees themselves. Generally people who were only visiting a community or felt that they had no cultural authority to speak on an issue informed me that this was the case. In the main, with the assistance of Waltja workers I spoke first to senior members of the community, and was guided by their suggestions as to potential interviewees. The existence of non-customary governance structures such as local community councils meant that I also needed to obtain the views of councillors. Overall, I tried to ensure representation from the following groups of people: people with traditional rights and interests, Aboriginal councillors, younger (15–39), middle-aged (40–59) and older (60 plus) men and women. These groups were not mutually exclusive.

3.6 Data collection and analysis

The interviews and their interpretation were necessarily an act of cross-cultural communication. As many anthropologists have noted, such communication is not merely a matter of the translation of words but also of concepts. In central Australia, where Aboriginal languages are widely spoken and customary relations to land still strong, the conceptual systems of Aboriginal people differ from those of non-Aboriginal people in sometimes radical ways.[1] As a result, translation, which 'requires close correspondences across conceptual systems' (Lakoff 1987:312), is not always possible. This does not mean that communication is not possible but rather that it involves understanding different ways of experiencing and constructing the world (see Lakoff 1987).[2] There was thus sometimes much discussion about what a question meant. Waltja workers assisted me in this task, and it also helped that many Aboriginal people spoke good English and that I understood some of the Aboriginal languages the interviewees used. I noted people's responses by hand and attempted to record the exact words of the interviewee; however, this was not always possible when a lengthy discussion ensued.

The next step involved entering the raw data into a Microsoft Excel datasheet. Responses were organised according to community and survey questions. Given the time constraints on the project, the various cross-cultural issues discussed earlier, and limited sample sizes, it was neither feasible nor desirable to attempt statistical analysis of the answers for each community. Rather, analysis involved a process of synthesising and describing data (Baker & Motton 2005:310), with similarities and differences in community perceptions identified and summarised. I have drawn on my knowledge of Aboriginal culture in interpreting the data.

I have presented information in different ways for different audiences. The discussion section of the report presents tables that compare the responses for each community in summary form. This allows the reader to form a broad picture of similarities and differences in perspectives. However, it is important to point out that the tables differ in both their intent and the way responses were selected. Table 5.2, on observations of camel presence, is relatively unproblematic. In general there was concordance among interviewees in each community about the themes discussed in relation to camel presence and densities. Tables 5.4, 5.5, 5.6, 5.7, concerning perspectives on camel impacts, and Table 5.11, concerning the need for assistance and support to manage feral camels, are more problematic. They show where a view was mentioned within a community; however, it does not follow that the view was commonly held. In contrast, Table 5.8 attempts to present a view with which most interviewees felt comfortable. However, it does not mean that everyone within a community proposed the same view. Further discussion of these issues follows each table.

3.7 Survey coverage

How well the survey sample represents the Aboriginal population in the feral camel range is a combination of:

- the number of communities and their location
- how many people were interviewed and who they were.

As Table 5.1 indicates, although there was a stronger focus on communities in areas known to have large camel populations, the survey has achieved a reasonably wide coverage of the Aboriginal communities within the feral camel range. Approximately 5.6% of Aboriginal communities within the

1 See Rose (1995: 5 & 165–171) for a discussion of the problems faced by a non-Aboriginal researcher with a scientific background researching resource management issues.

2 See Deborah Rose (1999, 2005a) for discussion of some Aboriginal understandings of environmental relations.

camel range were surveyed, giving an estimated survey sample of 22.6% of the population within the camel range. There was, however, a bias to places with larger populations. Indications are that camel numbers and impacts may actually be greater at places with smaller populations, at least in non-pastoral regions. Hence negative impacts of camels are probably conservatively reported.

Due to reasons discussed below, more comprehensive interviews were conducted in some communities than others. While the numbers of people interviewed in each community were not large, the fact that men and women of different ages and statuses were interviewed means that a reasonable sample of the range of views of people across a community was obtained. This is underlined by the high degree of repetition of perspectives and issues from different people and places (see Vaarzon-Morel 2008). At the same time, however, wider consultations and longer-term research within communities would likely reveal some other perspectives and issues.

Table 5.1: Community survey coverage

Within the camel range, there are 484 communities, including outstations, with a total population of 31 383:	
Number of communities surveyed	27
Estimated population of communities surveyed	7096
Mean population of communities surveyed	**263**
Number of communities not surveyed	457
Total population of communities not surveyed	24 287
Mean population of communities not surveyed	**53**
Proportion of communities surveyed	5.6%
Proportion of population surveyed	22.6%

3.8 Challenges and limitations

As with all rapid survey work, the research on which this report is based was limited by time constraints on the researcher and unexpected events in communities that influenced the selection of informants. These factors resulted in the sampling of some communities being more comprehensive than others.

The research happened when a major shift in Commonwealth–Aboriginal interaction was underway in the Northern Territory, resulting in many visiting bureaucrats being in the NT communities. While over time people's memories of the first days of the Intervention may fade, its implementation had implications for this research. The Intervention introduced changes that sometimes resulted in members of the community having increased levels of stress and uncertainty, which were not particularly conducive to a positive research environment. It is a measure of the interest in the project and the interviewees' desire for their views to be heard that despite the many pressures they were facing in their daily lives, they willingly engaged in discussions and answered questions.

Another challenge for the research process was that Waltja Nintiringtjaku workers were not available to assist with the interviews and discussions in all of the communities. The lack of such a person did not present insurmountable problems for the research. My familiarity with Aboriginal languages, social organisation, and cultural beliefs in the survey region facilitated the discussions and interpretation of the data.

In presenting observations of camel presence I sought to indicate people's perceptions of camel densities. However, the frequency of sightings partly reflects people's travel patterns and activities and cannot be taken as an accurate picture of camel density.

Finally, the findings of this research can be considered indicative of different Aboriginal perceptions and attitudes concerning feral camels throughout much of the feral camel range. However, while they are meant to inform future planning concerning feral camel management, they do not provide a blueprint for a particular course of action in a particular community. Further consultation is required in order to determine appropriate, achievable and acceptable camel management strategies for the different Aboriginal communities and land tenures. The consultations must involve people with customary interest in land, other community members, and representative bodies charged with managing Aboriginal land.

4. Findings: differences in perspectives among and within Aboriginal communities

4.1 Observations on camel presence

As Table 5.2 and Table 5.3 show, interviewees from all 27 communities surveyed reported that they had feral camels in the region surrounding their communities, with 21 perceiving that camel numbers were increasing. Interviewees from 20 communities said that they had often seen camels during the previous two years, while people in six communities reported only occasional sightings. (Interviewees at Mutitjulu were not asked about their frequency of sightings and therefore Mutitjulu is not included in the latter figures.) Interviewees from 13 communities reported that feral camels came close to the community. Camels were sighted near cattle and horse troughs, tanks, taps and water points, local airstrips, waste disposal plants, and buildings. There was general consensus within communities on these matters. In the section below that follows the tables I analyse key reasons for differences between communities.

Table 5.2: Observations of camel presence and perceived population trends by community

Jurisdiction	Do you have feral camels on your land? Yes/No*	Do feral camels come close to your community?	Has the number been increasing? Yes/No*	How often have you seen camels on your land in the past two years?		
				Often	Occasionally	Never
SA						
Amata	Y	Y	Y	Y		
Indulkana/Iwantja	Y		Y	Y		
Mimili	Y	Y	Y	Y		
Pukatja/Ernabella	Y		Y	Y		
Walalkara	Y	–	Y	Y		
WA						
Balgo	Y		Y		Y	
Billiluna/Mindibungu	Y		Y		Y	
Kanpa	Y	Y		Y		
Kiwirrkura	Y	Y	Y	Y		
Mulan	Y				Y	
Papulankutja	Y	Y	Y	Y		
Warakurna	Y	Y	Y	Y		
Warburton	Y	Y	Y	Y		
NT						
Areyonga	Y	Y	Y	Y		
Apatula/Finke	Y		Y	Y		
Haasts Bluff	Y			Y		
Atitjere/Harts Range	Y				Y	
Kintore	Y	Y	Y	Y		
Laramba	Y		Y		Y	
Mt Liebig/Watiyawanu	Y	Y	Y	Y		
Mutitjulu	Y	-	-	-	-	-
Nyirripi	Y	Y	Y	Y		
Bonya/Orrtipa-Thurra	Y			Y		
Titjikala	Y		Y	Y		
Mpwelarre/Walkabout Bore	Y	Y	Y	Y		
Willowra	Y	Y	Y		Y	
Yuendumu	Y		Y	Y		

*Only 'Yes' responses are shown.

Table 5.3: Summary of observations on camel presence and perceived population trends in surveyed communities

Questions	Explanation	No. of communities surveyed	Total
Do you have feral camels on your land?	Y/N*	27	27
Do feral camels come close to your community?	Y/N*	26	13
Has the number increased?	Y/N*	25	21
How often have you seen feral camels on your land in the past 2 years?	Often	26	20
	Occasionally	26	6
	Never	26	0

* Only 'Yes' responses are shown.

In general, reasons why camels enter some communities and not others relate to factors such as the location of a community within the feral camel range, whether culling has been carried out on surrounding country, the topography of the land on which the community is situated, and whether a community is fenced or not. These factors are also relevant to people's perceptions of camel densities and increases in population.

Of the communities surveyed, 22 are surrounded by Aboriginal land. One of these, Mutitjulu, is situated within the Uluṟu–Kata Tjuṯa National Park. The other five communities (Titjikala, Mpwelarre/ Walkabout Bore, Laramba, Bonya/Orrtipa-Thurra and Atitjere/Harts Range) are Aboriginal living areas (excisions) surrounded by non-Aboriginal pastoral leases. Camels are said not to be entering these communities. In the case of Mpwelarre/Walkabout Bore, it is not because camels have been culled on the surrounding area but because the living area is fenced.

As well, two of the survey communities on the APY Lands in SA are said not to be affected by camels because they are situated in rocky country, which camels do not like. (However, at Areyonga in the NT, which is also located among hills, camels were said to be so desperate for water that a few were entering the community via the creek.) The culling of camels on neighbouring pastoral leases has apparently reduced numbers around the NT Aboriginal communities of Apatula/Finke, Titjikala, Laramba, Bonya/ Orrtipa-Thurra and Atitjere/Harts Range. (Atitjere is also surrounded by hilly country.) According to interviewees, a recent cull of camels at Haasts Bluff, which is Aboriginal freehold land, has reduced camel impacts on the community.

Of the communities that reported occasional sightings of camels, three are located on the margins of feral camel country (Balgo, Billiluna, and Mulan), two others are excisions with pastoral leases (Laramba and Atitjere/Harts Range), and, as noted by interviewees, the country surrounding Willowra has only been penetrated by camels in the last several years. However, numbers are said to be increasing in the northern Willowra-Lander River region.

As mentioned earlier, people's sightings of feral camels reflect their patterns of travel as well as the presence of camels. Nevertheless, similarities in observations among people from a particular place provide a valuable picture of where feral camels are likely to be found, depending on the season and the availability of water. Aboriginal people's close observations and knowledge of country is a valuable resource that should be supported and used in the development and implementation of feral camel management strategies.

It is significant that all people interviewed for this survey reported having seen camels in the region surrounding their communities. This finding contrasts with earlier research in the NT by Nugent (1988) and Rose (1995). Nugent conducted a survey of Aboriginal attitudes to feral animals and land degradation in 15 Aboriginal communities in the Western MacDonnell Ranges and the south-east Tanami Desert, NT. Apart from Nyirripi, which was regarded as 'camel country' (Nugent 1988:17) and Mt Liebig and Haasts Bluff, where numbers were thought to be increasing, the general impression given is that the camel numbers were very low and that people's sightings of camels were infrequent.[3] There is no mention of camels being present at Willowra, Areyonga, and Yuendumu. People I interviewed at these places reported that camels were present in their areas.

Approximately six years after Nugent's report, Rose (1995) conducted an 18-month survey of attitudes and perceptions of land management issues among Aboriginal people of central Australia, NT. Of the places which I also surveyed he noted that feral camels occurred in the following areas: Areyonga, Atula, Haasts Bluff, Apatula/Finke, Kintore, and Nyirripi. However, there is little information on people's perceptions of camel densities around the various communities, nor is there much specific discussion of feral camels. Given the recent scientific data on the rate of increase of the camel population, it is likely that when Rose conducted his survey 13 to 14 years ago camels were not yet in high densities.

4.2 Perspectives on camel impacts

4.2.1 Negative impacts

In this discussion I use the term broader landscape values to encompass the following dimensions of Aboriginal people's environment: the natural and cultural resources used by people in a particular community (including sacred sites, bush tucker, and native animals), the built environment (i.e. infrastructure, buildings, and airstrips) of larger communities, and homelands, roads, and country surrounding a community.

Table 5.4: Negative impacts on broader landscape values mentioned by people in survey communities

Jurisdiction	Impacts on natural and cultural resources			Community infrastructure impacts	Home-lands	Fences	Safety concerns (fear of camels and road safety)	Impacts on animals
	Naturally occurring water sources	Bush tucker	Other culturally significant resources					
SA								
Amata	Y	Y	Y	Y	Y	Y	Y	Y
Indulkana/Iwantja	Y	Y						
Mimili	Y	Y	Y		Y	Y	Y	Y
Pukatja/Ernabella	Y	Y	Y		Y	Y	Y	Y
Walalkara	Y	Y	Y					Y
WA								
Balgo	Y	Y	Y			Y		
Billiluna/Mindibungu								
Kanpa	Y	Y	Y	Y			Y	Y
Kiwirrkura	Y	Y	Y	Y	Y		Y	Y
Mulan								
Papulankutja	Y	Y		Y	Y			Y
Warakurna	Y			Y	Y	Y	Y	Y
Warburton	Y	Y		Y				
NT								
Areyonga	Y	Y	Y				Y	Y
Apatula/Finke	Y	Y	Y				Y	
Haasts Bluff	Y	Y	Y		Y	Y	Y	Y
Atitjere/Harts Range							Y	
Kintore	Y	Y	Y	Y			Y	Y
Laramba	Y		Y		Y	Y		
Mt Liebig	Y	Y	Y	Y	Y	Y	Y	Y
Mutitjulu	Y		Y					
Nyirripi	Y	Y	Y			Y	Y	
Bonya/Orrtipa-Thurra	Y	Y	Y			Y	Y	Y
Titjikala	Y	Y	Y			Y	Y	Y
Mpwelarre/Walkabout Bore						Y		
Willowra	Y	Y	Y			Y	Y	Y
Yuendumu	Y	Y	Y			Y	Y	Y

Note: The views expressed were not unanimous within each place. The table records any mention of negative impacts by an individual interviewee in a particular community as a 'Yes'.

3 Nugent provides little information on people's observations on camel densities.

In respect of impacts on broader landscape values, 23 of 27 communities mentioned the impacts of feral camels on natural and cultural resources as the most significant issue they were concerned about (see Table 5.5). The safety risks that feral camels present were also a major concern and ranked second to impacts on natural and cultural resources. In 17 communities a large number of interviewees mentioned that the risk feral camels pose to road safety, and/or fear or wariness of bull camels in season (i.e. mating bulls) and/or of large numbers of camels, affected their use and enjoyment of country, including patterns of exploitation. In 16 communities roughly a third of interviewees perceived that feral camels impacted native animals. Fourteen communities mentioned that camels damage fences in country surrounding communities (including on non-Aboriginal pastoral leases). Interviewees in nine of the communities mentioned feral camel impacts to homelands/outstations (i.e. the built environment), while some interviewees in eight communities reported that camels were having a negative impact on community infrastructure (including buildings, associated hardware, and airstrips). The tabulated results are discussed in more detail below.

Table 5.5: Number of communities by state/territory where interviewees mentioned negative impacts on broader landscape values

Jurisdiction		Natural and cultural resource impacts	Safety concerns (fear of camels and road safety)	Impacts on animals	Fences	Homelands/ Outstations	Community infrastructure impacts
All	Total	23	17	16	14	9	8
NT	Subtotal	12	11	8	9	3	2
SA	Subtotal	5	3	4	3	3	1
WA	Subtotal	6	3	4	2	3	5

Note: The views expressed were not unanimous within each place. The table records any mention of negative impacts by an individual interviewee in a particular community.

Impacts of feral camels on natural and cultural resources

As discussed earlier, unlike for westerners, who tend to regard natural and cultural resources as separate categories, for Aboriginal people the two are intimately related. A natural resource may also be a cultural resource and vice-versa. For this reason I have not distinguished between the two. While in Table 5.4 above I have separated comments on water sources from bush tucker, it is important to keep in mind that water sources such as rockholes, soakages, claypans, and swamps may also be sacred sites, and that, along with bush tucker, Aboriginal people regard them as being of cultural significance. In Table 5.4 above, the category ‘other cultural resources’ encompasses cultural phenomena that are additional to the water sources and bush tucker already listed. The category includes both physical entities (for example, culturally significant sacred sites, places, trees, and resources such as bush medicine and native tobacco) as well as culturally valued experiences associated with customary use of country. There is necessarily some overlap between the categories. For example, if someone perceived camels to be polluting waterholes, he/she might also not want to camp near or use the waterhole. To take another example, some interviewees perceived that camels impacted kangaroos by scaring them away from water and feed; at the same time, they could disturb a kangaroo while it was being hunted or distract the hunter, thus impacting availability of bush tucker.

(a) Naturally occurring water sources

A shared perception of many interviewees in 23 of the 27 communities surveyed was that camels were negatively impacting naturally occurring water sources such as rockholes, soakages and other wetlands. Camels were said to be ‘messing up’ waterholes by polluting and depleting the water, eroding and degrading the area surrounding the water source (including vegetation and land), and dying both in and near water sources. Feral camel impacts on wetlands were of concern to a significant number of people. People’s concerns about camel impacts were multi-faceted and encompassed religious as well as aesthetic, practical, and physical dimensions. For example, people are concerned about camels 'stomping on sacred places' and damaging rockholes associated with Jukurrpa or Dreamings. They are also concerned about camels drinking dry the waterholes that people and animals depend upon.

A number of interviewees also commented that they do not like to see and smell the dead animals around the rockholes. Some interviewees said that camels sleep near rockholes, which affected their use of the area. Many other interviewees commented that whereas once they would freely have camped near and used the water sources, they are now much less likely to do so because of feral camels.

Concern about camel impacts on wetlands or naturally occurring water sources was greater in areas where camel densities were high. For example, it was not an issue in communities on the edge of the feral camel range, and tended to be much less of an issue at places such as Apatula/Finke, Atitjere/Harts Range, Pukatja/Ernabella, Titjikala, Laramba, and Bonya/Orrtipa-Thurra than at Kintore, Nyirripi, Amata, Mimili, Warburton, Kiwirrkura, Areyonga/Utju, and Mt Liebig and, to a lesser extent, Yuendumu, Haasts Bluff, and Willowra.

In respect of the NT, my findings differ from the earlier research of Nugent (1988) and Rose (1995). Apart from saying that at Nyirripi, where camel numbers were high, camels 'don't dig up soakages', Nugent (1988:47) notes little discussion of feral camel damage to naturally occurring water sources. He concludes that feral animals caused little damage to country (1988:13, 15). In contrast, Rose (1995:33) notes that feral animals caused damage to rockholes and soaks at Kintore, and that at Kintore and the Pitjantjatjara lands, a 'rockhole cleaning and protection program' (1995:33) had been implemented. He also noted that at Apatula/Finke camels were perceived to be 'bad for country' (1995:110), but apart from these examples there is little mention of camels negatively impacting water sources.

Camel impacts on rockholes, soakages, springs, and other naturally occurring water sources is a major issue for Aboriginal people. The provision of tap water has not obviated the significance of naturally occurring water sources in people's lives. As many anthropologists have noted (see D Rose 2005b), a great many are sacred sites, and for good reason. Strehlow noted that among Arrernte 'many of the finest waterholes … provided inviolable sanctuaries for kangaroos' (quoted in Bennett 1986:131). Peterson (1976:67) pointed out the importance of water '… in determining plant cover and hence available food', which in turn influenced patterns of population, use of country and social relations among people and groups. Deborah Rose has noted 'water is part of the sacred geography of people's homelands; it is part of creation, connection, and an ethic of responsible care' (2005b:48). Today water sources continue to be a major focus in Aboriginal people's relationships to country. Camel impacts of the type described by interviewees constitute a major threat to their cultural values.

(b) Bush tucker

Interviewees in 20 communities (see Table 5.4) mentioned that camels are negatively impacting bush tucker resources by stomping on them, eating them, and otherwise destroying them. Types of plant food commonly said to be impacted by camels include quandongs (*Santalum acuminatum*), bush banana (*Leichhartia*), bush currants (*Solanum centrale*) and bush potato (*Ipomoea costata*).

Some interviewees also mentioned that camels are reducing the availability of bush food by frightening kangaroos and other game away or by 'getting in the way' of the hunter and the prey. Importantly, concern was expressed not just in relation to current availability of bush tucker but also the consequences for future generations if bush tucker is significantly reduced. This concern related not only to diminishing supplies of bush tucker but also to lack of opportunity to teach future generations about bush tucker (see section on valuation of negative impacts).

Not all interviewees in communities where bush tucker impacts were noted were concerned about the matter. Some people were of the view that camels were just passing through and that the damage was relatively insignificant. Most people who were concerned about camel impacts on bush tucker indicated that problems were associated with large numbers of camels rather than individuals. A number of interviewees who were concerned about camel impacts on vegetation indicated that the effects were greater during dry times, such as the country is experiencing at present.

In general, stronger concern was shown about camel impacts in regions where camel densities were highest. For example, little concern was expressed about camel impacts on bush tucker at Apatula/ Finke, Balgo, Mulan, Billiluna, Laramba, Atitjere/Harts Range and Willowra. Interviewees in settlements in SA such as Walalkara, Pukatja/Ernabella, Amata, Mimili, and in settlements near the Gibson and Great Victoria Deserts, such as Kintore and Nyirripi, expressed greater concern. These are all areas where there are said to be large numbers of camels. There were diverse views concerning camel impacts on bush tucker at Warakurna, Kiwirrkura, Yuendumu and Areyonga/Utju. Interviewees in settlements surrounded by cattle stations, such as Apatula/Finke, Mpwelarre/Walkabout Bore, Laramba, Yuendumu and Atitjere/Harts Range, were more likely to compare camels favourably to cattle in terms of impacts on vegetation than interviewees at other places.

The findings show that interviewees hold a broad range of views concerning camel impacts on bush tucker. A comparison of these findings to those of Nugent (1988) and Rose (1995) with regard to central Australian settlements in the NT more than a decade earlier indicates that, in some areas at least, there has been a marked increase in both perceptions of feral camel impacts on bush tucker and concern about the matter. For example, Nugent comments in respect of Nyirripi that camels 'do not feed on anything humans might eat' (1988:17). Rose states that Aboriginal people recognise damage to country caused by large numbers of feral animals; however, he notes that, in general, 'the effects of feral animals on the country are not seen as a cause for concern' (1995:128).

(c) Other culturally significant resources

Interviewees in 19 communities expressed concern about camel impacts on culturally significant resources apart from naturally occurring water sources and bush tucker (see Table 5.4). Examples provided of such resources are as follows: Jukurrpa (Dreaming) trees, trees that provide shade for animals, bean trees (*Erythrina vespertilio*), bush medicine plants (for example *irmangka irmangka* [native fuschia *Eremophila alternifolia*]) and native tobacco (*Nicotiana* spp.). In addition, a number of interviewees mentioned that camels impacted their ability to use and enjoy the country, particularly when in large numbers or where bull camels were present. This issue is discussed in more detail below. As with bush tucker, concern about camel impacts was generally stronger in regions where camel densities were high and where cattle had not already considerably impacted country.

Safety concerns

Interviewees from 17 communities generally expressed concern over the danger camels posed both on and off road (see Table 5.4). Road accidents and fatalities are now an increasing occurrence in these regions. Interviewees reported that camels are difficult to see on the roads, particularly at night, and in the early morning and late afternoon when camels are most active. While not all the interviewees raised the issue of road safety, people were most strongly concerned about the matter at Kintore, Kanpa, Kiwirrkura, Pukatja/Ernabella, Mimili, and Yuendumu. Interviewees at the other survey communities expressed comparatively little concern about the matter. Concern was also expressed about camels wandering onto unfenced airstrips.

Fear or wariness of camels is beginning to impact people's use of country and patterns of exploitation. Interviewees in nine communities expressed a fear of bull camels, particularly during the mating season when they fought with other camels and jealously guarded their herd. Some also said they were cautious of large numbers of camels and that when hunting they often avoid areas where camels are known to be present. There are numerous stories about people's lucky escapes from a bull camel. For example, one interviewee said: 'When we break down, bull camels [can] chase people. One bloke walked from near Kintore when his car broke down. He was chased by a camel and had to climb a tree.' While this incident may appear slightly humorous, it is in fact a serious issue, particularly given the fact that some desert areas have few trees and that Aboriginal people's cars are often old and break down. Some interviewees said that they no longer camp out in certain areas because of camels. Many said that when they camp out they light fires to keep camels away and subdue them.[4] One interviewee said that he cannot live at his outstation because camels have damaged the tank and if he brings water it will only attract camels. Many people in high-density camel areas perceive that if something is not done to check the camel population the problems will escalate. Settlements where there was a strong concern about the issue were as follows: Kintore, Titjikala, Nyirripi, Warakurna, Kiwirrkura, Amata, Pukatja/Ernabella (in regard to Homelands) and Yuendumu. As well, one interviewee at Willowra expressed concern about the matter, as did another at Laramba in relation to Mt Wedge.

While, as yet, concern about the safety risks that feral camels pose is not universally shared, comparisons with Nugent (1988) and Rose (1995) in regard to the NT settlements reveal that it is a growing issue. In my opinion the negative impacts on Aboriginal people's use of country should not be underestimated. An exponential increase in the feral camel population has the potential to profoundly alter not only people's access to country but also the transmission of cultural knowledge and practices concerning country to future generations. The desert region could well be transformed from a benign, familiar, and familial landscape populated with mostly small non-aggressive animals, kinfolk, and ancestral spirits to an emptier, more alien landscape replete with danger.

Damage to outstations/Homelands and fences

Homelands that interviewees perceived to be negatively affected by camels include Angatja in SA and, in the NT, Warren Creek near Mt Liebig, Charlotte Waters near Apatula/Finke, and outstations of Haasts Bluff and Kintore. Types of damage mentioned included damage to taps, tanks, bores, windmills, buildings, fences, and vegetation including trees and bush tucker. In the main, interviewees who had close associations with homelands mentioned the damage to homelands, and they were concerned about it. Wider consultation is likely to reveal camel impacts on other homeland or outstation areas. While he does not mention camels, 13 years ago Rose (1995:47–8) found that people in NT central Australia expressed concern about damage to outstations by feral animals such as horses and cattle.

Interviewees in 14 settlements perceived that feral camels damaged fences (see Table 5.4). However, this did not necessarily mean that it was a matter of great concern to people. A number of the Aboriginal settlements surveyed (for example, Apatula/Finke, Atitjere/Harts Range, Titjikala and Yuendumu) are adjacent to, or surrounded by, pastoral leases, and interviewees are not responsible for the upkeep of fences on them. Not surprisingly, people are more likely to be concerned where the damage impacts them directly; for example, on outstations, around houses, and on Aboriginal land with pastoral operations. Haasts Bluff, Atula (Atnetye Aboriginal Land Trust), and Willowra are examples of the latter.

Impacts of feral camels on other animals

There was a broad range of perspectives concerning feral camel impacts on other animals, with no consensus either within or among communities. Overall, roughly a third of interviewees perceived that feral camels negatively affected other species, either directly or indirectly. Interviewees in 16 settlements perceived that feral camels negatively affect native animals (see Table 5.4) by competing with them for water and plant food, damaging their water sources, frightening them away from water sources, and generally disturbing them and eating their shade source. For example, one man perceived that feral camels impact native animals by depriving them of water:

4 This concern has been confirmed by a number of other anthropologists who work with Aboriginal people in central Australia. For example, I recently discussed the issue with anthropologist Diana James, who was planning a field trip with Pitjantjatjara women to the south of Uluṟu on Aboriginal land. She said that concern about camels was a factor in women's decisions about where and how to camp.

They frighten them away. The animals have gone somewhere. Kangaroos only drink rockhole at night time but camels are drinking the rockholes dry and damaging them. They are our hunting animals and they've gone because of no water. And emus too – they are frightening them away, drinking their water.

Yet another person commented that camels impacted vegetation on which other species depend: 'We have to go a long way to find *kuka* [meat] because camels hunting them away. Making the country dry. No grass – our tucker can't grow.' An interviewee from Walalkara commented: 'We have a big problem with camels. We are worried about [impacts on] mallee-fowls.' She also observed that camels deprived other animals of water and said: 'We want the rockholes to be clean for [native] animals and people to drink.' In general, interviewees who perceived camels to be having an affect on other animals came from regions where camel numbers were said to be high.

However, nearly half the interviewees in the same communities thought that feral camels had little or no impact on other animals. It was clear that some interviewees interpreted the question of whether feral camels caused problems for other animals as a moral question concerning intentional behaviour and motivation. More than one person pointed out that camels do not intentionally interfere with other animals (although they may do so with humans). Rose also found that most people he spoke to in the NT thought that feral animals did not 'interfere' with native species but that they could scare them away and disturb their environment (1995:100, 102–3, 112).

A few interviewees expressed concern about the possibility of disease being transferred from live and dead camels to other native animals, and a larger number were concerned about the potential for a dramatic increase in dingo numbers if camels were culled in large numbers (see later discussion on camel management).

4.2.2 Valuation of negative impacts

As noted earlier in the report, one set of questions that proved highly problematic concerned the 'valuation of negative impacts'. Most interviewees found it difficult to estimate the economic impacts on their community and country that camels caused in the last two years. It is not that people are not concerned about impacts, but rather that they are not used to applying a dollar value to culturally significant resources and experiences, nor indeed to objects in the built environment. Moreover, as mentioned earlier, many people are innumerate. Traditionally, Aboriginal culture was non-capitalistic and today Aboriginal communities remain underdeveloped in western economic terms. While Aboriginal people participate in the cash economy, their engagement with markets remains largely marginal. Much of the Aboriginal population in the region is impoverished and dependent on government welfare and financial assistance for the provision and maintenance of houses and other infrastructure. People often do not know the cost of repairs and maintenance, which is generally administered on a community rather than an individual household basis. It was difficult for me to find out from administrators the cost of repairs to houses and infrastructure as a result of camel damage. This can partly be attributed to the high turnover of staff and lack of corporate knowledge about this issue and the fact that the relevant agencies apparently do not keep such figures. For these reasons the matter of economic valuation of negative impacts was not strongly pursued with interviewees.

Another important issue is that because many Aboriginal people lack resources they often feel powerless to control and rectify problems, with the result that things such as camel impacts are accepted as being the way things are. However, changes wrought by large numbers of feral camels on the Aboriginal cultural environment have the potential to create significant and cumulative losses. These losses could include changes in patterns of exploitation and customary use of country, damage to rockholes and other culturally significant sites, a decline in bush food, medicine, tobacco, and other culturally valued resources, and loss of opportunity to teach younger generations about such things. Turner et al. maintain that if loss is:

... not obvious to others, is not readily measured, is not represented in a matter recognized as legitimate, or is a result of a series of compounding impacts that are not easily connected to an original action, the consequences can be invisible even though they prove devastating (Turner et al. 2008:1).

Further, they point out that such invisible losses are '… seldom considered, awarded compensation, or mitigated by decision makers and resource managers' but that the 'risk to people's overall health and capacity for resilience' (Turner et al. 2008:2) may be profound.

4.2.3 Positive impacts

This section outlines interviewees' perceptions of the positive aspects of feral camels. Table 5.6 indicates settlements where an interviewee mentioned a positive impact experienced in the previous two years or earlier. Table 5.7 indicates type of positive impact mentioned by number of settlements in each state/territory.

Table 5.6: Positive impacts of feral camels mentioned by some interviewees in survey communities

Jurisdiction	Selling camels		Butchering and eating camels	Mustering jobs/pet meat operations		Tourism		Other (e.g. owning camels as pets, wool products)
	Last 2 years	3 years ago or before		Last 2 years	3 years ago or before	Last 2 years	3 years ago or before	
SA								
Amata		Y	Y		Y		Y	Y
Indulkana/Iwantja								
Mimili		Y	Y		Y			Y
Pukatja/Ernabella								Y
Walalkara	–	–	–	–	–	–	–	–
WA								
Balgo			Y					Y
Billiluna/Mindibungu								Y
Kanpa								
Kiwirrkura								
Mulan								
Papulankutja								
Warakurna				Y				
Warburton								
NT								
Areyonga								
Apatuka/Finke		Y			Y			Y
Haasts Bluff								
Atitjere/Harts Range							Y	Y
Kintore			Y		Y			Y
Laramba								
Mt Liebig								
Mutitjulu								
Nyirripi			Y					Y
Bonya/Orrtipa-Thurra			Y		Y			
Titjikala			Y	Y	Y			Y
Mpwelarre/Walkabout Bore		Y	Y		Y	Y		Y
Willowra								Y
Yuendumu		Y						Y

Note: The views shown were not unanimous within each place. The table records any mention of positive impacts by an individual interviewee in a particular community as a 'Yes'.

Positive impacts associated with feral camels include income from camel-related jobs such as capturing and mustering, pet meat operations, opportunities for involvement in the sale of camels and tourism enterprises such as camel farms, rides, and safaris, meat for human and pet consumption, and products such as camel wool. The latter is used sporadically at Ernabella Arts for making art and craft items such as beanies for sale on the tourist market. Importantly, it is not just income that is valued in relation to camel work but also the opportunity for camels to provide meaningful and productive activity. While the number of interviewees who have benefited recently from feral camels is not large, the widespread and varying engagement of Aboriginal people with camels is impressive. In the following I discuss the benefits perceived to accrue from camels.[5]

Capturing and butchering of camels for local consumption

Youth involvement in the capturing and butchering of camels at Kintore provides meaningful activity, which apparently helps prevent substance misuse (see Squires 2008). It also results in an ongoing, if small scale, supply of cheap and healthy meat for the community, which is cooked by women in the Women's Centre for seniors and school children's lunches. A similar program has occurred at Docker River, with camels being killed and eaten on a more regular basis (see Tangentyere Landcare 2006:19–20). Some Amata people affiliated with Angatja Homeland and some people from Yaka Yaka, an outstation of Balgo, have also killed camels for local consumption by both humans and pets.

Kangaroo generally remains the meat of choice for many Aboriginal people in central Australia; however, camel meat is becoming more accepted. It is gaining a reputation as a health food, because it is low in fat and cholesterol (see Tangentyere Landcare 2006:15) and is perceived, at least by some people, as 'clean'. Camel meat is widely eaten at Kintore, although some older people do not like to eat it because they feel a responsibility to 'look after' camels, as it was Europeans with camels who first brought them rations and took them in from the desert. Some people also do not like to eat camels because of their Christian mythical association with the Three Wise Men. Throughout the world, people's food preferences are governed by moral considerations, custom, and identity, and Aboriginal people are no different (see Vaarzon-Morel 2008 for further discussion of this issue). People in settlements in the Ngaanyatjarra Lands (WA) are becoming increasingly accepting of camel meat (D Brooks 2008 pers. comm., 28 August), as are people at Amata and Mimili in SA, and Titjikala, Mpwelarre/Walkabout Bore, Nyirripi and Areyonga in the NT. However, most people at Balgo, Billiluna, Mulan, Willowra, Pukatja/Ernabella, Yuendumu, Haasts Bluff and Bonya/Orrtipa-Thurra are unaccustomed to eating it. At Laramba, there was considerable resistance to the idea. (No information was obtained on the matter at Mutitjulu.) Significantly, even those Aboriginal people who do not like to eat camel meat themselves tend to accept killing feral camels for meat for pet and human consumption as a legitimate and moral practice (see discussion on camel management below). Eating camels is not a completely new phenomenon among Aboriginal people in central Australia: a small number of people related stories about relatives who had killed and eaten camels in earlier times. For the most part the camel eaters were Pitjantjatjara, although stories of Warlpiri who had come across a wounded camel and killed it for meat were also told.

Commercial pet meat operations

As yet Aboriginal employment in the pet meat industry is small scale and mostly in Ngaanyatjarra communities in WA. It is regarded well by the local community and the Ngaanyatjarra Council Land Management Unit precisely because it is of a manageable scale, is non-intrusive, builds on the strengths of Aboriginal people, and is flexible. To date, local people in the communities of Warakurna, Jameson, and Tjukurla, on the Ngaanyatjarra Lands, have been employed in pet meat operations. Of these, Warakurna was surveyed for this project (see also Zeng & McGregor 2008).

Mustering, live removal, and sale of camels

A minority of people from Apatula/Finke, Mimili, Amata, Mpwelarre/Walkabout Bore, Kintore, Warakurna, Orrtipa-Thurra/Bonya, Titjikala, and Yuendumu have participated in camel mustering and/or selling activities, with the scale of operations ranging from the sales of a few camels to much larger and organised activities (see Table 5.6). Larger scale activities involving mustering, live removal

5 I do not distinguish here between feral camels and domesticated camels because of the general Aboriginal perception that feral camels are easily domesticated or broken in and 'made quiet'. Benefits are associated with both types of camels.

and sale of camels have been undertaken by people associated with Amata, Mimili and Kintore.[6] For example, an interviewee at Mimili had been involved in an Aboriginal-run activity in the early 1990s mustering and selling more than 50 camels near Fregon. The Bureau of Rural Resources gave them 'technical and marketing advice on the management and commercial use of the camels' Aboriginal Rural Resources Initiative (ARRI) (McNee nd:12). Perceived benefits from the project included income production, reduction of camel population and social benefits. It was clear that the interviewee had enjoyed, and was proud of what he considered to be a meaningful, relatively independent activity that utilised his skills and knowledge of country.

Aboriginal involvement in the camel tourist industry

Some Aboriginal people have been involved in the camel tourist industry. Two interviewees from Atitjere/Harts Range had worked for long periods of time taking tourists for camel rides at the Stuarts Well camel farm, south of Alice Springs. The son of one of the senior traditional owners of Mpwelarre/ Walkabout Bore works at the Aboriginal-owned tourist venture, the Camel Farm in Alice Springs, where he takes tourists on camel rides. In about 1988 or 1989, a family associated with Amata ran a tourist venture on their country at Angatja Homeland in SA. They mustered and broke in small numbers of camels to take tourists for rides to learn about Aboriginal culture and country and also partly as a way to manage the camels in the area. They were affiliated with the company Desert Tracks and, according to the interviewee, also took tourists on camel rides to Ayers Rock. They did not win the contract to continue these rides. Another company, which is also Aboriginal-owned and -run, now undertakes camel tourism in this area.

Historical associations with camels

In addition to the positive impacts already listed, it is important to note that many interviewees have strong historical associations with camels. Communities in which many older residents had strong historical associations with camels include Apatula/Finke, Amata, Pukatja/Ernabella, Mimili, Mutitjulu, Titjikala, Mpwelarre/Walkabout Bore, Nyirripi, Areyonga/Utju, Haasts Bluff/Ikuntji and Atitjere/Harts Range.

A few individuals in some other places, including Kintore, Balgo, Indulkana, and Yuendumu, also have strong historical associations. In other places people's associations were not as strong or widely shared, although some interviewees elsewhere did recall that their deceased relatives had used camels and/or that they had ridden camels when young.

The significance of historical associations is that people with such experiential links tend to value camels more highly than others and are more likely to be skilled handlers of camels. However, while it is sometimes the case that such people are more resistant to the idea of controlling the camel population and using them for meat and other products, this is not always the case. Indeed, the research shows that while members of the older generation who used camels respected and valued them, this did not mean that they abstained from eating them or using their fat and other products when necessary. As well, older people are very aware of the dramatic increase in the camel population during their lives, and they articulate the need to manage it.

Other positive aspects ascribed to feral camels

Although not, perhaps, an impact, other positive aspects ascribed to feral camels include the enjoyment derived from the use of feral camels as family pets and the excitement and pleasure many people feel in seeing feral camels (although at the same time they may be wary of them). Families in 10 of the 27 communities surveyed either keep camels as family pets or have kept them in the recent

6 The mustering and sale occurred during the late 1980s and early 1990s. It appears that the camels were mostly sold within Australia but some were also sold to the United States of America. Although not part of this survey, there are purpose-built cattle yards at Undurana, which are sometimes referred to as a 'camel farm', on Anselm Impu's country near Hermannsburg. More than 40 camels have been mustered, transported live, and sold. The Indigenous Land Corporation, Tjuwanpa Outstation Resource Centre at Hermannsburg, CLC, and mining company Santos Limited have been involved with this project.

past. The communities concerned are as follows: Apatula/Finke, Kintore, Balgo, Billiluna, Mimili, Titjikala, Mpwelarre/Walkabout Bore, Nyirripi, Willowra, and Atitjere/Harts Range. In addition, at the Mpwelarre/Walkabout Bore outstation 50 camels were kept in fenced camel paddocks.

Table 5.7: Positive impacts of camels: type of positive impact by number of settlements in each state/territory

Type of positive impact interviewees mentioned	Number of settlements where interviewees mentioned this impact			
	WA (n=8)	SA (n=4)	NT (n=14)	Total (n=26)
Sale of camels in last 2 years				
Sale of camels 3 years ago or before		2	3	5
Eating camels	1	2	5	8
Mustering and/or pet meat operation jobs in last 2 years	1		1	2
Mustering and/or pet meat operation jobs 3 years or more years ago		2	5	7
Tourism in last 2 years			1	1
Tourism 3 or more years ago		1	1	2
Other (e.g. owning camels as pets, wool products)	2	3	8	13

4.3 Perspectives on camel management

Many interviewees across the survey communities perceived a need for feral camel management (see Table 5.8). Although many people have skills that could be used in camel management programs, they lack the resources and infrastructure to manage camels and their impacts. As a result the harvesting that does occur is sporadic and low scale. Apart from two interviewees who had been involved in culling, feral camel management was largely restricted to hunting for meat for local consumption and the fencing of culturally significant resources and property. While some individuals had been involved in mustering and selling camels in the recent past, this was undertaken for European pastoralists.

In the following I discuss approaches to camel management that have been used and explore Aboriginal perspectives on camel management. I focus on differences between settlements. Table 5.8 and Figure 5.2 show attitudes to camel management in the survey settlements across the feral camel range. Table 5.9 shows attitudes to feral camel management by number of settlements in each state/territory.

4.3.1 Attitudes to camel management

Perceived need for control and/or management

Many interviewees thought that the feral camel population needs to be controlled (see Table 5.8). This was particularly the case in areas where camel densities are relatively high. Examples of the latter places include Kiwirrkura, Papulankutja/Blackstone, and Kanpa in WA; Amata and Walalkara in SA; Titjikala, Mpwelarre/Walkabout Bore, Areyonga/Utju, Mt Liebig/Watiyawanu, and Mutitjulu in NT. There was much less of a perceived need for camel management at Balgo, Billiluna, and Mulan, which are on the edge of the camel range. However, people at Balgo recognised that camel densities were higher further to the south-west in the Great Sandy Desert and to the south in the Gibson Desert, and that camel management was required in these areas. The need to control camel impacts is being increasingly accepted at Warburton, where camel numbers are increasing.

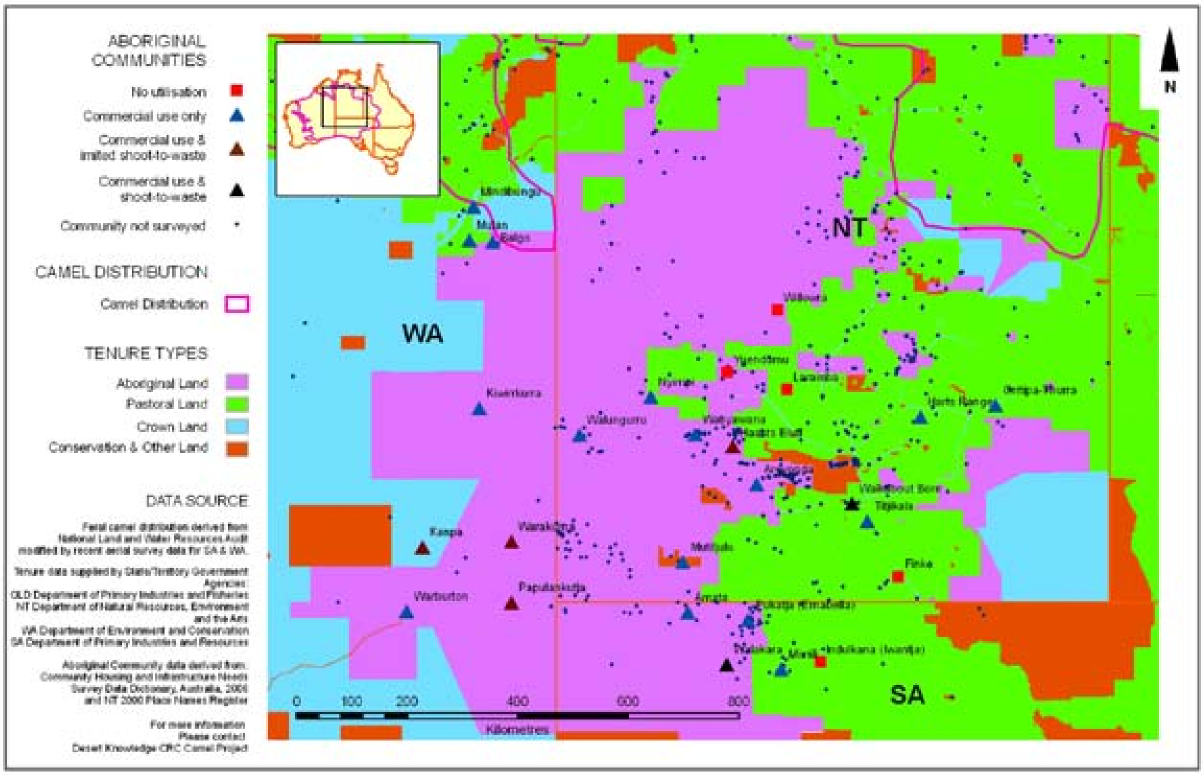


Figure 5.2: Aboriginal settlements' perceptions on feral camel management

There were some places where the removal of camels had occurred in the surrounding region via pet meat operations, for example, at Warakurna, and by culling, for example, at Haasts Bluff, Apatula/ Finke, Laramba, and Bonya/Orrtipa-Thurra. At Haasts Bluff most people felt that if camel numbers increased they should be controlled. One person stated, for example: 'Just get rid of them and get the environment back again.' However, at Apatula/Finke two-thirds of the interviewees did not perceive a need to control camels even if numbers were to increase in the region; others acknowledged the need to control camels 'if they breed up'. Although there are few camels at Bonya/Orrtipa-Thurra and Atitjere/Harts Range, many of the interviewees were associated with old Atula (now held by the Atnetye Aboriginal Land Trust), which is on the edge of the Simpson Desert, and recognised that camels 'are increasing, coming in from the desert' and need to be managed. A spokesperson for Apiwentye Pastoral Company, which runs cattle on Atula and had some camels removed already, also said that 'something had to be done' about the increasing numbers.

At Yuendumu, Willowra, Laramba, and Nyirripi, which are in the southern Tanami Desert (see Figure 5.2), people's perception of the need for camel management was less clear cut. Although in general many interviewees perceived a need to manage camel impacts, most were only prepared to consider limited management options (see below).

In contrast, interviewees at Amata, Mimili, and Walalkara in SA in the APY Lands indicated much stronger support for camel management. For example, at Mimili one person said: 'Get rid of them. Should finish them. We only want to see our *kuka* [meat], *marlu* [kangaroo], emu, and turkey. That's our food – not camels.' Another person at Walalkara voiced a similar sentiment: 'We need government to help us get rid of camels.' At Indulkana and Pukataja/Ernabella, people do not have a camel management problem, although a senior man from Indulkana was concerned about camel impacts in the APY Lands and wanted the problem removed, as did many interviewees at Pukatja/Ernabella.

While a minority of interviewees advocated the total removal of camels from their country, many others across the survey settlements specified that some camels should be kept for local consumption and as a resource to be used in the future. For example, a Balgo man remarked: ‘You never know, one day we might need camels. The Arabs might want them. One day people might come from overseas and want to talk business.’

Perspectives on culling

Apart from one who had been involved in culling at Haasts Bluff (where there was a cattle operation) and another person from Mpwelarre/Walkabout Bore who had undertaken culling on pastoral stations, no other interviewees had undertaken culling of feral camels. However, the APY Land Management Unit was said to have organised some culling.

In only two of the settlements surveyed, Mpwelarre/Walkabout Bore and Walalkara, were the interviewees comfortable with the idea of culling. Interestingly, people at Mpwelarre/Walkabout Bore kept camels themselves and had a long history of working on cattle stations on the edge of the Simpson Desert, where there are high numbers of camels. One informant said that although he felt compassion for camels and didn’t like them to be killed, he recognised that it was necessary sometimes:

> *Culling – they’ll have to do it, especially in the Simpson Desert. If they have to, it’s all right. Shooting camels by helicopter and leaving them to die is cruel, but you got to do it because in sandhill country you can’t chase them with a Toyota.*

The removal of camels was a high priority for the people at Walalkara. While they once had hoped to derive income by selling camel meat for pet meat, they were now prepared to cull camels themselves and to support aerial culling in order to protect the wetlands, vegetation, reptiles, and animals in the area, of which a number of species are endangered.

Only in a further four settlements was aerial culling considered to be acceptable, and then only if it was the only option and was undertaken away from roads and settlements. Three of these settlements were in WA, where people had been involved in, or had observed, a pet meat operation. It is likely that the presence of such an operation and the benefits it is perceived to bring in terms of employment, pet meat, and a reduction in camel numbers have influenced people in terms of accepting a more diverse range of camel management strategies than they otherwise may have. However, the sample size of the WA settlements was very small and further consultations in these places may reveal a range of different attitudes.

The fourth community, Haasts Bluff, is somewhat of an anomaly as a culling operation had been carried out on the surrounding Aboriginal land prior to the survey. The culling operation was carried out following consultation with the CLC so that the traditional owners could grant a grazing licence free of feral camels. Significantly, there was a change in land use from land formerly not used for cattle grazing to land that became fenced and brought under production as a grazing licence. The change resulted in economic and employment benefits for local people. Although two interviewees felt comfortable with culling as a management option – one of whom assisted with the culling operation – other interviewees expressed discomfort. The preferred management strategies of the latter were using camels for pet meat and human consumption and live harvesting.

Some interviewees (for example, in Mutitjulu, Atitjere/Harts Range, and Billiluna) said that they would accept culling if the carcasses were buried or burnt. They were worried about disease, smell, the sight of dead bodies, and an increase in the dingo population if large numbers of camels were culled and left to rot. Many people who were opposed to culling shared this concern. As discussed in more detail later, other reasons for opposition to culling include sentimental attachment, a sense of obligation to protect camels from harm, a strong cultural ethic against killing animals for waste, and a fear of environmental repercussions if camels are killed for waste.

What is significant is that Aboriginal attitudes are not homogenous and that among the diverse views expressed in the survey, there are people who accept culling as a viable option.

Live removal: the preferred management strategy

For the majority of interviewees the preferred camel management strategy was live removal for sale within Australia and for export (see Tables 5.8 & 5.9). However, the general perception was that local people should be involved in live-removal projects and that the workers and local community should derive income from associated activities. For example, at settlements such as Willowra, where there was considerable resistance to the idea of reducing camel numbers through pet meat operations or culling, many people were happy to have camels removed live. One senior male said: ‘If something happened with the market, people would be happy to sell them, muster them up.’

It was generally accepted that camels sold live could end up being processed for meat and other products, being used for bloodstock for overseas countries, or being used for tourism. Most people preferred that camels be used in this way rather than being shot and left to waste on their country. Through television many Aboriginal people have become mindful of global realities such as food and fuel shortages. Statements such as ‘we want to have them trucked away and sent for people overseas who have no food, like Africans’, and suggestions that overseas aid money should be used to provide jobs for people in Australia to produce meat to be donated overseas, were not rare.

Killing camels for use as pet meat and for human consumption

Many people indicated that killing camels for pet meat and human consumption was a desirable way to manage camel numbers. For example, at Walalkara people are said to be ‘… keen to start our own business shooting camels and butchering them for dog meat’. In general, opposition to the pet meating option was found in settlements that had little experience of eating camel meat and where camel numbers were still relatively low; for example, Laramba, Yuendumu, Willowra, and Apatula/Finke. Some people in these settlements were not opposed to the processing of camels for meat at abattoirs elsewhere but did not want camels killed on their land.

It was not always clear from interviewees in other places if people wanted commercial pet meat operations on their country or if they were merely in favour of low-scale local butchering and consumption of meat. Some people at Kintore indicated that they had considered the possibility of a commercial pet meat operator removing camels but that the return per kilo was too low. People in many other communities felt that they did not have enough information on the matter to indicate a preference one way or another. In only one community surveyed, Warakurna in WA, had commercial pet meat operations been undertaken. The Ngaanyatjarra Land Management Unit facilitated the operations, and had also organised pet meat operations at Jameson and Tjukurla (the latter were not surveyed). The structure of the operation was as follows: two non-Aboriginal shooters employed two Aboriginal people as guides to show them where to locate camels and which places to avoid for cultural reasons. The Aboriginal workers also operated the camel hoist. They were paid on a daily basis and the community also received camel meat. At the time of writing, the pet meat operator had been working in the region for approximately 30 weeks and had shot an estimated 3000 camels (G Sanders 2008, Project Officer, Ngaanyatjarra Land Management Unit, pers. comm., 8 May).

Apart from pet meat operations, some communities have captured and butchered camels for local human and pet consumption. Over the past two decades individuals had undertaken such activities on a low scale at Yaka Yaka, south of Balgo in WA; at Atula, Yuwalki (near Kintore), Titjikala, and Nyirripi in the NT; and at Angatja, Amata, and Mimili in the APY lands in SA. As mentioned previously, as part of a youth project at Kintore, during the past two years young men have periodically hunted and butchered camels for local community consumption. Key benefits arising from the camel activities were reported as follows: improved nutrition, the prevention of substance misuse through the engagement of youths in purposeful and enjoyable activities, caring for the environment, and free meat (Tom Holyoake

2008, Youth Worker, Kintore, pers. comm. 11 April). Although not part of this survey, Docker River in the NT has had a similar youth program involving the killing of camel for local consumption (see Tangentyere Landcare 2006). In addition to the above, an interviewee at Bonya/Orrtipa-Thurra said that he'd shot some camels at Atula and used their meat for dingo bait.

Most interviewees who had experience capturing camels perceived them to be highly intelligent animals with good memories. This has implications for control programs.

Managing camel impacts on country by fencing and through ranger activities

Some interviewees mentioned that to date they had participated in activities such as the fencing of significant resources and property. For example, at Apatula/Finke some interviewees had helped erect protective fencing, as had some interviewees at Warren Creek outstation near Mt Liebig. The Ngaanyatjarra Land Management project officer also indicated that land care activities such as maintenance and protection of waterholes are undertaken on the Ngaanyatjarra Lands. According to some interviewees at Mimili, the APY Land Management Unit undertakes similar activities with local rangers as part of the Caring for Country project. Assisted by CLC, traditional owners of land on the edge of the north Simpson Desert at Loves Creek and Atnetye Aboriginal Land Trust had also fenced and cleaned rockholes and soakages. Looking after rockholes and soakages and protecting them from damage by feral camels and cattle was seen as an important priority (see also Mahney 2002).

A common perception was the need to protect important places, trees, and bush tucker from camel damage. Some interviewees at Kintore, Amata, and Walalkara mentioned that camels had fallen into waterholes and died, but they had no means of pulling them out and had to wait until the camels decayed to clean out the waterhole. Suggested activities to help prevent negative camel impacts included fencing areas of cultural significance and assets such as airstrips, cleaning out and maintaining rockholes so that other animals could use the water, and the provision of water points away from significant places in order to protect these places, provide water for the camels, and enable them to be caught. For example, at Mutitjulu, suggestions included to 'make a dam to tempt camels away from waterholes and stop them dying in the summer; build a fence with a dam, camels come to drink and can't get back out, good way to muster; put a fence between SA and NT and then control camels in NT'. At Mt Liebig it was said that the airstrip needed to be fenced as camels were frequently wandering onto it.

Tourism

A few interviewees across the survey settlements mentioned tourism as a possible means of managing camels, although it was generally acknowledged that such management would be limited in scale (see Table 5.8).

Table 5.8: Attitudes to feral camel management in the survey communities

Jurisdiction	Do you think that feral camels need to be controlled? Yes/No*	If Yes, what kinds of management activities would you like?				
		Exclusion/ fencing/ providing water points/ other ranger type activities	Communities comfortable with shooting for waste/culling	Commercial options: pet meat and human consumption are acceptable	Aerial culling acceptable if the only option and away from roads and communities	Live removal acceptable
SA						
Amata	Y	Y		Y		Y
Indulkana/Iwantja	Y			No info. on this issue		Y
Mimili	Y	Y		Y		Y
Pukatja/Ernabella	Y	Y		Y		Y
Walalkara	Y	Y	Y	Y		Y
WA						
Balgo	Y	Y		Y		Y
Billiluna/ Mindibungu	Y			Y		Y
Kanpa	Y			Y	Y	Y
Kiwirrkura	Y	Y		Y		Y
Mulan				Y		Y
Papulankutja	Y	Y		Y	Y	Y
Warakurna	Y			Y	Y	Y
Warburton	Y			Y		Y
NT						
Areyonga	Y	Y				Y
Atitjere/Harts Range	Y			Y		Y
Apatula/Finke		Y		Y		Y
Haasts Bluff	Y			Y	Y	Y
Kintore	Y	Y		Y		Y
Laramba	Y	Y				Y
Mt Liebig	Y	Y		Y		Y
Mutitjulu	Y	Y		Y		Y
Nyirripi	Y	Y		Y		Y
Bonya/Orrtipa-Thurra	Y	Y		Y		Y
Titjikala	Y	Y		Y		Y
Mpwelarre/ Walkabout Bore	Y		Y	Y		Y
Willowra	Y	Y				Y
Yuendumu	Y	Y				Y

Note: The views shown were not unanimous within each place. Only 'Yes' responses are shown.

Table 5.9: Attitudes to feral camel management by number of communities in each state/territory

Jurisdiction	Do you think that feral camels need to be controlled?	Communities comfortable with culling	Commercial options: pet meat and human consumption are acceptable	Aerial culling acceptable if the only option and away from roads and communities	Live removal acceptable	Exclusion/ fencing/ providing water points/ other ranger type activities
	Yes/No*	Yes/No*	Yes/No*	Yes/No*	Yes/No*	Yes/No*
Total	25	2	22	4	27	18
WA	7		8	3	8	3
SA	5	1	4		5	4
NT	13	1	10	1	14	11

Note: Only 'Yes' responses are shown.

Camel information and education

Availability of information

Most Aboriginal people indicated that they lacked access to information about feral camel management. Apart from people at Amata and Mimili receiving information in the early 1990s from the Bureau of Rural Resources, people at Mutitjulu receiving information through joint management activities, and people at Walalkara receiving information through Australian Government programs, no other interviewees mentioned receiving information directly from government sources. For the most part, any information that they were able to obtain was said to be from non-government organisations such as The Central Land Council and land care groups in the NT, Anangu Pitjantjatjara Yankunytjatjara Land Management in SA, and Ngaanyatjarra Council in WA (see Table 5.10).

Table 5.10: Main sources of information on feral camels and their management by number of communities in each state/territory

Question		NT	SA	WA	Total
Where do you get information about camels and their management?	None				
	Government	1	3		4
	Aboriginal representative groups	10	3	5	18
	TV/other	10	2	1	13

Note: Responses concern sources of information prior to this project

Interestingly, many interviewees said that they saw programs about camels on the television and some had heard stories or announcements about camels on the radio. In the NT a small number had either been to, or heard about, the Undurana Camel Farm near Hermannsburg. In SA many interviewees were aware of camel management activities that had happened in the past at Fregon. The survey found that people largely relied on their own observations and word of mouth. Few interviewees mentioned printed matter as a source of information apart from Tangentyere Landcare's *The Camel Book*.

One of the aims of this project was to promote education on camel issues. This was achieved in several ways. Firstly, it occurred through the discussion and exchange of information concerning feral camels and their management among the interviewees, Waltja workers, interested community staff, and myself. For the most part this happened in people's settlements, but a field trip to inspect damage to country at Kintore also provided an opportunity for the exchange of information, as did a Waltja workshop held in Alice Springs in 2007. The camel sausage BBQs introduced many people to a new food experience. Tangentyere Landcare's *The Camel Book* proved a useful tool for sharing information with Aboriginal people. It has good visuals and is well set out. It provides basic information on the origin, distribution, and population of feral camels, their adaptation to, and impacts on, country, and options for management. The need for additional information is discussed in the following section.

4.3.2 Willingness to participate in feral camel management activities and the need for support

Most communities affected by feral camels indicated an interest in participating in feral camel management activities. However, they lack many resources and require a range of assistance. Most interviewees indicated that they would like more information on camel management options and issues, including the viability of commercial operations and avenues for job creation. They also wanted assistance in the form of financial support, resources, and training to manage feral camels and their impacts. Key areas suggested as possible sources of income and employment are as follows:

- mustering and live removal of camels for sale
- protection and maintenance of natural and cultural resources through ranger activities such as the following: cleaning out rockholes, erecting fences or 'Patjarr Spiders[7]' to protect wetlands, and other activities associated with looking after country

7 The Patjarr Spider is made out of a Toyota wheel rim and attached to spokes. It is used to straddle rockholes to prevent camels from falling in the water and dying. The

- capture and butchering of camels for pet meat and/or human consumption
- tourism
- transfer of camel handling knowledge and techniques to younger generations.

In general there was little interest in activities involving culling. A key theme was that camel management should create opportunities for Aboriginal people to engage in meaningful and 'productive work' (see Vaarzon-Morel 2008 for further discussion of this issue).

Meaningful work tended to be associated with activities that required engagement with country, and the outcomes of such work were culturally valued (see also Povinelli 1995). For example, mustering, looking after country in a customary way and ranger activities were thought of as 'real' work. People expected to be paid fairly for work associated with feral camel management. At the same time some people thought that camel management should be undertaken regardless of whether or not it was economically feasible because it would provide social and other benefits. In the following, I discuss in more detail key areas of interest for assistance and support to manage feral camels and their impacts.

Perceived need for more comprehensive information in culturally appropriate forms

Interviewees indicated that they wanted more detailed information about a wide range of feral camel management issues. People asked for feedback on this camel project – in particular, for information on economically viable management strategies and what is happening in other areas. They feel that they cannot make properly informed decisions about feral camel management without such information. They hear conflicting stories about the money to be made from selling camels. They want to know what the real situation is and how they can engage with employment opportunities while caring for their country and managing feral camels. In order to increase the understanding and ownership of such issues it is important to make information accessible to Aboriginal people across the feral camel range.

Aboriginal people are keen observers of change that is occurring in their local area. However, like other people, they do not always know what is happening on the broader scale. Thus, although people in areas of high camel density may be aware of the negative effects of feral camels, people in other areas may not be. This is important if existing support for feral camel management is to be strengthened and widened. It is also important if people are to appreciate the need for a collaborative feral camel management strategy across different land tenures and regions.

Given that traditional Aboriginal society had an oral tradition, that many people today are not functionally literate, and many speak English as a second language, information needs to be made available in appropriate, accessible, and culturally meaningful forms (see Vaarzon-Morel 2008 for suggestions concerning this issue).

Camel education is likely to be more effective if it is two-way and participatory in nature. It is important to recognise the depth of environmental knowledge held by older men and women who walked the country and knew what it was like before feral camel incursions took place. As senior members of clans associated with particular countries, they hold the corporate memory of the land. They can provide a long-term perspective on environmental change and should be supported to monitor and record observations on natural water sources, plants and animals and their habitats, as well as other cultural values (see Vaarzon-Morel 2008 for further suggestions).

Culling or shooting to waste

Overall, four communities indicated they were interested in receiving assistance with culling operations (see Table 5.11). However, with the exception of Walalkara and Mpwelarre/Walkabout Bore, interviewees expressed little interest in carrying out culling activities themselves. One interviewee at Mpwelarre/Walkabout Bore said that he was keen to help the government manage camels, as he wanted a job and had experience not only in mustering but also in tracking camels and in the aerial culling

---

Spider is a Ngaanyatjarra Land Management invention and the name Patjarr derives from the place where they were designed (Tangentyere Landcare 2006: 13).

of horses. According to Jeannie Robin, whose family cares for their traditional country within the Walalkara IPA, her father is prepared to cull camels to protect his country but requires assistance to do so. She stated:

> *We need government to help us get rid of camels. We need help with motorcars and helicopters. Robin [father] is happy to shoot them. We want to have country with more food. We want the rockholes to be clean for animals and people to drink. [In order to do this] first get rid of all camels – truck them away or kill them. We need help from the government to help country be strong.*

In addition to culling, a few interviewees suggested castration of male camels and biological controls to stop camels reproducing as possible feral camel strategies.

Live removal or harvesting camels for sale

Most communities were interested in the live removal and sale of camels and associated employment and income opportunities (see Table 5.11). Perceived activities involved in live harvest included: tracking, mustering and yarding, loading onto trucks and sale of live camels. For example, a middle-aged man at Mimili who had mustered and sold camels with the assistance of the Bureau of Rural Resources in the early 1990s said: 'I really want to truck them away and earn money.' There was a general perception that live harvesting jobs would provide productive activity for young people. It was also clear from some people's comments that part of the reason they felt comfortable about such work was because it resembled stockwork, in which many older-generation males were skilled.

People perceived that camel mustering would be of interest to young men, because it involved engagement with country and physical work, it utilised older people's knowledge and skills, and was a source of income. For some people, live harvesting clearly held the promise of the excitement and romance associated with the stockwork of earlier days. In order to be able to engage in live harvesting, however, people need appropriate equipment and vehicles, which they currently lack. Most people did not fully understand what was required to operate a profitable financial enterprise and wanted marketing and financial assistance.

It was clear from people's comments that they envisaged flexible harvesting operations that they controlled, rather than an externally driven commercial enterprise that required them to deliver a certain quota at a particular time. One man at Areyonga suggested that Aboriginal men could be trained up as contractors, who could hire their services out for mustering. Only two survey communities, Mpwelarre/ Walkabout Bore and Yuwalki, near Kintore, reported having yards for holding camels or facilities for loading them onto trucks. In the case of Yuwalki, the yards are old and would need to be checked for their suitability. There were also said to be camel facilities near Fregon and steel yards on Mt Wedge.

Using camels as pet meat and meat for human consumption both locally and for sale

In many of the settlements there was strong general support for shooting camels to use for pet meat and human consumption (see Table 5.11). However, this does not mean that everyone wanted to participate in such activities themselves. Sometimes middle-aged and older women suggested that it was a good idea for younger men to do this, but several young men also said they were interested in participating in such activities, as did some older men.

Some people were interested in capturing and killing camels so that the meat could be used locally, and others were interested primarily in selling pet meat. For example, at Walalkara people said: 'We are keen to start our own business shooting camels and butchering them for dog meat. We'll sell it to Alice Springs.' People in some other communities felt that they did not have enough information on the matter to indicate a preference one way or another.

The problem of dead carcasses littering the countryside was raised by interviewees in relation to both the culling and the butchering of camels for pet meat. Concern was expressed about the possibility of unpleasant smells emanating from rotting carcasses if camels were killed near human habitation and roads. People were worried about the sight of dead camel bodies, associated disease and smell, and an increase in the dingo population. If pet meat operations were to expand on Aboriginal land and these concerns were not properly addressed, it could prove counterproductive for camel management in the long term. It is important for reasons of health and cultural values that slaughtering and disposal of camels does not occur near natural occurring water sources and drainage lines.

Protection and maintenance of natural and cultural resources through ranger type activities

People expressed widespread interest in receiving more assistance than is presently available to care for their traditional country. Many interviewees supported the need for more paid positions to look after country and protect culturally significant resources from the effects of feral camels. Suggested activities focused on the exclusion of camels from, and the protection and maintenance of, culturally significant resources. They included:

- fencing of water sources and areas perceived to need protection, including community airstrips
- use of Patjarr Spiders
- provision of extra bores and water points to attract and facilitate the capture of camels
- cleaning and maintenance of rockholes and other naturally occurring water sources
- monitoring and looking after country, including sacred sites and culturally significant trees.

Although some people mentioned that they wanted to fence rockholes and other water sources, others felt that fencing was not a good solution as it prevented native animals from drinking water and separated the water source from the surrounding country of which it was a part. They wanted information on other options. Some people – for example, at Laramba and Yuendumu – explicitly stated that they wanted more ‘ranger work’. Paid ranger work has only recently been introduced to some of the survey settlements, and others are still not familiar with the concept. Although only a minority of people explicitly mentioned the need for more community ranger jobs, this should not be taken to mean that people do not want to look after country. Importantly, discussions with interviewees revealed that it was mostly when people were visiting their traditional countries away from major settlements that they became aware of the negative impacts of feral camels on the land and the broader cultural values at stake.

For Aboriginal people, visits to country are generally multi-purpose and can include activities such as: hunting and gathering bush tucker, gathering firewood, school language and culture camps, sacred site survey and community ranger activities organised by land councils and/or carried out independently, firing of country, and camping out with family. The visits often provide opportunities for younger people to learn about Jukurrpa from older, more knowledgeable kin. Aboriginal people believe that the health of people and country is sustained by carrying out such activities (see Povinelli 1995, Pawu-Kurlpurlurnu et al. 2008). It is within this wider cultural context of looking after country that feral camel management should be approached. Feral camels should not be regarded as a separate problem from other issues associated with the proper care of country. However, support by externally resourced organisations such as land councils is required if they are to visit, monitor, and care for the more inaccessible country.

Tourism

While people in eight communities suggested that camels could be used in tourist enterprises and that they would need assistance in carrying out such enterprises (see Table 5.11), only a few interviewees from a minority of communities expressed strong interest in developing independent camel tourist operations. They were from Atitjere/Harts Range, Amata (in association with Angatja), and Mt Liebig.

Transfer of knowledge and skills

Some interviewees had worked with camels in the past and are interested in working with them again. As noted often throughout this report, many middle-aged and older people have strong historical associations with camels, having used them as a mode of transport until the mid-1970s. While some people bought their camels from other people, in the past a number captured and broke in ('making quiet') feral camels themselves for domestic use. Some people who have worked in the camel tourist industry are experienced at capturing camels, breaking them in and inserting pegs in their noses. These people are interested in transferring their knowledge and techniques to younger generations, and are keen to support camel management activities that involve the training and employment of Aboriginal youths. There are such people at Atitjere/Harts Range, Mpwelarre/Walkabout Bore, Amata and Angatja outstation, Apatula/Finke, Yuendumu, Nyirripi, and Mimili. It will be important to build on this knowledge and interest base when developing and implementing feral camel management plans.

Table 5.11: Perceived need for assistance and support to manage feral camels, noting types of activities suggested

Jurisdiction	Fencing, use of Patjarr Spiders/yard building, provision of water points and/or ranger type work	Help for mustering and live removal	Culling/shooting to waste	Tourism	Shooting for local human or pet meat consumption
SA					
Amata	Y	Y		Y	
Indulkana/Iwantja	Y	Y			
Mimili	Y	Y			Y
Pukatja/Ernabella	Y	Y		Y	Y
Walalkara	Y	Y	Y		Y
WA					
Balgo	Y	Y		Y	Y
Billiluna/Mindibungu					
Kanpa	Y	Y	Y		Y
Kiwirrkura	Y	Y			Y
Mulan					
Papulankutja	Y	Y			
Warakurna			Y		Y
Warburton		Y			Y
NT					
Areyonga	Y	Y			
Apatula/Finke	Y	Y		Y	Y
Haasts Bluff	Y	Y			Y
Atitjere/Harts Range		Y		Y	
Kintore	Y	Y		Y	Y
Laramba	Y	Y			
Mt Liebig	Y	Y			
Mutitjulu	Y	Y		Y	Y
Nyirripi	Y	Y			
Bonya/Orrtipa-Thurra/Atula/ Simpson Desert repeat claim area	Y	Y			Y
Titjikala	Y	Y		Y	Y
Mpwelarre/ Walkabout Bore		Y	Y		
Willowra	Y	Y			
Yuendumu	Y	Y			

Note: The views shown were not unanimous within each place. The table records any mention of need for assistance and support to manage feral camels by an individual interviewee in a particular place as a 'Yes'.

4.3.3 Perspectives on potential uses for feral camels

As discussed earlier, Aboriginal involvement in commercial activities is currently limited to the occasional employment of a few people in the pet meat industry, some mustering work for non-Aboriginal people involved in live removal and sale (local abattoirs and some export overseas), and using camels in the tourist industry. However, there was general agreement in all settlements on a number of potential uses for feral camels as follows.

A majority of interviewees strongly support the development of a stronger camel industry to contribute to feral camel control if it created opportunities for increased employment and income for Aboriginal people. Many people suggested that camels could potentially be used for the following purposes: meat for human and pet consumption, and a source of employment and income (for example, activities such as capturing and mustering camels for live removal and sale). Some people also mentioned the following as potential uses: tourism, products such as wool, fat for use with bush medicine (as was used by some Pitjantjatjara and Arrernte people in earlier times), the production of hides for use in the manufacture of boots and clothes, and as a mode of transport. Apart from the use of camel fat that some Pitjantjatjara people specifically mentioned, suggestions were put forward by interviewees from across the survey range, with no discernable differences between settlements.

With the exception of Aboriginal people who had worked as stockmen on cattle stations or who had been involved in the mustering and selling of camels or had discussed the matter with the CLC Land Management Unit, most interviewees did not know how much income could be derived from the sale of camels but believed that a camel industry would be economically viable. Some people had heard that camels could sell for $1000 per beast; some others put the figure lower, others higher and a significant number said it depended on the market. However, many interviewees said that they had no idea about the price of a camel.

4.4 Implications

As used in this report, the term 'feral' refers to introduced animals that were once domesticated and now run wild. I found that although the interviewees do not have an equivalent term in their own language and most do not use the term 'feral' when speaking English, there is concordance with the way people perceive bush camels and the concept 'feral'.

In his earlier study of Aboriginal perspectives on feral animals, Nugent (1988:2) concluded that although people recognised that feral animals had once been strangers to the country, they now thought of them as belonging to the country. Moreover, he found that 'feral animals are not thought to be a problem nor are they thought to cause land degradation' (Nugent 1988:15; see also p 13). He also noted that some older people regard feral animals as 'God's creatures' (Nugent 1988:13). Seven years after Nugent's study, Rose (1995) conducted research among Aboriginal people in the NT region of central Australia on their perceptions of land management issues, including feral animals. He also concluded that while non-Aboriginal people generally regard feral animals as pests, Aboriginal people perceive them to 'belong on the country' (Rose 1995:xx). He observed that

> *The effects of feral animals on the country are not seen as a cause for concern. It is seen as a natural phenomenon that animals eat the grass and raise a bit of dust. To separate the impact of feral animals from native species on these grounds is not seen as logical. People see the contemporary ecosystem as an integrated whole so they don't see some species belonging while others do not* (Rose 1995:xx).

It is now 20 years since Nugent's study and 13 years since Rose's. Over the intervening period the feral camel population has grown – in some places dramatically.

The findings from this DKCRC project indicate that in areas where there are now high densities of feral camels they are becoming a significant issue for Aboriginal people. Rather than seeing them as being part of the 'integrated whole' (Rose 1995), many people now perceive feral camels as causing unwanted impacts on waterholes, people's use of country, bush tucker, and animals. The issues presented by feral camels are complex and not easily resolved. This is not only because people lack information and resources to manage feral camel impacts, but also because feral camels challenge people's cultural values and ways of acting in relation to other species.

The development of effective participatory camel management strategies involves knowing which options are acceptable to people and why. Although many people were concerned about the effects of camels on country, they were not comfortable with all the suggested management strategies. In what follows I discuss some reasons why. I briefly explore some of the key ways that Aboriginal people think about feral camels and the moral dilemmas that confront people when considering how to control unwanted feral camel impacts. In adopting this approach I draw on the work of the environmental philosopher Jamieson, who proposes that environmental problems not only involve 'scientific, technological and economic considerations' but also 'considerations about ethics, values and the aesthetic dimensions of the environment' (2008:23).

'Belonging to country'

As noted by Nugent, some Aboriginal people state that feral camels 'belong to country'. By this it is often meant that if feral camels are born and grow up on country then they share a relationship with it and its people. Some people who had worked with and kept camels regarded them as 'family'. In talking about camels in this way people extended concepts applied to humans and native species to camels. At the same time however, they also distinguish between feral camels, native species, and people in ways which are relevant to this discussion.

When an Aboriginal person is said to 'belong to country' it is commonly understood to mean that he/she has an enduring relationship with it as a result of a culturally valued connection. For example, the person may have grown up in the country and/or be linked to it through a mechanism such as birth, conception, or descent. Different rights in country arise from different types of connections, depending on the law and custom of the person's group. For example, for Warlpiri people descent from the father's father is of prime importance. It is thought that a person shares the spiritual essence of the ancestral being that is associated with their father's father's country. The ancestral being may be an animal or plant species or other entity. Anthropologists refer to this type of relationship between people and species as 'totemism'. As noted by anthropologist Deborah Rose:

> *The totemic relationship invariably requires that people take responsibilities for their relationship with another species, and learn that their own well-being is inextricably linked with the well-being of their totemic species* (1996:28).

Jukurrpa is the era when the Aboriginal world came into being through the activities and journeys of ancestral beings. These beings:

> *... brought order, meaning and obligation to the world, so that all of its constitutive elements, natural and human, became amenable to common lawful processes and regularities* (Meggitt 1972:71).

The journeys of these beings are commonly referred to in English as Dreaming tracks or 'songlines' and the places at which they performed activities as 'sacred sites'.[8]

Although Aboriginal people draw analogies between humans and the non-human world, they differentiate between feral camels and native species. Significantly, no interviewees believed that camels have a totemic link with country or that they have Jukurrpa (Dreaming). Thus, while at one level feral camels may be regarded as 'belonging to country', at another level they are also seen as different. The fact that camels do not have a Dreaming means that they are not integral to people's relations with

8 Although Aboriginal people throughout central Australia share the concept of Jukurrpa, models of land tenure and how people are affiliated with land can vary. For example, while Western Desert people emphasise place of birth as being an important criterion for affiliation to country, others such as Arrernte and Warlpiri prioritise descent from the father's father. This variation did not seem to greatly influence people's perspectives on whether feral camels belonged to country.

country and its species. Unlike native animals for which there are Dreamings and for which people perform ceremonies, no one has fundamental responsibility for feral camels. In the past when camel numbers were low it is likely that their relationship to country was not perceived as an important issue. However, increasing numbers of camels and competition for culturally significant resources has led some people to refute the view that camels belong to country. For example, an interviewee commented: 'They don't belong here … They've got no Dreaming. No Jukurrpa. They are *yapakari* – strangers – not belonging to us.' Yet another person stated: 'That's Bin Laden's camels. Camels don't belong here. They brought it from overseas … No Jukurrpa for camels. They're not from here – from overseas.'

Perspectives on culling and using feral camels for meat

The customary law that Aboriginal people observe in relation to their management of country was laid down in the Jukurrpa. Customary law is enforced by senior men and/or women of a community. It involves not just 'explicit social rules' but also a 'morally right order of behaviour' (Meggitt 1972:71). This 'morally right order of behaviour' guides the way people relate to humans and other local species. Moral consideration is not restricted to native species but also to other animals. Aboriginal people respect the right of other animals to life and feel sympathy for animals killed for no reason. As the following quote illustrates, Aboriginal people have a strong cultural ethic against killing animals for waste that is part of Aboriginal Law or Jukurrpa:

> *I respect animals, any animal. If you shooting it for skin or hunting, that's all right. But killing it and leaving it is not right. A couple times a fella shot kangaroos and left the skinny ones, just taking the tail. I said to him, 'I caught you shooting for nothing. You can't do that. You are wasting for the future, for people to eat. That's against the Law. That's why we respect animals; that's Jukurrpa.*

Although not everybody subscribed to the view, some interviewees explained that they did not accept culling because they associated camels with the Three Wise Men in the Bible story about the birth of Jesus. In this view camels have a special symbolic status as God's animals, and killing them for waste will attract retribution. Punishments mentioned included ill health, death, and environmental repercussions such as drought. For example, an interviewee said 'We'll have no rain because they've shot camels. Camels are God's gift. If you shoot them, no rain.' In my view Christian camel symbolism has more in common with the Aboriginal ethic not to kill animals for waste than might appear to be the case at first glance. As the following quote indicates, some interviewees clearly saw a unity between the Aboriginal Christian beliefs about camels and Aboriginal Law concerning killing:

> *It's bad to kill and not eat them. In the Bible it says what you kill you eat. [Aboriginal way] you don't kill for fun – you can get boned. Kangaroo is our Dreaming and culture. We follow Laws through that. You'll get a good hiding if you kill for nothing.*

In Aboriginal Jukurrpa there is a close association between, on the one hand, rain, renewal of species (life) and the health of people and country and, on the other hand, acting appropriately toward other animals. Many rituals are concerned with these themes and it is believed that failure to perform them can result in drought, death, and sickness. Aboriginal Christian beliefs about camels have a similar theme (see Vaarzon-morel 2008 for a more detailed discussion of this issue).

Some interviewees were opposed to culling and eating camels because they had close historical associations with them and felt that they should not mistreat them. Many such interviewees said that they 'felt sorry' for feral camels. In expressing this emotion they were conveying feelings of relatedness and a reciprocal duty of care (see Myers 1986:105–6; D Rose 1999:181). Expressions of sorrow were also sometimes meant as judgements (Myers 1986) about the cruelty of culling.

It should be clear from this brief discussion that feral camels raise complex issues for Aboriginal people. As feral camels grow in number and become an increasing threat to the environment, they occupy ever new physical as well as conceptual spaces. In thinking about feral camel impacts on country and how best to manage them, many Aboriginal people feel conflicted. One interviewee expressed the dilemma as follows: 'Every time I drive I feel sorry for camels, and I worry for my country.'

For the interviewees, making decisions about feral camel management involved making moral judgements. At the heart of such judgements are 'reasons for action that reflect a host of concerns involving the interests that are at stake' and also 'the harms that would be caused …' (Jamieson 2008:42). The dramatic increase in the feral camel population in many parts of central Australia over the last few decades, coupled with awareness of their negative impacts on cultural resources and country has led some interviewees to adopt a more contingent view on feral camels than previously would have been the case. As the earlier findings indicate, people in communities such as Walalkara in SA that are heavily impacted by camels perceive that unless feral camels are managed, their country will become dry and devoid of animals and plants and other culturally valued resources. In considering what is at stake, they have weighed up their concern for feral camels as sentient beings against their concern for country. Although their preference is to kill camels for pet meat to sell, they are willing to consider culling if it is the only option. In their view, culling has a vital purpose – the maintenance and renewal of country.[9] On the one hand this position represents a significant shift in perspective from one where culling is perceived as 'killing for nothing'. On the other hand it is consistent with the Aboriginal ethic which stresses the need to care for country and related beings (see D Rose 2005a).

The point is not that everyone should adopt the Walalkara position, but that a range of approaches to camel management are needed in response to different circumstances. There is not just one Aboriginal perspective on feral camels but multiple, sometimes seemingly contradictory, views that can co-exist within the same community. As this report has shown, there is much concern among people about feral camel impacts, particularly where numbers are high. At this point in time the commonly preferred management strategy is live harvesting. Aboriginal people perceive live harvesting to have multiple benefits, including reduction of the camel population, employment and income opportunities and, not least, maintenance of broad cultural values including country and people's relationship with it. However, people's acceptance of, and willingness to participate in, a wider range of feral camel management strategies could change dramatically if appropriate information, resources, and culturally valued livelihood opportunities were provided (see Vaarzon-Morel 2008).

One of the aims of this project was to enable the development of an effective participatory camel management strategy. Towards this end I have presented and analysed a range of perspectives that Aboriginal people and communities hold on feral camels and their management. I have noted that Aboriginal views on the topic are not monolithic. I have also explored some cultural themes that underpin or are relevant to different and emerging views. The point that I make is that if effective long-term camel management strategies are to be developed, Aboriginal perspectives, values, and attitudes must be respected. This does not mean reifying a particular viewpoint but understanding the reasons for the views and assisting people to make meaningful decisions about management strategies (see Turner et al. 2008). This is not simply a matter of providing information but working with people in a participatory way so that they take ownership of issues and solutions.

Feral camels should not be treated as a single issue and separated from other concerns that Aboriginal people have about their country, family, and livelihoods. The research shows that it was mostly when people were visiting their traditional countries away from major settlements that they became aware of the negative impacts of feral camels on the land and the broader cultural values that are at stake. It is within this wider cultural context of looking after country that feral camel management should be approached. However, people require resources, the support of organisations such as land councils,

9 This view is not widely held across the camel range.

and financial recognition of the value of the work if they are to visit, monitor, and care for the more inaccessible parts of their country. An approach that focused on productive relations from an Aboriginal cultural as well as western economic perspective would truly incorporate the 'multi-economism' (Povinelli 1995:506) that has evaded much of settler–Aboriginal relations to this day. It would incorporate 'local cultural beliefs about the limits and meanings of *human* and *environment*' and not just focus on 'scientifically apprehended "facts" of ecological and economic systems' (Povinelli 1995:507).

5. Conclusion

- Aboriginal people are key stakeholders in the management of feral camels and their impacts.
- Many Aboriginal people, particularly those who live in high density camel areas, see a need to harvest feral camels and control their impacts.
- A few Aboriginal people are currently involved in camel management. However a small number have broad experience working with camels and have relevant skills and knowledge, which they are keen to use in feral camel management programs on Aboriginal land. It is important to both recognise and build on this knowledge and interest base when developing and implementing feral camel management plans.
- Aboriginal people lack the necessary support and resources to play a greater role in feral camel management.
- Generally Aboriginal people lack detailed and accessible information about feral camel management issues. They therefore cannot make fully informed decisions about management options and ways to develop and implement management programs and activities. They are keen to obtain more information on these matters, and associated training.
- The majority of Aboriginal people interviewed were not comfortable with all of the approaches to managing feral camels. However, the Aboriginal 'community' is not homogenous. There are diverse perspectives emerging in response to transformations being brought about by feral camels on Aboriginal land.
- The research shows that people with greater camel management experience tend to have different attitudes to others. At the present time, the range of camel management approaches (Edwards, McGregor et al. 2008) is not generally available to Aboriginal communities.
- Aboriginal people are interested and willing to engage in collaborative management programs. However, interest varies within communities and among communities throughout the feral camel range. It is also predicated on the meaningful engagement of Aboriginal people in the programs and the creation of opportunities, support and investment in areas such as jobs, income, resources, and training.
- It is essential that government agencies engage with Aboriginal people, communities, and organisations representing Aboriginal land interests in developing and implementing a cross-jurisdictional management framework for managing feral camels and their impacts.

6. Recommendations

- Provide Aboriginal people with accessible and relevant information on camel management issues.
- Provide community survey participants with feedback on the findings of this camel project in the form of meetings and workshops.
- Facilitate the sharing of knowledge and information among the different stakeholder groups within a two-way learning framework.
- Undertake coordinated follow-up consultations to determine appropriate and acceptable feral management strategies for the different Aboriginal communities. Consultations involving people with customary interest in land and involving other community members to be undertaken and coordinated by representative bodies charged with managing Aboriginal land.

- Provide Aboriginal people and communities interested in feral camel management projects with support and assistance in the form of information, resources, training, and capacity building. This should include support for Aboriginal groups who want to operate independent ‘flexible capture’ programs.
- Harness the willingness and capacity of Aboriginal people to engage in feral camel management as well as their intimate knowledge about camel impacts and presence when developing and implementing a cross-jurisdictional management approach by undertaking appropriate consultations and providing necessary support and opportunities for collaborative engagement.
- Base the selection and support of camel management options on Aboriginal needs associated with the integrated management of natural and cultural resources as well as on economic criteria.

7. References

Baker EA and Motton FL. 2005. 'Creating Understanding and Action Through Group Dialogue', In *Methods in Community-Based Participatory Research for Health*, eds BA Israel, E. Eng, AJ Schulz and EA Parker. John Wiley and Sons, Inc., San Francisco.

Bennett DH. 1986. *Inter-species ethics: Australian perspectives*, Discussion papers in environmental philosophy, no. 14. Australian National University, Canberra.

Edwards GP, McGregor M, Zeng B, Saalfeld WK, Vaarzon-Morel P and Duffy M. 2008. Synthesis and key recommendations. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 331–360. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Jamieson D. 2008. *Ethics and the Environment: An Introduction*. Cambridge University Press, Cambridge.

Lakoff G. 1987. *Women, Fire, and Dangerous Things: What Categories Reveal about the Mind*. University of Chicago Press, Chicago.

Mahney T. 2002. How we did land assessment and planning work on Loves Creek station, In *Planning for Country: Cross-cultural approaches to decision-making on Aboriginal lands*, F Walsh & P Mitchell (Eds.). Jukurrpa books, IAD Press, Alice Springs.

McNee A. no date. 'Aboriginal Employment in Sustainable Land Management', In *Interface*, pp10–13. Bureau of Rural Resources.

Meggitt MJ. 1972. Understanding Australian Aboriginal society: kinship systems or cultural categories? Kinship studies in the Morgan centennial year, The Anthropological Society of Washington, Washington DC.

Myers F. 1986. *Pintupi Country, Pintupi Self*. Smithsonian Institution Press, Washington and London & Australian Institute of Aboriginal Studies, Canberra.

Myers F. 1998. Always Ask: Resource Use and Land Ownership among Pintupi Aborigines of the Australian Western Desert, In *Traditional Aboriginal Society*, 2nd edn, ed. WH Edwards, Macmillan Education Australia, South Yarra.

Nugent R. 1988. 'Some Aboriginal Attitudes to Feral Animals and Land Degradation'. Central Land Council, Land Management Section, Unpublished.

Pawu-Kurlpurlurnu WJ, Holmes M and Box A. 2008. *Ngurra-kurlu: A way of working with Warlpiri people*, DKCRC Report 41, Desert Knowledge CRC, Alice Springs. Available at http://www.desertknowledgecrc.com.au

Peterson N. 1976. The natural and cultural areas of Aboriginal Australia: a preliminary analysis of population groupings with adaptive significance, In *Tribes and Boundaries in Australia*, ed. N Peterson. Australian Institute of Aboriginal Studies, Canberra.

Povinelli EA. 1995 'Do rocks listen? The cultural politics of apprehending Australian Aboriginal labor'. *American Anthropologist*, vol. 97, no.3, pp 505-518.

Rose B. 1995. 'Land Management Issues: Attitudes and Perceptions amongst Aboriginal People of Central Australia', Report for the Cross Cultural Land Management Project. Central Land Council, Alice Springs.

Rose D. 1996. *Nourishing Terrains: Australian Aboriginal Views of Landscape and Wilderness*. Australian Heritage Commission, Canberra.

Rose D. 1999. 'Indigenous Ecologies and an Ethic of Connection' in *Global Ethics for the 21st Century*, ed. N Low. Routledge, London.

Rose D. 2005a. 'An Indigenous Philosophical Ecology: Situating the Human', *The Australian Journal of Anthropology*, vol. 16, no. 3, pp. 294–305.

Rose D. 2005b. 'Indigenous water philosophy in an uncertain land', in *From Disaster Response to Risk Management*, eds. LC Botterill and DA Wilhite, Springer, The Netherlands.

Squires N. 2008. 'Camel hunting, the new Aboriginal pastime', *Telegraph.co.uk*, 26 February. Available at: http://www.telegraph.co.uk/news/main.jhtml?xml=/news/2008/02

Sutton P. 2003. *Native Title in Australia: an Ethnographic Perspective*. Cambridge University Press, Cambridge and Port Melbourne.

Tangentyere Landcare. 2006. *The Camel Book.* Reprinted by the Desert Knowledge Cooperative Research Centre 'Cross-jurisdictional Management of Feral Camels'project, with support from the Australian Government.

Turner N, Gregory R, Brooks C, Failing L and Satterfield T. 2008. 'From Invisibility to Transparency: Identifying the Implications', *Ecology and Society*, vol. 13, no. 2, [Online] Available at: http:/www.ecologyandsociety.orh/vol13/iss2/art7/

Vaarzon-Morel P. 2008. *Key stakeholder perceptions of feral camels: Aboriginal community survey*, DKCRC Research Report 49. Desert Knowledge CRC, Alice Springs.

Zeng B and Edwards GP. 2008. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Appendix 5.1: Focus questions for survey with local Aboriginal communities

Interview Time: _______hours_____/_____/_____

Interviewee information

- **Interviewee: *Name:* ____________________________** ***Sex:*** Male Female
  Age: Old (60 plus), Middle Aged (40–60), Young (15–25) (25–40)
- Community: Name:_______________________________________
- Jurisdiction: WA, SA, NT, Qld

Background (relevant biography and history)

- How long have you lived here in this community?
- Where did you grow up?
- Have you had much to do with camels when you were growing up or later?
- What about your parents?
- Have you worked with cattle or other animals?
- Education and literacy level:

Education	Primary school	Secondary school	Tertiary school	Other

- Current and past employment:

Subject area 1: Awareness of feral camel presence

- Do you know camels? No Yes
- Do you have feral camels on land surrounding your community? **YES** **NO**

If yes:

- How close in? How fresh are the tracks?
- How long have camels been coming near the community? (Months/years)
- Are the numbers of camels coming in increasing? **YES** **NO**

If yes:

- How often did you see feral camels in the past two years?
  More than once a week; once a week; monthly; a couple of times every year; every so often
- What is the usual number that you see?
  Less than 10, 10–50, 50–100, 100–500, >500

What is the biggest group of camels you have seen in the past two years?	>100	100–50	50–20	20–10	<10

- Where is your traditional country?
- Is it your FF? MF? Other
- Camel distribution: Where do you see most camels?
- What do you think/feel about wild/feral camels?

Subject area 2: Awareness of negative impacts

- Do wild/feral camels cause any problems? **YES** **NO**

If yes:

- What about if there are a lot of camels?
- What sort of problems do they cause?
  (e.g. damage to houses; damage to land; damage to rockholes; damage to sacred sites; damage to bush tucker resources)
- Have you noticed that they eat/damage any particular type of trees or plants?
- How do they cause damage (e.g. by eating, tearing, stamping)?
- Any stories about camels and problems?
- Do you think that feral camels cause a problem for other animals? **WHY?**
- Do you think that feral camels cause a problem for country? /Are they bad for country? **WHY?**
- Do you think that feral camels cause a problem for your community? **WHY?**

Subject area 3: Camel management

- Do you do anything to reduce feral camel numbers and/or impacts (e.g. muster and sell, hunt for food, shoot to waste, fencing)? **YES** **NO**

If yes: What and where and when?

- Who else was involved in these activities?
- Did you get paid for these activities and how much?
- Who paid you?
- What do you think camels can be used for? (i.e. What kind of things can you make out of them or do with them?)
- Have you ever been involved in selling camels?
- What do you think about selling camels to make money?
- How much do you think camels can sell for?
- Do you have any yards to hold wild camels that are mustered?
- Do you have any facilities to load camels onto trucks?
- What do you think should be done about camels/with camels?
- Do you think they need to control camel numbers?
- What do you feel about shooting camels and leaving them lie in the bush? (Consider: Bad; You can on your land but I won't; OK for me on my land; I will help you do it on my land.)
- Why do you feel this?
- Would you like help from government or other groups to manage the camels in your area?
  YES **NO**

If yes:

- What kinds of management activities would you like?
- How do you get information to assist you with camel management (e.g. TV, print, land management organisations, word of mouth)?

Chapter 6: Review of legislation and regulations relating to feral camel management (summary)

R Carey

M O'Donnell

G Ainsworth

S Garnett

H Haritos

G Williams

GP Edwards

M McGregor

B Zeng

Contributing author information

R Carey: Research Associate, School for Environmental Research, CDU, Darwin, NT 0909

M O'Donnell: Lecturer in Law, School of Law and Business, CDU, Darwin, NT 0909

G Ainsworth: Research Associate, School for Environmental Research, CDU, Darwin, NT 0909

S Garnett: Director, School for Environmental Research, CDU, Darwin, NT 0909

H Haritos: Research Assistant, School of Law and Business, CDU, Darwin, NT 0909

G Williams: Lecturer, Resource Management, School of Australian Indigenous Knowledge Systems, CDU, Darwin, NT 0909

GP Edwards, B Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871

M McGregor: General Manager (Research), Desert Knowledge Cooperative Research Centre, PO Box 3971, Alice Springs, Northern Territory 0871

Contents

List of shortened forms

DKCRC	Desert Knowledge Cooperative Research Centre
NRM	Natural Resource Management
NGO	Non-government organisation

Acknowledgements

This report is Chapter 6 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

Chapter 6: Review of legislation and regulations relating to feral camel management (summary)

1. Introduction

Camel management in Australia is a complicated issue. This is not only because of a lack of available information on camels themselves including population, movements, biology, and impacts, but also due to the economic, social, cultural, and legislative/regulatory aspects of camel management.

In order to assess the legislative/regulatory aspects of camel management, in February 2007 the Desert Knowledge CRC (DKCRC) sought expressions of interest from suitably qualified and experienced individuals, firms, consortia, NGOs, and research centres to 'review legislation and regulations about feral camel management in Australia'. The responsibilities, as outlined in the Terms of Reference for the intended work, were as follows:

1. Prepare a detailed timeline and outline of the review report, to be approved by DKCRC Camel Project Steering Committee prior to signing a contract
2. Write a review report. The report will be approximately 25–30 pages (or 10 000 to 15 000 words) in length and should include a review of the current legislation, regulations, and policies at both federal and state/territory levels relating to consumptive and non-consumptive management approaches to feral camel management.

   The review will include current legislative documentation on feral animals, and will be particularly focused on feral camels, Aboriginal land management, firearm management, pet meat, game meat, international animal trading (live export, meat export), animal welfare, movement including transportation, and other related documentation.
3. The review should highlight similarities and differences between the relevant jurisdictions – Commonwealth, Queensland (Qld), New South Wales (NSW), South Australia (SA), Western Australia (WA), and the Northern Territory (NT) governments – and identify the changes that would be required for future cross-jurisdictional cooperative actions.
4. Create a database that includes the outlined information with hyperlinks to the full text of all documents reviewed.

The contract was awarded to Charles Darwin University.

2. The review

The legislative review report is in Carey et al. (2008). The analysis focused on eight areas of legislation and regulations relating to feral camel management: ownership, legal obligation to control, legal obligations for welfare, access, welfare over-riding other access restrictions, culling, processing, fencing, and transport.

3. Main points of discussion in Carey et al. (2008) in respect of issues that might impede effective cross-jurisdictional management of feral camels

3.1 Who has ownership of feral camels?

As a general proposition a feral camel is not owned by either the landowner or the government – the Crown – unless state or territory legislation provides otherwise. This occurs in two limited situations outlined in the Key Provisions for NSW and SA only. However, feral camels can become the property of someone when killed or taken, used, and/or domesticated by the person claiming title to the animal. The taking of possession of the camel can occur by capturing it, confining it, or killing it and thus acquiring rights to the use of the animal. Relevant state and territory legislation can prescribe that feral camels cannot be taken or used without a relevant licence or permit, but only WA and Qld appear to do this.

The parliaments of Australia have the power to change the common law and regulate how feral camels can be owned, taken, and used. If the ownership of feral camels were made uniform through legislation in Australia regardless of the land title on which a camel was found, then the basis could be set for a clear line of responsibility for the management of feral camels. However, there may be strong resistance by government to suggest that feral camels become the property of the Crown in the absolute sense, because it would shift the responsibility away from private landholders under pest type legislation. While the Crown could then legislate uniform provisions to allow access to all land titles to control and manage feral camels in cooperation and partnership with landholders, and set in place a uniform licensing system for their farming and use, there would need to be an appropriate balance between the impost on tax payers and the benefits to landholders.

3.2 Who has responsibility to control feral camels? What are a landholder's legal obligations to control camels?

There is a variety of legislative provisions that provide a potential basis for a landholder's obligation to manage feral camels on his or her land.

Perhaps unsurprisingly, unless a statutory agreement has been entered into the most definite source of a landholder's obligation to manage feral animals generally is the relevant feral animal control legislation of each jurisdiction.

There is considerable variation between the jurisdictions in terms of the way in which the relevant legislation provides for feral animal control and the status attributed to feral camels under that legislation.

Occupiers of freehold land, leasehold land, and certain Aboriginal land in WA are obliged to destroy, prevent, and eradicate feral camels on or in relation to their land. In all other jurisdictions, obligations for landholders to manage feral camels will only arise where:

- a landholder has a statutory duty of care for the land, and in the circumstances it is reasonable that the duty extends to the management of feral camels
- conditions attaching to a lease of Crown land require the control or management of feral camels
- a statutory authority, such as a minister, pastoral board, or soil commissioner has issued a direction requiring the landholder to manage feral camels on his or her land
- land is required to be managed in accordance with a management plan that provides for the management of feral camels
- the landholder has entered into a statutory agreement which creates obligations for the management of feral camels.

3.3 What animal welfare obligations do land managers have on their land?

Legislation relating to the welfare of animals is reasonably consistent across the jurisdictions where feral camels are found. Feral camels are afforded the same welfare obligations as other animals inasmuch as they should not be mistreated, abused, tortured, or injured. However, apart from this and some exceptions noted above related to the notification of disease in animals 'at large' on properties, there is no general animal welfare responsibility that applies to feral camels existing on a landowner's property. A landowner is not responsible for the welfare of feral camels on their property unless there is a deliberate action taken to harm the animal (subject to the exceptions noted below) or to bring it under control in some way. Where a feral camel is taken into the control of a person, however temporarily, welfare legislation treats that animal in the same way as if it were owned. The full responsibility of care rests with the person in charge.

Exemptions exist in all states where harm to a feral camel is seen to be done in response to feral animal control, eradication or management of a pest, and/or in response to compliance with another act that operates within that jurisdiction. A licence/permit is required where compliance with the relevant state or territory animal welfare act or other state or territory act necessitates holding of such.

Where a practice inflicts harm on a feral camel, in some states (WA and SA) defence of the harm lies in the use of an accepted code of practice and, where the harm in carried out in a humane way, in minimising pain and alleviating suffering as quickly as possible. In other states and territories, the legislation and concurrent regulations identify specifically what sorts of actions cannot be carried out on camels as well as the instances when actions of harm are sanctioned and the conditions of those sanctions. In most cases the sanction is carried out as a result of either a veterinary professional's assessment or through appeal to provisions in another act of legislation in that jurisdiction.

3.4 What regulations govern access to land where camels exist?

The access provisions of the legislation in each jurisdiction are reasonably consistent, save for variations in drafting and terminology. There are, however, some key differences, which are outlined below.

The key differences with respect to government officials accessing land for control of feral camels are that firstly, in NSW and Qld feral camels are not a declared pest and so access cannot be achieved in that manner. Secondly, in SA access for these purposes is subject to an objection by traditional owners, and the relevant Minster has the final say after such an objection is made as to whether access will be permitted. There may also be one important exception to this situation with respect to Aboriginal land in the NT and whether it can be subject to a declaration as to the control of feral camels. There is a question mark over whether the law in the Territory Parks and Wildlife Conservation Act providing for the declaration of a feral animal control area under section 48 of that Act by the relevant NT Minister is able to operate concurrently with the NT Land Rights Act and thereby authorise entry to Aboriginal land without a permit. Carey et al. (2008) offer no concluded view about this situation. It is a question of some legal complexity.

3.5 Does animal welfare legislation apply to override requirements for gaining access in certain circumstances?

Animal welfare legislation is relatively consistent across the state and territory jurisdictions in providing a means by which inspectors and police officers may legally access land. However, the legislation clearly has not been drafted with feral animals roaming at large on property in mind.

Despite this fact powers of entry under animal welfare legislation may enable access to land to address welfare concerns for feral camels in certain circumstances.

In this respect a key impediment is likely to arise where, as in the case of SA and WA, legislation conditions an inspector's or police officer's ability to legally access land on a reasonable belief that an animal welfare offence has been committed. Unless an owner/occupier of land either takes deliberate action to harm a feral camel or bring it under their control, they cannot be said to have committed an animal welfare offence merely by failing to act to protect the welfare of feral camels roaming at large on their land. On this basis, it may be that an inspector or police officer does not have power of entry for the purpose of addressing concerns over the welfare of feral camels that are not under the landowner's control.

3.6 How does welfare legislation affect the fencing of waterholes to exclude camels, the shooting of camels, and the licensing of shooters?

Most of the legislation in this area is relatively consistent, particularly the biological control legislation. Animal welfare legislation, even though there is variable legislative recognition of the recommended codes of practice, is also underpinned by the same humanitarian principles across the country. As a result it is likely that the fencing of waterholes to exclude camels as a deliberate control mechanism, however desirable, would run foul of welfare legislation. It remains to be determined whether some waterholes could be protected because of the cultural significance to Aboriginal people.

There are, however, some important differences between jurisdictions. There are also areas of legislation that will make it difficult for control operations to move smoothly across borders. These relate to the fencing and protection of waterholes, firearm registration, cross-border camel control, and licensing of interstate shooters.

The legal capacity to protect waterholes from camels is unclear where those waterholes are of Aboriginal heritage value. While, in all jurisdictions, fencing waterholes to exclude camels that otherwise have no access to water would be contrary to animal welfare legislation regardless of whether those jurisdictions recognise the relevant code of practice, it is possible that these strictures are overridden by the requirement to protect heritage values. It is more likely, however, that both sets of laws apply, meaning alternative water sources would need to be provided.

The legislation of individual states and territories makes it difficult to move firearms across borders. While it may be possible for regulatory agencies to trace firearms on a national database, each firearm must have a place of storage in a single jurisdiction. Only in SA, and possibly in Qld and WA, is it possible to use firearms registered elsewhere. In all other jurisdictions only firearms registered in that state or territory can be used. Welfare and code of practice stipulations mean that class C or D firearms have to be used to shoot feral camels. These classes of firearms have the power to kill a camel outright, whereas it is unlikely that firearms of lower calibre would kill camels easily.

There are many small inconsistencies across jurisdictional boundaries with respect to licensing, but the most serious constraint is on visiting shooters, even if they have licences. Such shooters can usually take out temporary licences for short periods. For longer periods they need to be resident, or be intending to be resident, and would have to wait 28 days for approval after application. While cross-border controls are technically feasible for licensed shooters, there are substantial administrative handicaps. This is particularly true in the NT, where notification of cross-border movement has to be given within two days of arrival.

3.7 What regulations apply to the processing of camels?

For the most part the meat industry is well coordinated across the country, but there is one difference that could make the use of camel meat more likely than it is at the moment. Only in the NT do feral camels have to be brought to an abattoir for slaughter. Given there are now so few abattoirs in the NT, this places a substantial constraint on the use of wild camels for meat fit for human consumption. Everywhere else they can be killed and used as game meat, although, in Qld, there is no post-mortem observation or disposition written.

3.8 What regulations apply to the transport/movement of live camels?

The animal welfare legislation analysed in the context of keeping and transporting camels is fairly consistent across the jurisdictions in promoting a duty of care towards the humane treatment of camels. The only discrepancy is the obligation to refer to relevant codes of practice. However national standards for the transport of livestock are applicable across all jurisdictions and take precedence over the codes. The live export of camels is regulated by Commonwealth export legislation and national transport standards, which are consistent across the country.

The disparity of camel classification between jurisdictions (from declared species to stock) may have a significant impact on the national adoption of camels in a domestic or pastoral context. In WA, with its strict quarantine provisions, explicit legislation clarifies the responsibilities of a camel owner in terms of introducing and domesticating a declared species. In NSW the legislation regards the camel as an animal of low risk to be kept in private collections or as an exhibit and passed only between licensees. Meanwhile in the NT, Qld, and SA, which have a history of working with camels as stock, either camels are already being integrated into pastoral leases, or pastoral experience and pragmatism are guiding management principles.

In terms of transporting camels domestically by rail, road, air, or sea, there are minor differences between the types of travel documents required. Most of the jurisdictions, except SA, insist on the issue of a waybill for identification and traceback purposes and a clean bill of health for disease control. This is consistent with transportation procedures for other stock species and is not considered a hindrance to their movement.

The main obstacle to transportation of camels is the high cost. The *Model Code of Practice for the Welfare of Animals: The Camel* stipulates that due to their height, camels can be transported on single deck vehicles only. In effect this doubles the cost of transporting camels as opposed to other stock which can be loaded on double-decker vehicles, or which can fit more animals per deck.

4. Recommendations of the review

Carey et al. (2008) made the following recommendations to ameliorate identified legal impediments to the cross-jurisdictional management of feral camels:

1. Ownership
   - The clear market failure that arises from the inadequacy of current legislation with respect to ownership of feral camels be corrected, potentially by identifying explicitly that ownership is vested in the Crown.
2. Legal obligations to control
   - A consistent set of requirements be developed for all arid zone tenures that spells out the circumstances under which landholders are obliged to control camels as a duty of care to public land and where that responsibility falls to the government.
3. Legal obligations for welfare
   - Although inconsistencies exist across borders, the general provisions of welfare legislation are consistent and no recommendations were made for change.
4. Access
   - In relation to the question as to whether feral animal control areas apply in the NT to Aboriginal land under the NT Land Rights Act, that negotiations take place to settle the question and possibly include camels in the definition of wildlife so that section 73(c) of the Act can apply.
5. Welfare overriding other access restrictions
   - No recommendations for change.
6. Culling
   - Identify the circumstances under which protection of water sources by fencing would be acceptable, particularly in relation to important Aboriginal cultural sites that are being damaged by camels.
   - Engage with others to adopt national registration laws so that a firearm registered under one jurisdiction retains that registration regardless of jurisdiction.

- Reform NT Firearms Act in particular to allow easier access to professional shooters from interstate. The South Australian model seems the most practical for these purposes.
- Revise the NT Public Health (General Sanitation, Mosquito Prevention, Rat Exclusion and Prevention) Regulations to match the reality of animals dying in places where they will never be buried.

7. Processing
   - Reform the NT legislation to list camels as game meat so that they can be processed in the same way as buffalo or banteng.
8. Transport
   - Welfare standards of domesticated camels could be improved by ensuring universal mandatory adoption of relevant codes of practice, such as those found in the South Australian *Prevention of Cruelty to Animals Act* and the Commonwealth Australian *Standards and Guidelines for the Welfare of Animals – Land Transport of Livestock*.
   - Classification of domesticated camels as a stock animal in each jurisdiction could help to simplify the traffic of camels across borders.

5. Reference

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H and Williams G. 2008. *Review of legislation and regulations relating to feral camel management*, DKCRC Research Report 50. Desert Knowledge CRC, Alice Springs.

Chapter 7:

Evaluation of the impacts of feral camels

GP Edwards

B Zeng

WK Saalfeld

Contents

Contributing author information

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Keith Saalfeld: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia.

Tables

List of shortened forms

APY	A<u>n</u>angu Pitjantjatjara Yankunytjatjara
AUD	Australian dollar
BOM	Bureau of Meterology
CLC	Central Land Council
NPYWC	Ngaanyatjarra Pitjantjatjara Yankunytjatjara Women's Council
NRETAS	Natural Resources, Environment, The Arts and Sport (NT Government Department of)
NRM	Natural Resource Management
RFDS	Royal Flying Doctor Service
UKTNP	Ulu<u>r</u>u–Kata Tju<u>t</u>a National Park

Figures and graphs

Acknowledgements

This report is Chapter 7 of the final report for the project ‘Cross-jurisdictional management of feral camels to protect NRM and cultural values’. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

We thank Petronella Vaarzon-Morel, Fiona Walsh, David Alexander, David Hewitt, Andrew Drenen, Michael Balharry, Nick Swadling, Grant Williams, Peter Latz, Theresa Nano, Bob Henzell, Brian Watts, Chris Moon, Phil Gee, and Mark Williams for their advice and input with respect to various aspects of this report. We thank in particular Tracey Guest, Peter Barker, and Jayne Brim Box for their generous contributions to the case studies herein. Bo Raphael, Lyndee Matthews, James Wright, and Jenine Baker provided useful comments on drafts of this report.

Chapter 7: Evaluation of the impacts of feral camels

1. Summary

In this chapter we provide an assessment of the positive and negative impacts of feral camels. The impacts of pest animals typically fall into three main categories: economic, environmental, and social/cultural. The negative impacts of feral camels are manifested in all three areas, whereas positive impacts are largely confined to the economic arena. In this chapter we also provide an assessment of the disease risk posed by feral camels. In most instances we were able to estimate the fiscal magnitude of negative economic impacts but not of positive impacts. We were unable to estimate the monetary value of environmental or social/cultural impacts.

Negative economic impacts of feral camels mainly include direct control and management costs, impacts on livestock production through camels competing with stock for food and other resources, damage of infrastructure, and damage to people and vehicles due to collisions. The annualised monetary value of direct control and management costs (including government in-kind management costs, research costs, and landholder management costs) was estimated to be $2.36 million. The annualised monetary value of costs associated with damage to infrastructure on pastoral leases, Aboriginal settlements and conservation lands, damage to the dog fence, production losses, and road accidents was estimated to be $8.93 million. The annualised benefit that accrues to landholders mainly through the selling and eating of feral camels was estimated to be $0.62 million. This equates to an annual net economic loss of $10.67 million due to feral camels. We were unable to obtain reliable estimates of the economic value of damage to remote airstrips or of camels mustered and sold by Aboriginal people.

Negative environmental impacts of feral camels include damage to vegetation through feeding behaviour and trampling; suppression of recruitment in some plant species; damage to wetlands through fouling, trampling, and sedimentation; and competition with native animals for food and shelter.

Feral camels have significant negative impacts on the social/cultural values of Aboriginal people. Camels damage sites, such as waterholes, that have cultural significance to Aboriginal people; they destroy bush tucker resources, reduce people's enjoyment of natural areas, create dangerous driving conditions, and cause a general nuisance in residential areas.

Although we were unable to estimate the monetary value of the environmental and social/cultural impacts of feral camels, such impacts are significant. Of particular concern is damage to, or associated with, wetlands which are both biologically and culturally/socially important. Camels not only damage the ecology and hydrology of wetlands, they can remove free-standing water and even destroy the ability of some wetland types to hold water. Wetlands are refugia for many native animals during droughts, and threats to wetlands and their environmental, cultural, and production values are a serious concern.

The climate change forecast for arid Australia out to 2030 is for a temperature increase of 1–1.2^{o}C, higher frequency of hot days, a decline in rainfall of between 2–5%, higher evaporation rates, and higher frequency of droughts. Under this scenario, even if camel populations remain static, the negative impacts of camels are likely to be exacerbated. The exotic disease risk associated with feral camels is also likely to increase if camels are brought into closer contact with stock as they seek out scarcer water resources.

We established a positive density/damage relationship for camels and infrastructure on pastoral properties which is likely to hold true for environmental variables and cultural/social variables as well. Therefore, irrespective of climate change, the magnitude of the negative impacts of feral camels will undoubtedly increase if the population is allowed to continue to increase. Furthermore, the likelihood

that camels would be epidemiologically involved in the spread of exotic diseases like bluetongue and surra (were there to be outbreaks of these diseases in Australia) is also very likely to increase with population density.

The positive density/damage relationship established for camels and infrastructure on pastoral properties indicates that the degree of damage increases significantly when camel densities exceed 0.4 camels/km^2. This suggests that there are real gains to be made in maintaining camel densities on pastoral leases at <0.3 camels/km^2. Nevertheless, damage still occurs at densities <0.3 camels/km^2. It would seem that, in order to safeguard the survival of quandongs, curly pod wattles, and bean trees camel densities need to be kept at or below 0.3 camels/km^2. There is an obvious need to clarify this threshold for these and other highly palatable species. On the basis of our current understanding, we recommend that feral camels be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.

1.1 Recommendations

- That management of feral camels should focus on mitigation of negative impacts, not reduction in the number of camels per se. However, as there is a positive relationship between camel density and degree of damage, reducing camel density will often be fundamental to achieving damage mitigation.
- That on the basis of our current understanding, feral camels be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.
- That there is a need to quantify the density/damage relationship for feral camels for response variables (particularly environmental variables) for which the relationship is not known across a range of environments and with particular emphasis on identifying the threshold density below which impacts are negligible.

2. Introduction

Over the last 15 or so years, there has been a paradigm shift in the area of vertebrate pest control. The shift has been from animal control to animal damage control (Hone 2007). This shift recognises the fact that pest abundance by itself is not actually the problem; rather, it is the harmful impacts of the pest that are the problem (Hone 2007). Accordingly, the aim of vertebrate pest control should be to mitigate the damaging impacts of pests rather than controlling the pests themselves (Hone 2007, *Australian Pest Animal Strategy* 2007). Invariably there is a positive relationship between pest abundance and degree of impact, so damage mitigation involves reducing pest abundance (Hone 2007). Other factors that can affect the extent of pest damage include the availability of the resource that is being damaged (often a positive relationship), variation in landscape features that can lead to spatial heterogeneity in damage levels, and time of year (Braysher 1993, Hone 2007). Often there exists a threshold pest density below which damage is either non existent, negligible, or tolerable. The presence of a threshold means that not all pests have to be removed in order to mitigate damage (Hone 2007).

In Australia, the harmful impacts of pest animals fall into three main categories: economic, environmental, and social/cultural (Hart & Bomford 2006; *Australian Pest Animal Strategy* 2007). Pest animals such as rabbits and goats compete with livestock and wildlife for pasture and other resources, particularly during dry periods. Other pest animals including mice and some birds, such as the starling, cause extensive damage to crops. Predation by wild dogs and foxes can result in significant financial loss to producers through stock deaths and sub-lethal effects, including scarring. Predation by foxes and cats also poses a serious threat to the survival of many native animals. Pigs, goats, horses, and other pests can damage infrastructure on national parks, farms, and pastoral lands. Pest species such as the pig and water buffalo have the potential to adversely alter ecosystem function and can threaten the survival of native plants. Some feral animals such as pigs, wild dogs, and feral horses may threaten human welfare and may pose a threat to the containment and eradication of disease outbreaks. Pest animals also have a social cost, which is often overlooked. This cost can include stress due to crop loss or the death of livestock or the economic hardship which follows. Pest animals may also have significant adverse effects on the cultural values of Aboriginal people through, for example, the loss of totemic species through predation, or damage to culturally important sites such as waterholes through trampling and fouling. In 2004, the Pest Animal Control Cooperative Research Centre estimated the total impact cost of pest animals in Australia to be $720 million annually for control-related costs, production losses, and the environmental impacts of some species (McLeod 2004, see Table 7.1). This figure is considered to be at the lower end of the scale (Hart & Bomford 2006).

Table 7.1: Annual impact of pest animals

		Triple bottom line impact					
	Total	Economic		Environmental		Social	
	$m	Impact	$m	Impact	$m	Impact	$m
Fox	227.5	◆	37.5	◆	190.0	⬩	nq
Feral cat	146.0	⬩	2.0	◆	144.0	⬩	nq
Rabbit	113.1	◆	113.1	⬩	nq	⬩	nq
Feral pig	106.5	◆	106.5	⬩	nq	⬩	nq
Dog	66.3	◆	66.3	⬩	nq	⬩	nq
Mouse	35.6	◆	35.6	⬩	nq	◆	nq
Carp	15.8	⬩	4.0	◆	11.8	⬩	nq
Feral goat	7.7	⬩	7.7	⬩	nq	⬩	nq
Cane toad	0.5	⬩	0.5	⬩	nq	⬩	nq
Wild horse	0.5	⬩	0.5	⬩	nq	⬩	nq
Camel	0.2	⬩	0.2	⬩	nq	⬩	nq
Total	719.7		373.9		354.8		nq

nq = not quantified ◆ = bigger impact ⬩ = smaller impact

Source: Extracted from McLeod 2004

The negative impacts of feral camels are perceived to cut across all three of the damage categories expressed above (i.e. economic, environmental, and social/cultural: Edwards et al. 2004). Although the negative impacts of feral camels were considered by McLeod (2004), the estimated total cost of the damage ($200 000 per annum for economic impact alone) is considered a rubbery figure because there is a paucity of robust data on camel impacts. Braysher (1993) outlined a three-step process in determining whether or not a pest animal is causing a problem and, where a problem exists, the nature, severity, and extent of the problem:

1. define the perceived problem in terms that measure damage
2. assess available information and/or collect the data needed to evaluate the perceived problem
3. identify the scope of the perceived problem.

This process places the problem in its social/cultural and biophysical context (Braysher 1993). The damage caused by a pest animal can be evaluated by observational studies or through experimentation (Hone 2007). Experimental approaches involve manipulating pest abundance in order to define density/damage relationships and identify thresholds. Also, because pest animal damage can often be described by relationships between variables, modelling can be used to understand the dynamics of the system under investigation, identify thresholds, and predict the effects of management actions (Hone 2007). In reality, it is very difficult to quantify all aspects of a pest animal's impact.

The economic damage caused by pest animals (e.g. crop loss, aircraft bird strikes) can usually be estimated quite easily in monetary terms, which allows for simple economic analyses (Hone 2007). In contrast, damage to environmental and social/cultural values can rarely, if ever, be evaluated in monetary terms. For these values, the measurement of indicator variables to gauge the quality of the resource (e.g. water quality, degree of trampling) or specific value judgements (e.g. prevention of a species' local or global extinction, time spent on country by Aboriginal people) with no specific economic basis are often used. However, in some instances, impact on environmental and/or cultural/social values may not be readily quantified (Braysher 1993).

In this chapter we follow the three step process of Braysher (1993) in order to refine our understanding of the damaging (negative) impacts of feral camels. We also note the realised and potential benefits (positive impacts) of feral camels.

3. Methods

A range of different non-experimental techniques was used to assess the positive and negative impacts of feral camels. We attempted to define perceived problems and benefits in ways that could be measured and then assessed the available information and/or collected new data to evaluate the perceived problem. In certain situations we scaled up damage information from particular sites to assess the overall scope of the problem.

3.1 Economic impacts

We collected information on the economic impacts of feral camels through:

1. standardised interviews with pastoral, conservation, and Aboriginal landholders conducted in person, by telephone, or by mail (see Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a for details)
2. statistical information held by government agencies
3. formal interviews with key contacts and informants
4. published literature and reports.

In most instances we were able to estimate the fiscal magnitude of negative economic impacts but not of all positive impacts. We conducted a simple cost-benefit analysis on the available economic data relating to impacts.

3.2 Environmental impacts

We collected information on the environmental impacts of feral camels through:

1. standardised interviews with pastoral, conservation, and Aboriginal landholders conducted in person, by telephone, or by mail (see Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a for details)
2. published literature and reports
3. formal interviews with scientific experts and key contacts and informants
4. observational case study research.

We were unable to estimate the monetary value of environmental impacts.

3.3 Social/cultural impacts

We collected information on the social/cultural impacts/benefits of feral camels through:

1. standardised interviews with pastoral, conservation, and Aboriginal landholders conducted in person, by telephone, or by mail (see Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a for details)
2. published literature and reports
3. formal interviews with scientific experts and key contacts and informants
4. observational case study research.

We were unable to estimate the monetary value of social/cultural impacts.

3.4 Disease risk

We collected information on the disease risk posed by feral camels through:

1. published literature and reports
2. formal interviews with scientific experts and key informants.

We were unable to estimate the monetary value of the disease risk posed by feral camels.

3.5 Scope of the problem

Different techniques were applied in order to generalise information collected at specific sites to the whole of the camel range to get an overall estimate of the scope of economic impacts. The approaches used in particular situations are detailed in the relevant sections below.

4. Economic impacts

Negative economic impacts of feral camels mainly include direct control and management costs, impacts on livestock production due to camels competing with stock for food and other resources, damage to infrastructure and property, and damage to people and vehicles due to collisions.

4.1 Direct control and management costs

Direct control and management refers to the activities and actions directed at mitigating the negative impacts of feral camels including camel control-related research, planning and extension activities, and on-ground control actions.

From 1998 to 2008, on the basis of statistical information held by government agencies and reports, the total operational investment in direct control and management by government agencies and research organisations was $4.37 million (Figure 7.1). Note that the numbers in Figure 7.1 do not include the resources invested in camel management by pastoral or conservation land managers or the in-kind contribution of government agencies, research organisations, camel-related industries, or individuals. Since 2004/05, the annual amount of money invested in camel management by government agencies and research organisations has approximately doubled. This is probably a response to the increasing numbers of feral camels (Saalfeld & Edwards 2008) and increasing impacts (this chapter).

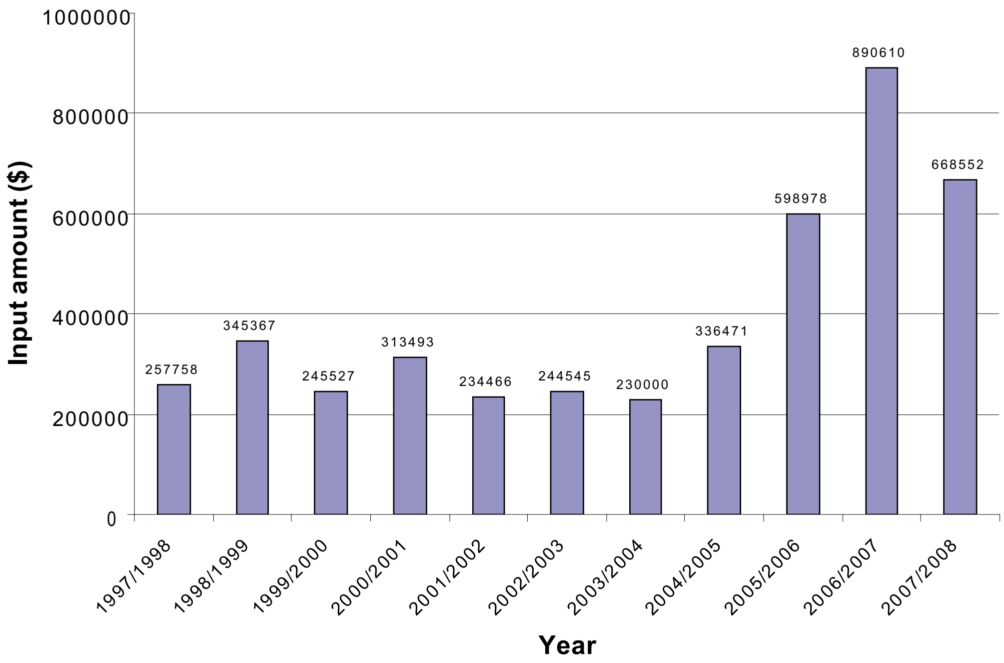


Figure 7.1: Operational input to camel management by government and research organisations over the period 1997–2008, exclusive of in-kind support

The Northern Territory (NT) government currently contributes about $0.1 million annually in in-kind support to the management of feral camels through support of research and operational personnel (e.g. qualified aerial shooters) involved in 'on-ground' management (Glenn Edwards 2008, NRETAS, pers. comm.). Assuming that the other two states with large camel populations (Western Australia and South Australia) contribute the same amount of in-kind support, the total amount of in-kind is $0.3 million annually.

A two-year (July 2005 – June 2007) breakdown by activity of the annual amount of money invested by both government (and research organisations) and pastoral and conservation landholders in the management of feral camels over the period captured by the pastoralist and conservation manager surveys (Zeng & Edwards 2008a, 2008b) indicates that pastoralists contributed about 59% and conservation managers 5% of the total amount invested (Table 7.2).

Table 7.2: Annual amount of money invested by both government (and research organisations) and pastoral and conservation landholders (excluding in kind contributions) in the management of feral camels averaged over the period captured by the pastoralist and conservation manager survey, July 2005 – June 2007

	Survey/ monitoring ($)	Research: camel management ($)	Research: industry ($)	Inputs for commercial use ($)	Culling ($)	Other actions ($)	Total ($)	%
Pastoralists (calculated from survey data reported in Zeng & Edwards 2008a Tables 3.11, 3.16)	0	0	0	288 956	525 735	400 142	1 214 833	59.1
Conservation land managers (calculated from survey data reported in Zeng & Edwards 2008b Tables 4.9, 4.14)	-	-	-	-	-	-	96 729	4.7
Government, research organisations	127 500	319 975	84 350	101 818	69 651	41 500	744 794	36.2
Total	127 500	319 975	84 350	390 774	595 386	441 642	2 056 356	100

4.2 Damage to infrastructure, property, and people

In rural areas of arid and semi-arid Australia, damage to property and infrastructure by camels falls into three main categories: pastoral lands suffer major damage to fences, yards, and water troughs; government agencies and remote settlements suffer major damage to buildings, fixtures, fences, and bores; individuals suffer injury (including death), damage, and financial loss through vehicular collisions involving feral camels.

4.2.1 Pastoral properties

There are 1189 pastoral properties within or on the margins of the range of feral camels, covering an area of 2.22 million km^2 (Zeng & Edwards 2008a). Two hundred and nine of these pastoral stations (i.e. 17.6%) were surveyed through the interview process described above. These stations covered an area of 706 489 km^2 (i.e. about 32% of the total pastoral area of interest). Results of the survey are given in detail in Zeng & Edwards (2008a).

Overall, 74.2% (155/209) of land managers reported that camels had been found on their properties and 70.3% (109/155) of landholders claimed that camels caused some damage on their properties over the past two years. On the basis of the per square kilometre estimate of damage for surveyed properties, the value of infrastructure damage was estimated to be $2.40 million annually across all pastoral properties within or on the margins of the camel range (i.e. damage to fences, yards, and water equipment) (Zeng & Edwards 2008a). Figure 7.2 shows some of the damage inflicted by camels on infrastructure on pastoral properties.

(a) (b)

Figure 7.2: (a) Self mustering gates on Andado station (NT) that have been damaged by camels; (b) Fence line on boundary between Tempe Downs station and Watarrka National Park (NT) damaged by camels in November 2008

Note: 7.2a image courtesy of J Bloomfield; 7.2b image courtesy of K Schwartzkopff

4.2.2 Remote settlements

There are 89 major Aboriginal settlements (population >100 people) within the range of feral camels (see Vaarzon-Morel 2008a, 2008b). In recent years, there have been periodic reports of large numbers of feral camels entering some Aboriginal settlements in some regions in search of water. In the survey conducted with Aboriginal landholders, inhabitants in 19 of the 27 settlements surveyed indicated that camels caused damage to infrastructure in their communities or on outstations near the communities (Vaarzon-Morel 2008a, 2008b). Camels were reported to have damaged buildings, fences, and water-related infrastructure including taps, windmills, and evaporative air conditioners. Figure 7.3 shows some of the damage inflicted by camels on infrastructure in Aboriginal settlements. The monetary cost of this damage was not estimated in the survey.

(a)

(b)

Figure 7.3: (a) Toilet on an Aboriginal settlement near Warburton in the Ngaanyatjarra lands (WA) that has been damaged by camels (image courtesy P. Morrison); (b) Windmill at Blackstone in the Ngaanyatjarra lands (WA) that has been damaged by camels.

The most widespread and serious incursion of camels onto Aboriginal settlements occurred over the summer of 2006/07. At this time there was an influx of many, perhaps tens of thousands, of apparently starving and thirsty camels onto pastoral leases to the south of Alice Springs and onto Aboriginal settlements in the A<u>n</u>angu Pitjantjatjara Yankunytjatjara (APY) lands in SA, the Ngaanyatjarra lands in WA and in the Petermann Ranges in the NT (see Figure 7.4). An account of this incident is given in Case Study 8.1 below.

In January 2008, feral camels entered Tjukurla community in the Ngaanyatjarra lands (WA) where they caused damage estimated at more than $5000. David Hewitt (2008, Relief Manager, Punmu Community, Ngaanyatjarra lands WA, pers. comm.) gave the following description of the damage:

> Camels knocked down a gate to the school principal's house (he was on holidays). Next morning there were six in the yard. They had broken off a tap, spent the night wallowing in mud caused by the flowing water, and left an awful mess on the concrete verandah.
>
> One weekend they removed a hand basin from the verandah of a vacant community house and broke the tap. As most people were away for the weekend the water ran for a couple of days. There was an awful mess by the time someone finally reported it and the main community water tank almost ran dry.
>
> Camels camped for a couple of weeks on the verandah of another vacant community house leaving droppings completely covering the verandah. The Aboriginal people tried to drive the camels out by pushing them with the bullbar of a vehicle. They injured one camel that subsequently died.
>
> A fellow watching TV one afternoon heard a noise out the back of his house. There was a camel in his laundry trying to get a drink.
>
> It was very hot in January and the camels were desperate for water. One of the leading men in the community suggested that we re-activate a hose that was running into a hole in the ground just beyond the main tank to give the camels water and keep them out of the community. Only problem there was that we only had one bore pumping and with the hot weather we had no water to spare.

There has also been recent camel damage to infrastructure at Kalka in the APY lands and at Warakurna in the Ngaanyatjarra lands. At Kalka in 2008, a mob of over 100 camels broke down the fence to a children's playground to reach a tap that was leaking, totally destroying the playground equipment that had cost the community $30 000 to install (David Hewitt 2008, Relief Manager, Punmu Community, Ngaanyatjarra lands WA, pers. comm.). At Warakurna in the summer of 2006/07, the estimated economic loss caused by camels was in the order of $100 000 due to damage to fences, air conditioners, houses, water tanks, wind mills, and cleanup activities (Chris Moon 2007, former Community Development Advisor, Warakurna, pers. comm.) (see Case Study 1).

On the basis that (a) inhabitants in 12 of the 23 major communities (population > 100) surveyed indicated that camels caused damage to infrastructure (excluding fences) in their communities or on outstations near the communities (Vaarzon-Morel 2008a, 2008b), and (b) there are 89 major Aboriginal settlements (population > 100) within the range of feral camels, and assuming that (c) the mean damage figures for Kalka, Tjukurla, and Warakurna ($135 000/3 = $45 000) are indicative of annual damage figures for other remote settlements that experience camel damage, the total annual monetary value of camel damage to infrastructure on remote settlements is 12/23*89*$45 000 = $2.09 million. Although this figure may appear high, it probably accurately reflects the true cost of repairing infrastructure damage in remote settlements. It is also worth noting that, our scaling up process was conservative as we did not include the four surveyed Aboriginal communities that reported infrastructure damage only to fencing. Finally, it is worth making the point that the damage estimate used for the scaling up procedure is based on data for only three communities and may not be a representative sample.

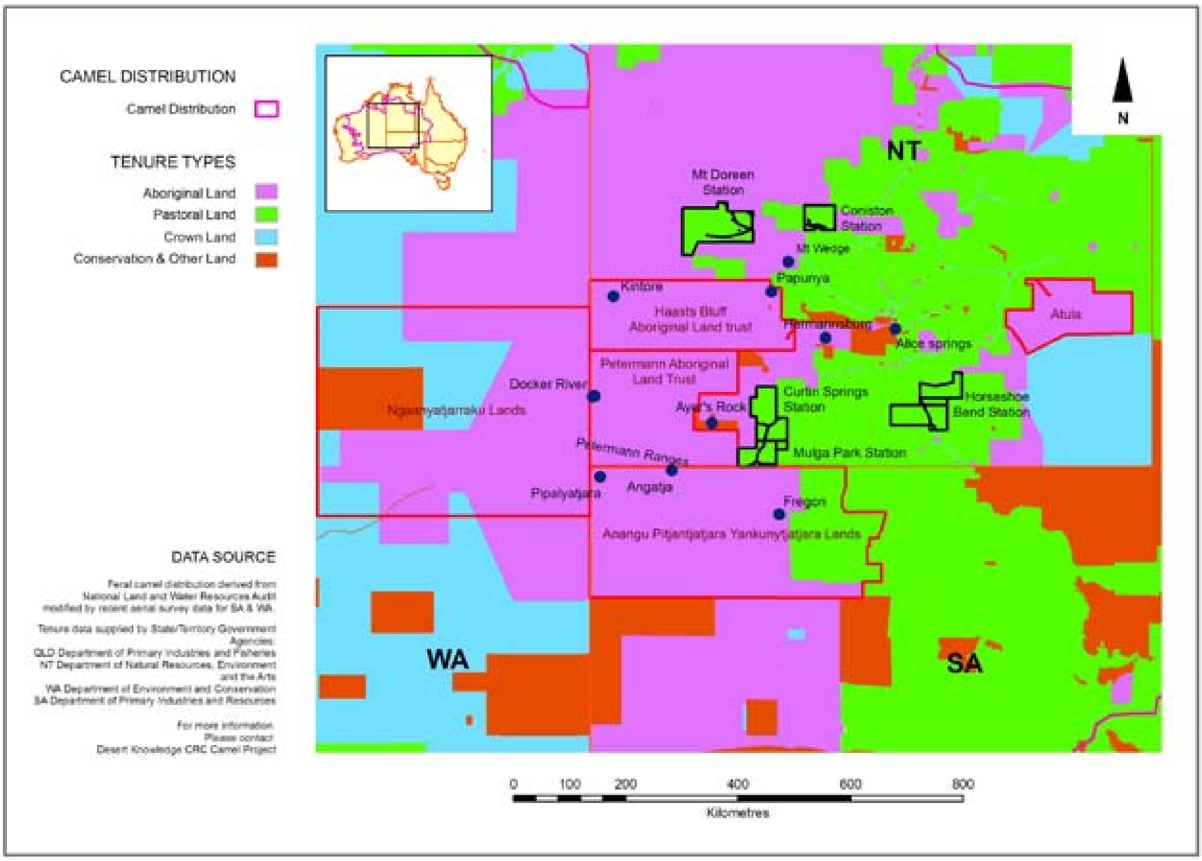


Figure 7.4: Map of arid Australia showing the location of some key places mentioned in the text

4.2.3 Conservation reserves

Thirteen conservation managers (including both site managers and regional managers who manage a group of reserves/parks) were surveyed through the interview process described above. The managers represented 70 nature reserves, conservation parks, timber reserves, forest reserves, and national parks within or on the margins of the camel distribution. These parks/reserves covered 250 629 km^2, which is about 40% of the entire area of conservation lands in or on the margins of the camel range (approximately 630 811 km^2). Results of the survey are given in detail in Zeng & Edwards (2008b).

Feral camels were reported as present on about 51 % of reserves. Camels were reported to cause problems on 94.4% (34/36) of the reserves on which they were reported present. Damage to water sources was reported in 64.7% (22/34) of cases, damage to fencing in 29.4% (10/34) of cases, and other damage in 9% of cases. On the basis of the per square kilometre estimate of damage for surveyed reserves, the value of infrastructure damage was estimated to be $0.08 million annually across all conservation lands within or on the margins of the camel range (i.e. damage to fences, yards, and water equipment) (see Zeng & Edwards 2008b).

4.2.4 Dog Fence

The 'dog fence' was built to protect the sheep industry from wild dog damage. The fence is 5614 kilometres long, extending from Jimbour in Queensland (Qld) to the Great Australian Bight (see Saalfeld & Edwards 2008). Increasingly, feral camels are damaging the dog fence, particularly along the southern sections. It is estimated that feral camels cause at least $43 361 damage to the fence each year in SA alone (Michael Balharry, Executive Officer, Dog Fence Board, SA).

4.2.5 Airstrips

There are about 1100 airstrips (airports, heliport, and landing grounds) in or on the margins of the camel range. About one-third of these airstrips are located in areas where there are medium to high camel densities. These airstrips are used by local communities for transportation, by the Royal Flying Doctor Services (RFDS) for heath services/emergency rescue, as well as for some special purposes such as tourism and expeditions. Increasingly, feral camels pose a threat to aviation safety by damaging the airstrips or by their presence on the airstrips.

David Hewitt (Relief manager, Punmu Community, Ngaanyatjarra lands WA), provided the following comments on the issue in the Nyanngtjiarra lands (WA):

> The airstrip at Amata was recently fenced at a great cost to keep camels away and already they are trying to push it over. In another community to the west of here where my wife was relieving last year, the mail plane has threatened to cease calling unless the camels are controlled. (David Hewitt 2003, pers. comm.).
>
> (Hereafter, David Hewitt 2008. pers. comm.):
> It is only a matter of time before there is a serious collision between a camel and an aircraft.
>
> At Tjirrkarli two years ago we had to hunt camels off the airstrip before the mail plane could land.
>
> While I was working at Blackstone last year they trampled over the airstrip lights damaging about six of them.
>
> At Warakurna the police were called in to shoot several camels that would not leave the strip.
>
> At Pipalyatjara fencing of the strip was started but the community ran out of money when it was about half finished. The money spent on fencing could be better spent on a more lasting control of camels, such as shooting them.

> At Punmu we have a mail plane twice a week and I have to go out half an hour before the plane is due to check for camels on the airstrip. An attempt had been made to fence the strip but camels knocked the fence down, maybe last year. I have seen fresh tracks and droppings out there; the airstrip is five kilometres from the community. There could be a terrible accident between a camel and a light aircraft and I will be proposing an urgent cull of camels around the strip but it is hard to determine who is responsible there.

Camels have also caused problems on airstrips at Kiwirrkura in the Ngaanyatjarra lands (WA) and Mt Liebig in the NT (Vaarzon-Morel 2008b).

4.2.6 Road crashes

As the feral camel population increases, so does the number of vehicular collisions involving camels. Such collisions impose a high cost on regional economies, including labour loss (workplace, household, and community), repair and replacement costs for vehicles, loss of quality of life, insurance administration, legal fees, long-term care, travel delays, medical fees, and workplace disruption (BTE 2000).

The NT is the only jurisdiction that officially records information on whether road accidents are linked to camels. Information provided by the Department of Planning and Infrastructure of the NT shows that from 2003 to 2006 there were 26 accidents involving hitting horses or camels, injuring nine people (Table 7.3). Assuming that the proportion of camel-related crashes is one-third of these numbers (Grant Williams 2007, Road Safety NT, pers. comm.), it is estimated that there were 2.17 camel-related crashes annually over the period, injuring 0.75 people. In June 2008 two people were killed when their vehicle hit a camel while travelling between Yuendumu and Lajamanu, north-west of Alice Springs.

Table 7.3: Horse/camel-related road accidents in the NT, 2003–2006

Year	Total no. of accidents	Total no. of injuries	Total no. of fatalities	Crash no. related to horses/camels	No. of injuries in horse/camel related crashes	No. of fatalities in horse/camel related crashes
2003	2401	1114	53	8	4	0
2004	2142	1054	35	5	2	0
2005	2151	1009	55	6	2	0
2006	2049	911	44	7	1	0

In 2006, a herd of inquisitive camels delayed freight services into the NT by 24 hours after getting in the way of a 2.3 km-long freight train. The train hit four camels out of a herd of 10, just short of the NT border at Wirrida, SA. The collision damaged the train's air brakes system and crews had to repair the train before it could continue (*NT News* 2006). There was no report of the estimated cost of this incident.

There were at least seven collisions between vehicles and camels on the Ngaanyatjarra Lands in WA (Table 7.4) between 2003 and mid-2008, or about 1.4 annually.

Table 7.4: Vehicle collisions involving camels over the period 2003–2007, Ngaanyatjarra Lands WA

Approx. date	Details
2003	An environmental health officer in this region (Warburton area) did over $1000 damage to his vehicle in a collision with a camel recently and an Aboriginal person suffered serious injuries following a collision with a camel last year. Another issue we noticed last week is that the camels are having their dust baths on the roads. An otherwise smooth surface can suddenly be heaps of soft sand – a major hazard for vehicles.
Late 2003	Anthropology consultant hit two camels, 10 km west of Warburton. Both camels dead, vehicle presumably written off.
2004 or 2005	Two camels were hit and killed near Warakurna. Vehicle presumably written off.
2004 or 2005	Wife of Community Development Advisor at Tjirrkarli sideswiped a camel.
2004	The school vehicle (a troop carrier) rolled and one teacher was off work for a year.
2006	Two Ngaanyatjarra Health staff hit a camel and rolled vehicle on the back road to Patjarr. One person was off work for months.

Note: Information provided in 2007 by Andrew Drenen (Central Land Council, formerly land management officer with Ngaanyatjarra Land Council) and David Hewitt (Relief Manager, Punmu Community, Ngaanyatjarra lands WA).

In other states, there is no specific statistical information about camel-related crashes, but animal-related collisions are recorded. According to information from NRMA Insurance (NRMA 2005), there were more than 17 700 vehicle collision claims nationally for animal-related accidents in 2003. Camels were included in the ‘Others’ category for which there were 81 listings in SA, 116 in WA, and 6 in the NT (Table 7.5). The NT ‘Other’ figure of 6 is 2.77 times higher than the estimated annual camel-related accident figure of 2.17 calculated above. This provides a basis for estimating the number of camel-related accidents for SA and WA (i.e. WA, 116/2.77 = 41.9; SA, 81/2.77 = 29.3). However, because the NT data on which this calculation is based are a small sample, and camel density and the number of settlements varies within each jurisdiction, these estimates may be highly inaccurate. On the basis that there are have been 1.4 accidents involving camels per year from 2003–2007 in the Ngaanyatjarra Lands, which comprise about 10% of the area occupied by camels in WA, the WA figure may be closer to 14 accidents per year involving camels. Thus, a rough estimate of the number of vehicle collisions involving camels in Australia each year is 27.7 (10.5 in SA, 14 in WA, 2.2 in the NT).

The average cost of a road crash in SA is $29 303 (in 2004 AUD) (Baldock & McLean 2005). Using this figure, the speculative minimum monetary cost of camel-related road crashes in WA, SA, and NT is currently about $900 000 (in 2008 AUD) annually, assuming an annual inflation rate of 2.5%.

Table 7.5: Number of animal-related collision claims for SA, WA, and the NT

	Kangaroo	Dog/Cat	Cow/Horse	Wombat	Fox	Sheep	Other	All Animals
SA	805	169	41	5	17	24	81	1142
WA	1414	195	51	0	6	16	116	1798
NT	84	16	9	0	1	0	6	116

Source: NRMA Insurance collision claims research 2004

4.3 Lost pastoral production

About 32% of pastoralists surveyed through the interview process described above indicated that camels had a negative impact on pastoral production through competition with cattle for food and water, disturbing cattle, and cattle escaping through fences damaged by camels. The value of production loss was estimated to be $3.42 million annually across all pastoral properties within or on the margins of the camel range (see Zeng & Edwards 2008a).

4.4 Indirect economic impacts

Camels produce the greenhouse gas methane as a by-product of enteric fermentation. The value of these methane emissions in the context of emissions trading is considered as part of this research project in Drucker (2008) and in Edwards, McGregor et al. (2008).

5. Environmental impacts

Negative environmental impacts of feral camels include damage to vegetation through feeding behaviour and trampling; suppression of recruitment in some plant species; damage to wetlands through fouling, trampling, and sedimentation; and competition with native animals for food and shelter.

5.1 Damage to vegetation

The diet of feral camels is discussed in Saalfeld & Edwards (2008). Camels have a broad diet, and although they are considered to be browsers, they have been observed to feed on most of the available plant species in areas where the diet has been examined, including pasture species (Dörges & Heucke 2003, Peeters et al. 2005). Camels are generally very flexible with food selection, particularly in drought times, but show distinctive preferences for certain plant species. During dry times camels mainly consume leaves from trees, while in wet periods they favour ground vegetation (Dörges & Heucke 2003). Camels damage trees and shrubs when browsing and can severely defoliate preferred trees, shrubs, and vines (Dörges & Heucke 2003; Copley et al. 2003; Vaarzon-Morel 2008b). They also inhibit recruitment of their preferred food species by suppressing flowering and fruit production and by browsing and killing juvenile plants (Dörges & Heucke 2003). It is considered that camels have the ability to cause the local extinction of highly preferred species like the quandong (*Santalum acuminatum*), plumbush (*S. lanceolatum*), curly pod wattle (*Acacia sessiliceps*), native apricot (*Pittosporum augustifolium*), bean tree (*Erythrina vespertilio*), and *Lawrencia* species (Dörges & Heucke 2003). In 2008, Peter Latz (Ecological consultant, Alice Springs, pers. comm.) noted that both quandong and native apricot had declined dramatically in the Petermann Ranges south-west of Alice Springs (see Figure 7.4) compared with the situation in the 1970s (see also Vintner & Collins 2008). Latz attributed this decline to a combination of inappropriate fire regime and camel browsing. Latz also noted severe damage to desert poplar (*Codonocarpus cotinifolius*) by camels (see also Vintner & Collins 2008). A list of the plant species on which camels are believed to have an impact is in Table 7.6.

In central Australia, serious and widespread negative impacts on vegetation have been recorded where camels occur at densities of >2 animals/km^2, though damage to highly palatable species occurs at much lower densities (Dörges & Heucke 2003). In more arid country near Lake Eyre, significant negative impacts on vegetation have been recorded where camels occur at densities of >1 animals/km^2 (Phil Gee 2008, Rural Solutions, pers. comm.). Camels already occur at localised densities >2 animals/km^2 over much of their current range (Saalfeld & Edwards 2008). Figure 7.5 shows some of the impacts of feral camels on vegetation.

Table 7.6: Plant species of central Australia considered vulnerable to local extinction or severe impact as a result of camel browsing

Species name	Common name	Conservation status [a]	Palatability to camels [b]	Vulnerability to local extinction/ severe depletion from camel browsing [c]
Santalum acuminatum	Quandong	Vulnerable	Extremely high	Extremely high
Acacia oswaldii	Umbrella wattle	Data deficient	?	Extremely high
Marsdenia australis	Bush banana	-	Very high	Extremely high
Marsdenia viridiflora	Bush banana	-	?	Extremely high
Erythrina vespertilio	Bean tree	-	Extremely high	Extremely high
Santalum lanceolatum	Plumbush	-	Very high	High to Extremely high
Acacia sessiliceps	Curly-pod wattle	-	Extremely high	High
Pittosporum angustifolium	Native apricot	-	Very high	High
Codonocarpus cotinifolius	Desert poplar	-	Very high	High
Brachychiton gregorii	Desert kurrajong	-	High	High
Rhyncharrhena linearis	Mulga bean	-	?	High
Canthium latifolium	Native currant	-	High	High
Eremophila longifolia	Emu bush	-	Very high	High
Ventilago viminalis	Supplejack	-	Very high	High
Salsola tragus	Buckbush	-	Very high	High
Crotalaria cunninghamii	Bird flower	-	Very high	High
Vigna lanceolata	Pencil yam	-	?	Moderate
Atalaya hemiglauca	Whitewood	-	Very high	Moderate
Tecticornia verrucosa	Mungilpa	-	High	Low to Moderate
Ipomoea costata	Bush potato	-	Very high	Low to Moderate
Acacia victoriae	Acacia bush	-	Very high	Low
Acacia aneura	Mulga	-	High	Low
Solanum spp.	Bush potato	-	Moderate	Low

[a] *Territory Parks and Wildlife Conservation Act* and Albrecht et al. (2007)

[b] following Dörges & Heucke (2003)

[c] Based on Dörges & Heucke (2003) and information provided by Peter Latz, Theresa Nano, and Fiona Walsh in 2007 and 2008

Note: Species are listed by decreasing vulnerability to camel browsing

(a)

(b)

(c)

Figure 7.5: (a) Desert poplar on Curtin Springs station (NT) that has been damaged by camels; (b) quandong tree in Great Victoria Desert (WA) that has been damaged by camels; (c) Mulga trees on Curtin Springs station (NT) that have been damaged by camels

Note: 7.5a image courtesy of P. Latz; 7.5b image courtesy of D. Ferguson; 7.5c image courtesy of L. Matthews, Curtin Springs station.

5.2 Damage to wetlands

There are many different types of arid wetlands: salt lakes; saline swamps; saline channels; freshwater claypans; open freshwater lakes; wooded swamps; shrubby swamps; herbaceous swamps; permanent and long-lasting waterholes and rockholes; springs; ephemeral rivers and waterholes on large ephemeral rivers (see Duguid et al. 2005 for definitions). Although wetlands form a relatively small proportion of the arid landscape they are of high biological importance (Duguid et al. 2005). Wetlands support a diverse and distinctive range of plants and animals, are important for a range of migratory birds, serve as refugia and as source populations for aquatic animals and plants, and serve as refugia for many terrestrial animal species during drought (Duguid et al. 2005; Box et al. 2008). The larger wetlands and wetland aggregations that occur within the current range of the feral camel are shown in Appendix 11.12 in Saalfeld et al. (2008). The need for water coupled with the need to consume salt (Wilson 1984), which occurs naturally in vegetation fringing saline wetlands, means that camels frequent wetland habitats across arid Australia (Dörges & Heucke 2003). In these areas, the negative impacts of feral camels can be significant. Camels can drink all of the water in small waterholes, rockholes, or soaks leaving little or no water for native wildlife or people (Copley et al. 2003; Vaarzon-Morel 2008b; Fiona Walsh 2008, CSIRO, pers. comm.). Camels also fall into rockholes and get bogged in soaks where they subsequently die causing pollution, eutrophication, and infill/siltation (Copley et al. 2003; Vaarzon-Morel 2008b). Figure 7.6 shows some of the impacts of feral camels on wetlands. In the survey conducted with Aboriginal landholders, inhabitants in 23 of the 27 settlements surveyed raised concerns over the impacts of camels on wetlands (Vaarzon-Morel 2008a, 2008b). Case studies 8.2 and 8.3 below provide an account of the impacts of camels on selected wetlands in central Australia. Saalfeld and Zeng (2008) provide an account of some of the activities being undertaken on Aboriginal lands and on pastoral leases in respect of protecting wetlands from the impacts of feral camels.

Figure 7.6: Camels around a dry waterhole near Docker River (NT) in February 2007

Note the dead and dying camels in the waterhole (Image courtesy of R. Bugg)

5.3 Other sites of biological significance

In addition to wetlands, there are numerous other sites of biological significance within the range of the feral camel. These include sites with threatened fauna and sites of botanical significance (see Saalfeld et al. 2008). The extent of the impacts of feral camels on these sites is unquantified.

6. Social/cultural impacts

Feral camels have significant negative impacts on the social/cultural values of Aboriginal people. Camels damage sites, such as waterholes, that have cultural significance to Aboriginal people; they destroy bush tucker resources; reduce people's enjoyment of natural areas; create dangerous driving conditions; and cause a general nuisance in residential areas. Negative impacts in remote settlements and driving conditions are described in sections 4.2.2, 4.2.5, and 4.2.6 above.

6.1 Damage to Aboriginal culturally significant sites

Aboriginal culturally significant sites include sacred sites, burial sites, ceremonial grounds, water places, places of birth, places (including trees) where spirits of deceased people are said to dwell, and resource points (areas with concentrations of food or areas where ochres, flints, particular food types, or other important resources can be obtained) (Petronella Vaarzon-Morel 2008, Consulting anthropologist, pers. comm.). In particular, water places (waterholes, rockholes, soaks, springs, etc.) are special places for desert Aboriginal people and many, but not all, are sacred sites (Yu 2002). The reason for this is obvious. As stated above, wetlands are drought refugia for many types of terrestrial wildlife. Prehistorically, wetlands were also drought refugia for Aboriginal people, providing not only water but also good hunting, even in dry times. Nowadays, wetlands still provide reliable drinking water for Aboriginal people when they are out on country and are used for recreational and ceremonial purposes. Thus, the negative impacts of camels on wetland areas (which are described above and in the case studies below) also have a very important social/cultural dimension. It is worth restating that, in the survey conducted with Aboriginal landholders, inhabitants in 23 of the 27 settlements surveyed raised concerns over the impacts of camels on wetlands (Vaarzon-Morel 2008a, 2008b). It is also worth noting that inhabitants in 19 of the 27 settlements that were surveyed indicated that camels caused damage to culturally significant sites other than water-related sites (Vaarzon-Morel 2008b). The negative impacts of camels on sites that are culturally important because of plant/food resources are described in the next section.

6.2 Damage to plant species of cultural/economic value to Aboriginal people

Many plant species are of cultural and/or economic value to desert Aboriginal people. At least 35 of the plant species that occur in central Australia and are known to have a contemporary resource value to Aboriginal people are either highly palatable or preferred camel food species and, as such, are vulnerable to damage and decline by camel browsing (Table 7.7). These plants are used by Aboriginal people for a range of purposes including medicinal, ceremonial, artefact production, or as a food resource (Latz 1995). Many species are of great significance due to their dreaming associations, though it is not within the scope of this research to consider the impact of camels on this aspect in any exhaustive manner. In the survey conducted with Aboriginal landholders, inhabitants in 20 of the 27 settlements surveyed indicated that camels caused damage to plants of cultural or economic value (Vaarzon-Morel 2008b).

A small-scale commercial industry in bushfood production based on wild-harvest by Aboriginal people has been in operation in central Australia for several decades. Between 2000 and 2005, about 30 species were traded for food and/or landscape rehabilitation (Walsh & Douglas in review). Harvesters sold an average of 7.5 tonnes of seed and fruit products each year from 2000–2004 with a wholesale value of about $90 000 per annum. The main species traded were bush tomato (*Solanum centrale* fruit), mulga (*Acacia aneura* seed) and dogwood (*Acacia coriacea* ssp. *sericophylla* seed) (Walsh and Douglas in review). In terms of the regional economy of central Australia, the wild-harvest bush foods industry is small and the economic impact of camels on the industry relatively minor. The three main commercial species are considered relatively common and at low risk of local extinction or damage as a result of camel browsing (Table 7.7). Nevertheless, camels do affect the efficiency of seed collection by damaging seed or fruit-bearing trees and because people collecting seed avoid areas with camels due to concerns over their personal safety (Vaarzon-Morel 2008b; Walsh in prep.). For example, quandong (*Santalum acuminatum*), a species that has high customary value and potentially has high commercial value, is now listed as vulnerable in the Northern Territory due to camel damage (Woinarski et al. 2007).

It is important to realise that the collection of bush foods, whether for commercial sale or personal use, is extremely important to Aboriginal people in the cultural/social sense (Fiona Walsh 2008, CSIRO, pers. comm.). There are multiple cultural values inherent in bush foods and bush food collection activities. Bush food collecting trips provide an opportunity to engage in other cultural activities such as burning and the maintenance of culturally important sites. They also provide for the transfer of knowledge and skills from older to younger people and for social communication between individual harvesters (NPYWC 2003). Just as importantly, collecting bush foods (and associated activities) provides enjoyment and an opportunity to escape the many pressures associated with living on remote settlements (Walsh & Douglas in review). Currently, the impact of camels on bush foods is much more important from a cultural/social perspective than an economic one. However, camels do reduce economic opportunities for the development of bush produce enterprises (Fiona Walsh 2008, CSIRO, pers. comm.).

Table 7.7: Plants of cultural significance and their vulnerability to local extinction or decline as a result of camel browsing.

Species name	Common name	Significance as contemporary resource or cultural value[a]	Contemporary resource value	Palatability to camels[b]	Vulnerability to local extinction/ severe depletion from camel browsing[c]
Santalum acuminatum	Quandong	High	artefact, fruit	Extremely high	Extremely high
Erythrina vespertilio	Bean tree	High[d]	artefacts, edible tuber, commercial artefacts and beads (seed, wood)	Extremely high	Extremely high
Marsdenia australis & M. viridiflora	Bush banana	High	fruit	Very high	Extremely high
Santalum lanceolatum	Bush plum	Moderate to High	fruit	Very high	High to Extremely high
Pittosporum augustifolium	Native apricot	Low		Very high	High
*Eremophila longifolia**	Emu bush	Moderate	ceremony	Very high	High
Ventilago viminalis	Supplejack	High	ceremonial, sugarbag, gum	Very high	High
Brachychiton gregorii	Desert kurrajong	Low	seed food, shade, edible tuber	High	High
Rhyncharrhena linearis	Bush bean	Moderate to High	fruit	Unknown	High
Ipomoea costata	Bush potato	High	edible tuber	Very high	Moderate to High
Capparis mitchellii (also 2 northern species)	Bush orange, split jack	Moderate to High	fruit, shade	Very high	Moderate to High
Cucumus melo subsp. *agrestis*	Bush cucumber	Moderate	fruit	Unknown	Moderate to High
Carissa lanceolata	Conkerberry	Low	fruit	Very high	Moderate
Boerhavia spp.	Tar vine	High		Very high	Moderate
Pterocaulon spp.	Apple bush	Low	medicine	Very high	Moderate
Acacia tetragonophylla	Dead finish	High	seed food, medicine	Very high	Moderate
*Acacia pruinocarpa**	Black gidgee	High	ashes, edible gum, seed	High	Moderate
*Canthium attenuatum**	Bush currant	High	fruit	High	Moderate

Species name	Common name	Significance as contemporary resource or cultural value[a]	Contemporary resource value	Palatability to camels[b]	Vulnerability to local extinction/ severe depletion from camel browsing[c]
Vigna lanceolata	Pencil yam	Moderate to High	edible tuber	Unknown	Moderate
Owenia reticulata	Desert walnut	Moderate	kernel, gum, shade	Unknown	Moderate
Grevillea juncifolia	Desert grevillea	High	honey	Very high	Low to Moderate
Grevillea eriostachya	Honey grevillea	High	honey	High	Low to Moderate
Tecticornia verrucosa	Samphire	Low	seed	Unknown	Low to Moderate
Acacia victoriae	Victoria wattle	High[d]	commercial seed	Very high	Low
Capparis spinosa subsp. *nummularia*	Bush passionfruit	Moderate to High	fruit	Very high	Low
Acacia aneura (especially sub-species other than *tenius*)	Mulga	High[d]	firewood, shade, artefact timber, honey, honey ant, ashes, red kangaroo habitat, commercial artefact production, commercial seed	High	Low
Acacia kempeana	Witchetty bush	High	edible grub	High	Low
Acacia coriacea	Dogwood	High[d]	green seed food, dry seed commercial	Moderate	Low
Corymbia opaca	Bloodwood	High[d]	artefacts, sugarbag, bush coconut, commercial artefacts and beads	Moderate	Low
Solanum centrale	Bush tomato	High[d]	Fruit food, commercial fruit	Moderate	Low
Solanum ellipticum	Bush tomato	Moderate	fruit	Moderate	Low
Solanum chippendalei	Bush tomato	High	fruit	Unknown	Low
Stylobasium spathulatum		Low[d]	commercial artefacts (seed)	Unknown	Low
Acacia murrayana		High[d]	commercial seed	Unknown	Unknown
Acacia colei		High[d]	seed food - commercial seed	Unknown	Unknown

[a]Contemporary significance of species varies regionally and further consultations are required with Aboriginal people to gain a better understanding of each species local importance

[b]Following Dörges & Heucke (2003)

[c]Based on Dörges & Heucke (2003) and information provided by Peter Latz, Theresa Nano, and Fiona Walsh in 2007 and 2008

[d]Species is of commercial importance

* Camels and/or fire prevent plants from reaching maturity or full potential and may render them worthless as resource species

Note: Species are listed by decreasing vulnerability to camel browsing.

6.3 Safety concerns

In the survey conducted with Aboriginal landholders, inhabitants in 17 of the 27 settlements surveyed expressed concerns over the dangers that camels posed both on and off the road (Vaarzon-Morel 2008b). Camel-related road accidents are discussed in 4.2.6 above. Concerns over camels are affecting the way that people use country (Vaarzon-Morel 2008b). For example, many people claimed that they no longer camped out in areas with lots of camels and would not leave children unattended in such areas (Vaarzon-Morel 2008b). This may restrict the transmission of cultural knowledge and practices concerning country to future generations (Vaarzon-Morel 2008b).

7. Disease risk

In general, camels in Australia suffer little disease. Skin disease, including sarcoptic mange, is the most prevalent cause of camel morbidity (Brown 2004) in Australia. Camel pox, another skin disease that causes considerable morbidity and fatalities in camels in overseas countries (Koenig 2007) is not present in Australia. In 1999, a review of Australia's preparedness for exotic disease outbreaks focusing on feral herbivores concluded that camels were unlikely to be involved in exotic disease outbreaks (Henzell et al. 1999). This conclusion was underpinned by a camel population estimate of 170 000 (based on that of Short et al. 1988 with an estimated correction factor of 4) (Robert Henzell 2008, SA Animal and Plant Control Group, pers. comm.). This centred on the assumptions that camels were sparsely distributed in the arid zone, mainly inhabited remote areas, had little contact with other species (especially stock), and only infrequently visited water points (Henzell et al. 1999). The situation is now quite different: the current camel population is estimated to be at least seven times higher than the estimate used for the Henzell et al. (1999) review (Saalfeld & Edwards 2008); camels are increasingly moving out of remote areas and coming into regular contact with cattle and other feral animals (Zeng & Edwards 2008a); and camels now regularly visit water points across their range (section 5.2), including stock waters on pastoral leases (Zeng & Edwards 2008a). While it is arguably still the case that the likelihood of an exotic disease being introduced into an area occupied by camels is still lower than for many other parts of Australia, there is now an increased likelihood that camels would be epidemiologically involved in the spread of diseases like bluetongue, Rinderpest, Rift valley fever, surra (trypanosomosis), and bovine tuberculosis were there to be outbreaks of these diseases in Australia (Brown 2004; Robert Henzell 2008, SA Animal and Plant Control Group, pers. comm.). Whether camels would be epidemiologically involved in the spread of foot-and-mouth disease is still open to debate (Manefield & Tinson 1996, Wernery & Kaaden 2004).

8. Case studies

8.1 Incursion of camels onto remote Aboriginal settlements and pastoral properties in January–March 2007 in the vicinity of the 'western deserts'

Most of central Australia experienced below average rainfall over the period 2002–2006 and at the start of 2007 conditions were very dry in most parts of the region. In December 2006 there were reports of camels moving into remote Aboriginal settlements (Warakurna) in WA in search of water. In mid-January 2007, a narrow band of rain that extended through Alice Springs and into SA (flooding Hawker and Coober Pedy), exacerbated the situation. While pastoral properties to the immediate south of Alice Springs received some rain at that time, the Great Sandy, Great Victoria, and southern Tanami Deserts (i.e. the western deserts – see Figure 7.7) received no rain and remained very dry. Camels responded by moving eastwards out of the dry deserts, apparently following the rain. There was an influx of many, perhaps tens of thousands, of apparently starving and thirsty camels onto pastoral leases to the south of Alice Springs and onto Aboriginal settlements in the APY lands in SA, the Ngaanyatjarra lands in WA, and in the Petermann Ranges in the NT (Figure 7.4).

Several pastoral properties in the NT (including Mulga Park and Curtin Springs) experienced considerable damage to infrastructure and the depletion of scant stock water reserves as a result of the camel influx. There was also intense competition between cattle and camels for what little forage remained. Pastoralists responded by ground shooting camels and by engaging the services of a pet meating contractor. Mulga Park and Curtin Springs stations shot to waste approximately 4500 camels (using ground-based shooters) during the 2006–2007 summer and the months that followed.

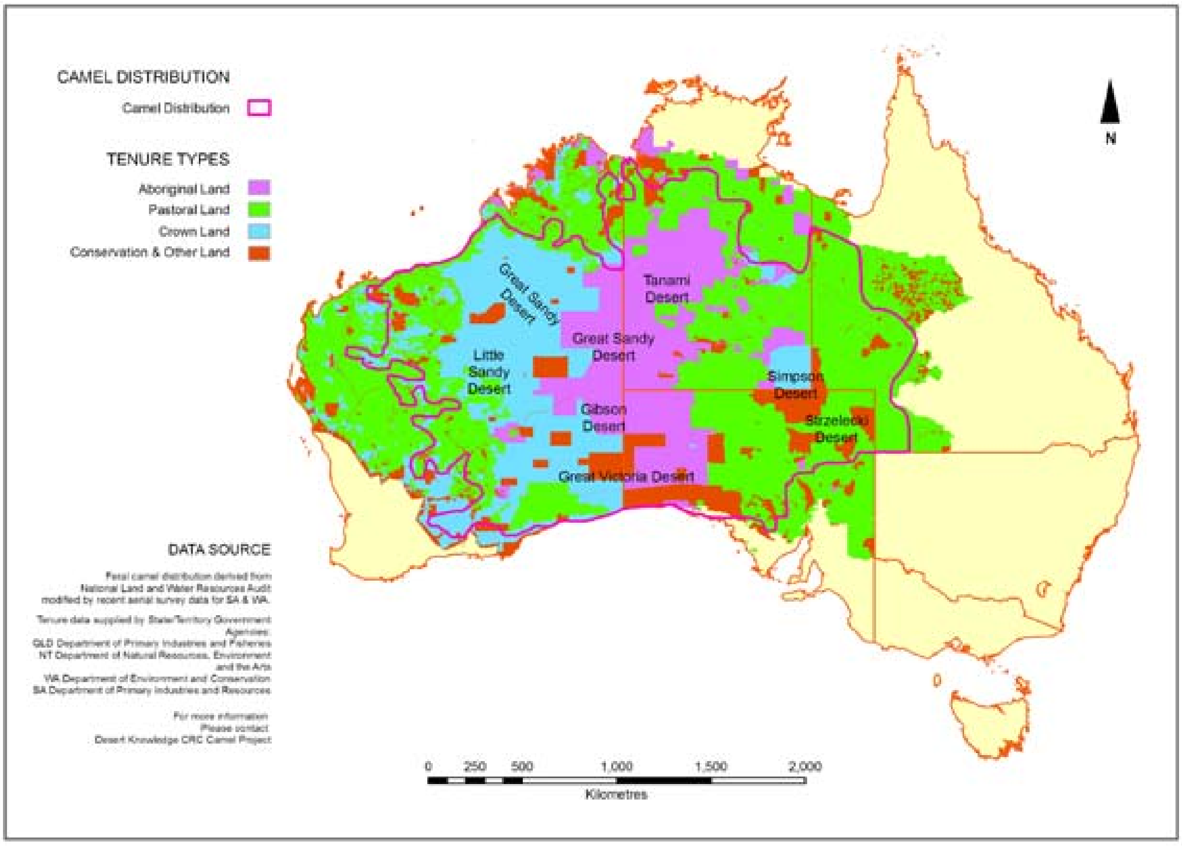


Figure 7.7. Map showing the deserts of Australia's rangelands

Figure 7.8: (above) Camels on Mulga Park station (NT), February 2007; (right) Camel within Warakurna settlement (WA), February 2007

Source: 7.8 (above) image courtesy Mulga Part Station;
7.8 (right) image courtesy L. Matthews, Curtin Springs Station

On the Aboriginal lands, hundreds of dead camels were found in waterholes south of the Petermann Ranges, often near settlements, and near Docker River in the NT (Figure 7.4). On 28 February 2007, Brian Watts (Chief Executive Officer at Docker River in the southwest corner of the NT) advised 'the community has major problems with the camels. Each morning there are between 500–600 camels roaming through the community in search of water. Each night we turn on three fire hydrants for several hours to provide some water. Each day I drag one or two dead camels from the community'. The

Centralian Advocate newspaper in Alice Springs reported thousands of camels were dying of thirst at Docker River at this time. Camels in Docker River caused severe damage to water-related infrastructure including taps, water tanks, toilets, and evaporative air conditioners.

The situation was no different in SA where mobs of up to 500 feral camels moved into settlements in the western APY lands and caused considerable damage and fouling to water supplies and infrastructure (Mark Williams 2008, Senior Technical Adviser, Department of Water, Land and Biodiversity Conservation, SA, pers. comm.). In March 2007 near Amata in South Australia, 46 dead camels were pulled from one rockhole alone (David Hewitt 2007, Relief Manager, Punmu Community, Ngaanyatjarra lands WA, pers. comm.).

In Warakurna, one of 12 settlements of the Ngaanyatjarra lands about 800 km west of Alice Springs, the estimated economic loss caused by camels over the 2006–07 summer was in the order of $100 000 due to damage to fences, air conditioners, houses, water tanks, wind mills, and cleanup activities (Chris Moon 2007, former Community Development Advisor, Warakurna, pers. comm.).

The Western Desert camel problem dissipated in the third week of March 2008 following widespread rainfall. Most of the camels rapidly returned to the more remote desert country within a few days, although some remained on fringing pastoral properties in higher than expected numbers.

During the summer 2006–07 camel incident there were significant issues in respect to human health and safety and concerns over the welfare of the camels. In the NT, the Central Land Council (CLC) held a series of emergency consultations with traditional owners at Docker River on how to best tackle the immediate camel crisis for the community, while discussions continued with the Indigenous Land Corporation regarding support for addressing the growing problem in the broader south-west region of the NT. After initial strong resistance from traditional owners to a culling proposal, an agreement was eventually reached to undertake an aerial cull of all camels within a 50 km radius of the community using the limited financial resources available to the CLC and assisted by Parks and Wildlife NT. However, the cull did not occur due to the rapid and complete dispersal of camels from the Docker River area following significant rainfall in the west virtually on the eve of Parks and Wildlife deploying a helicopter to carry out the shoot (David Alexander 2007, CLC, pers. comm.). In SA, the Department of Water, Land and Biodiversity Conservation held two meetings with key stakeholders (March 6 and 14, 2007) to scope the camel problem and discuss emergency management options. The APY Executive did not support a proposal to aerially cull the camels on affected settlements and expressed the view that without integrated cross-jurisdictional management, strategic planning, and adequately funded control there would be ongoing increases in the population and corresponding impacts at a landscape scale (Mark Williams 2008, Senior Technical Adviser, Department of Water, Land and Biodiversity Conservation, SA, pers. comm.). The APY Land Management Group responded to the immediate problem by moving camels away from settlements using helicopter mustering and turning on some bores outside of settlements to provide water for the thirsty animals. The APY Land Management Group is currently exploring a range of commercial utilisation opportunities for camel meat to provide a long-term solution to the camel problem in the APY lands.

In summary, there were significant economic and social impacts from the invasion of Aboriginal settlements and pastoral leases by camels from the western deserts over the summer of 2006–07. There were also major issues in regards to animal welfare. There was neither a pre-existing plan outlining how to respond to this type of situation, nor a reserved pool of money to immediately fund appropriate management intervention. Any aerial culling operation to manage the immediate camel problem would have been expensive – it is possible that as many as 10 000 camels would have to have been removed in order to mitigate impacts and resolve animal welfare issues. The cost of aerial culling varies with the density of the target species over a range of $20–100 per animal (see Saalfeld & Zeng 2008). Assuming that aerial culling costs would have been at the lower end of this range because the camels were aggregated, it would have cost a minimum of $200 000 to remove 10 000 camels from affected areas if that were the required level of management. Management actions at this scale are relatively ineffective in dealing with the overall camel problem. Without integrated cross-jurisdictional management, strategic planning, and adequately funded control, there will be ongoing increases in the population (Saalfeld & Edwards 2008) and corresponding impacts at a landscape scale. Although there is resistance to the culling of camels to waste on Aboriginal lands (Vaarzon-Morel 2008a, 2008b), support for culling programs may be forthcoming if the need is major and pressing as occurred at Docker River in 2007.

8.2 General observations of camel impacts on waterholes across central Australia

Appendix 7.1 contains (1) a synthesis of the negative impacts of camels on waterholes, based on observations made across central Australia; and (2) a preliminary assessment of the negative impacts of camels on sites in Uluṟu–Kata Tjuṯa National Park (UKTNP) and the Petermann and Katiti Land Trusts.

8.3 Detailed assessment of camel impacts on a culturally important site in central Australia

Appendix 7.2 contains a detailed assessment of camel use of and negative impacts on a permanent spring located near UKTNP.

9. Positive impacts of feral camels

Feral camels can have both positive economic and environmental impacts. Landholders can derive economic benefit from feral camels by using them for food (Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a) or by selling them for uses which include pet meat and meat for human consumption (Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a). Economic benefit from the sale of camels by landholders accrues along the supply chain as transporters, wholesalers, agents, meat processors, and meat marketers handle the product.

9.1 Benefits to landholders

In the survey conducted with pastoral landholders (Zeng & Edwards 2008a), 10 of 209 respondents (4.8%) derived some income from selling camels, 32 (15.3%) reported eating camels, and two (1.0%) reported deriving some other economic benefit from camels (e.g. some pastoralists in Qld are using feral camels for woody weed control). The value of the benefit that pastoralists realised from feral camels was estimated to be about $0.59 million annually across all pastoral properties within or on the margins of the camel range (Zeng & Edwards 2008a).

In the survey conducted with conservation landholders (Zeng & Edwards 2008b), three out of 70 reserves derived some income from selling camels, while three reported eating camels. The value of the benefit that conservation landholders realised from feral camels was estimated to be about $0.03 million annually across all conservation properties within or on the margins of the camel range (Zeng & Edwards 2008b).

In the survey conducted with Aboriginal landholders (Vaarzon-Morel 2008a, 2008b), inhabitants in nine of the 27 settlements surveyed indicated that they had at some stage derived economic benefit from mustering and selling camels; inhabitants in nine settlements indicated that they killed and ate camels; while inhabitants in 13 settlements indicated that they derived other benefits from camels, mainly from keeping young camels as pets (Vaarzon-Morel 2008b). People in most settlements expressed the view that feral camels should be used to provide benefits to local people including income and jobs (Vaarzon-Morel 2008b).

9.2 Benefits to those involved in the meat and pet meat industries

The use of camels for pet meat and meat for human consumption is discussed in Zeng & McGregor (2008).

9.3 Tourism

The tourism industry uses a small number of camels, mainly in trekking-type businesses and in novel racing events. Currently, there are around 28 camel tourism businesses (camel farms) established primarily for camel rides and camel desert trekking (Table 7.8). Some of these enterprises are Aboriginal owned. To what extent these tourism-based enterprises rely on feral as opposed to domesticated camels is unclear (Zeng & McGregor 2008). What is clear is that only a relatively small number of camels is involved.

Table 7.8: Camel tourism businesses

Business name	Location	Activity
Explore the Outback Camel Safaris	William Creek, SA	Desert trekking
Outback Camel Company	Fortitude valley, Qld	Desert trekking
High Country Camel Treks	Mansfield, Victoria	Scenic camel rides and safaris
Frontier Camel Tours	Alice Springs, NT	Scenic camel rides and safaris
The Bush Safari Company	Waikerie, SA	Scenic camel rides and safaris
Pichi Richi Camel Tours	Quorn, SA	Scenic camel rides and safaris
Camelot Park	Qld	Scenic camel rides and safaris
Camel Company Australia	Noosa, Qld	Scenic camel rides and safaris
Outback Camel Adventures	Capalaba, Qld	Scenic camel rides and safaris
Cameleer Park Rides and Safaris -	Perth, WA	Scenic camel rides and safaris
Kimberley Camel Safaris & Bushwalks	Broome, WA	Scenic camel rides and safaris
Camel Expeditions	Exmouth, WA	Scenic camel rides and safaris
Pyndan Camel Tracks	Alice Springs, NT	Scenic camel rides and safaris
Curtin Springs camel rides	Curtin Springs, NT	Scenic camel rides and safaris
Camels Australia	NT	Scenic camel rides and safaris
Red Sun Camels	Broome, WA	Scenic camel rides and safaris
Broome Camel Safaris	Broome, WA	Scenic camel rides and safaris
Kings Creek Station Camel Safaris	King Creek, NT	Scenic camel rides and safaris
Barrier Range Camel safaris	Broken Hill, New South Wales	Scenic camel rides and safaris
Port Macquarie Camel Safaris	Port Macquarie, New South Wales	Scenic camel rides and safaris
Ross River Homestead camel rides and safaris	Ross River, NT	Scenic camel rides and safaris
Camel Safaris & Balara Homestead	(Coominya, Qld	Scenic camel rides and safaris
Yallingup Camel Safaris	Yallingup, WA	Scenic camel rides and safaris
Calamunnda Camel Farm	Perth, WA	Scenic camel rides and safaris
Comeroo Camel Station	Comeroo, New South Wales	Scenic camel rides and safaris
Camel Rides	Cosgrove, Victoria	Scenic camel rides and safaris
Lookout Camels	Whoota, New South Wales	Scenic camel rides and safaris
The Stables Yanchep camel rides	Yanchep, WA	Scenic camel rides and safaris

There are two relatively well-known camel races in Australia: the Alice Springs Camel Cup and the Boulia Desert Sands camel races. These races are held annually and are primarily tourism events that use domesticated camels; there is no camel racing industry in Australia.

Currently, tourism-related activities that use camels do not play a significant role in the management of wild camels, nor are they likely to in the future (Zeng & McGregor 2008).

9.4 Environmental benefits

There are currently about 5000 camels in captivity in Qld and some are being used for controlling woody weeds like Prickly Acacia (*Acacia nilotica*), Mesquite (*Prosopis* spp.), and Parkinsonia (*Parkinsonia aculeata*) on pastoral lands (Nick Swadling 2007, Industry Development Officer, Department of Primary Industries and Fisheries, Qld, pers. comm.). This is the only acknowledged environmental benefit attributable to camels.

10. Relationship between negative impacts and density

In order to establish the nature of the density/damage relationship for feral camels, we examined the association between camel density and the monetary value of infrastructure damage reported by pastoralists in the pastoral survey over the two-year period (July 2005 – June 2007) (Zeng & Edwards 2008a). Although some pastoralists also provided estimates of lost production due to camels, we did not use these data for this analysis because some aspects of lost production damage are perceived impacts, which may or may not be real. In contrast, assessments of infrastructure damage are typically based on observed impacts (e.g. broken fences, damaged yards, etc.).

For each pastoral property that estimated the monetary value of infrastructure damage, we assigned a camel density value on the basis of the density distribution model provided by the Krigging interpolation described in Saalfeld & Edwards (2008).

There was a positive association between density and the level of infrastructure damage reported (Figure 7.9). Analysis of variance with damage as the dependent variable indicated that there were significant differences in the level of damage at different densities ($F_{4,111} = 18.7$, $P<0.001$). The Bonferroni Multiple Range Test indicated the following groupings by density category for the damage means (groups within matching brackets were not significantly different):

(0.1–0.2 0–0.1 **[**0.2–0.3**)** 0.3–0.4**]** >0.4

Damage at camel densities <0.2 camels/km^2 was significantly lower than at densities >0.3 camels/km^2 and damage at densities >0.4 camels/km^2 was significantly greater than that incurred at lower densities. This pattern is reflected in the location of individual pastoral properties that reported damage (Figure 7.10).

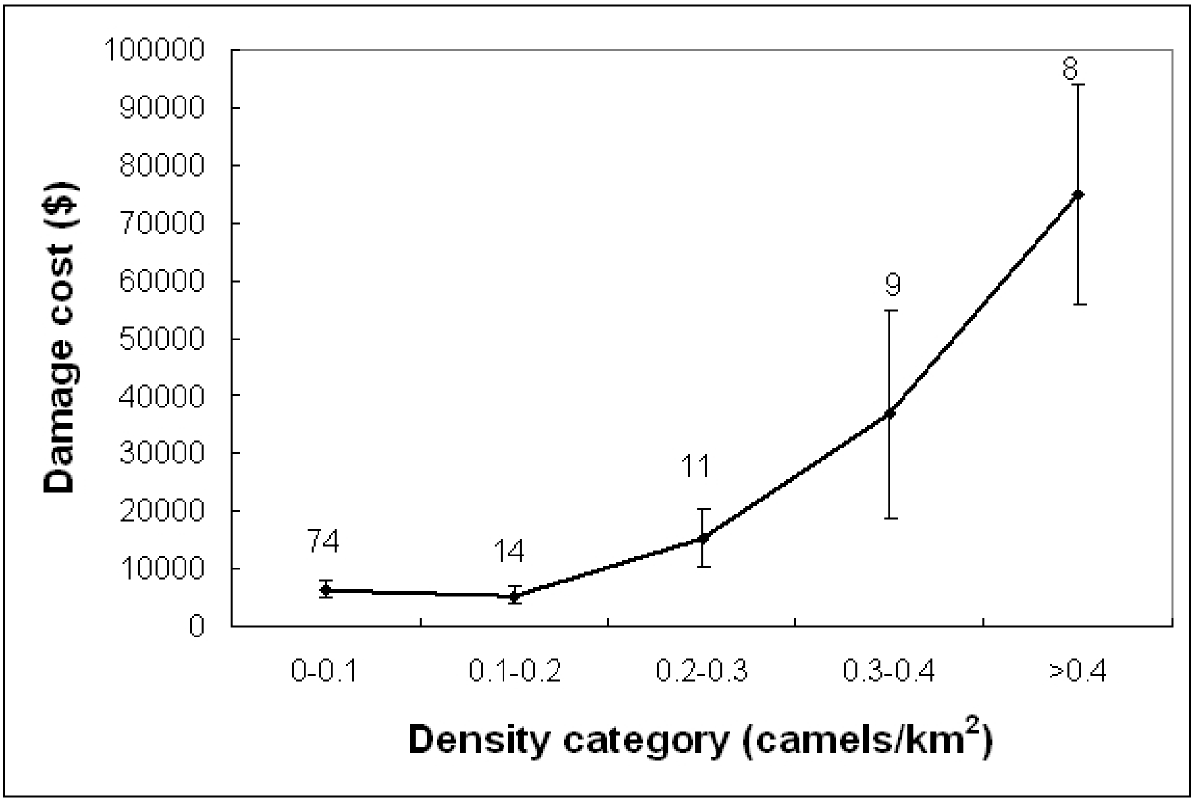


Figure 7.9: The relationship between the mean value of infrastructure damage reported by pastoral properties over the period July 2005 – June 2007 and the estimated mean density of feral camels on the property

Note: Figures are sample sizes. Error bar is standard error.

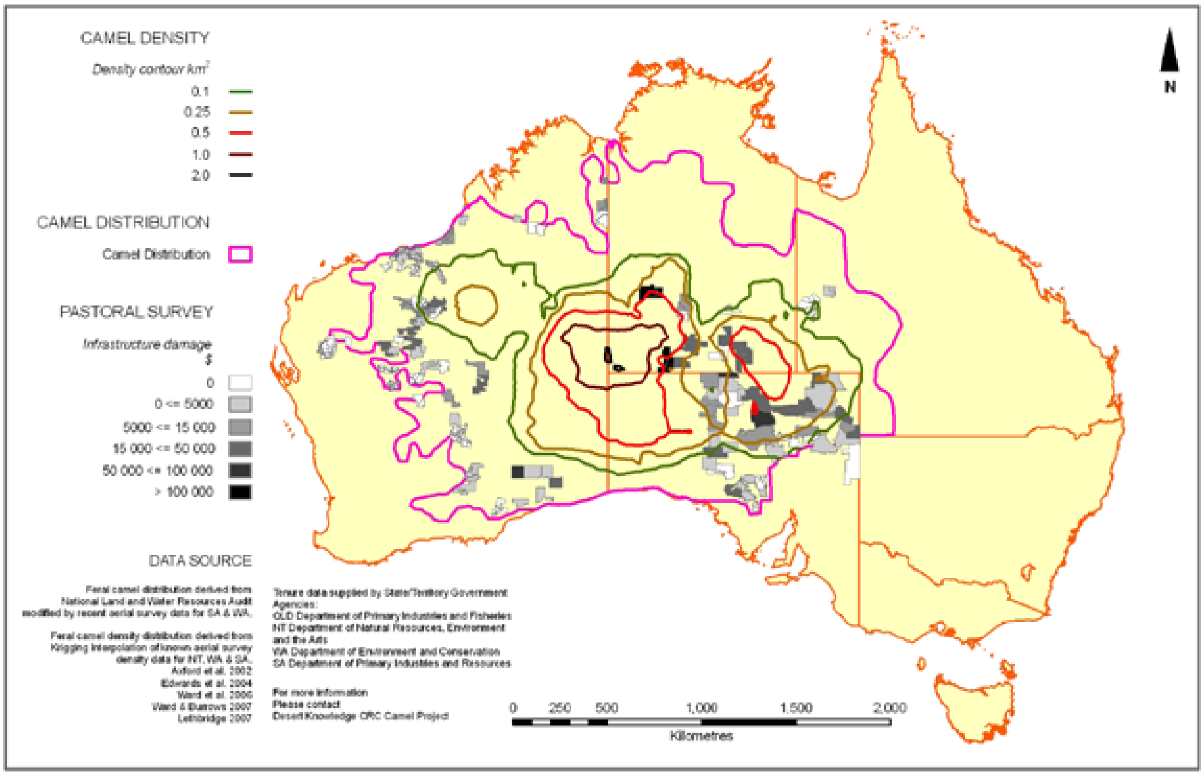


Figure 7.10: Map showing the level of damage reported by individual pastoral properties in relation to camel density contours

11. Discussion

Table 7.9 provides a summary of the monetary value of the economic impacts of feral camels described in this study. The negative economic impacts arise from direct damage by camels to infrastructure, property and people and losses in production, and costs associated with management-related activities. The positive economic impacts of feral camels with respect to landholders arise from the consumption and sale of camels. In Table 7.9 we have not attempted to capture the economic benefits of commercially utilised feral camels that accrue to those further up the supply chain. On the basis of this approach, the negative economic impacts outweigh the positive economic impacts by a factor of about 18. The net economic impact is -$10.67 million annually. We were unable to obtain reliable estimates of the economic value of damage to remote airstrips or of camels mustered and sold by Aboriginal people.

Although we were unable to estimate the monetary value of the environmental and social/cultural impacts of feral camels, such impacts are significant. Of particular concern is damage to, or associated with, wetlands which are both biologically and culturally/socially important. Camels not only damage the ecology and hydrology of wetlands, they can remove free-standing water and even destroy the ability of some wetland types to hold water. As a result, the ability of wetlands to act as refugia for many types of aquatic and terrestrial wildlife, particularly during droughts, is being undermined. Many Aboriginal people raised this as an issue during the survey of Aboriginal communities, particularly in relation to highly prized kuka (bush meat) species including red kangaroos (*Macropus rufus*), emus (*Dromaius novaehollandiae*), and bustards (*Ardeotis australis*). Aboriginal people saw these species as being deprived of grass and water by camels, and being scared away, and therefore declining in abundance (Vaarzon-Morel 2008b).

Table 7.9: The annualised monetary value of the economic impacts of feral camels

Cost/benefit component	Cost ($ million)	Benefit ($ million)	Net cost/benefit ($ million)
Economic impacts			
1) Direct control and management costs			
Govt. in-kind management cost	-0.30		-0.30
Govt. management/research cost[a]	-0.75		-0.75
Pastoralist management cost	-1.21		-1.21
Conservation land management cost	-0.10		-0.10
2) Damage to infrastructure/property/people			
Pastoral stations	-2.40		-2.40
Aboriginal settlements	-2.09		-2.09
Conservation reserves	-0.08		-0.08
Dog fence	-0.04		-0.04
Airstrips	NQ		
Road crashes	-0.90		-0.90
3) Production loss			
Pastoral stations	-3.42		-3.42
3) Landholder benefit			
Selling, eating, other uses (pastoral)		0.59	0.59
Selling, eating, other uses (Aboriginal)		NQ	
Selling, eating, other uses (conservation)		0.03	0.03
Total	-11.29	0.62	-10.67

[a]Includes non-government conservation lands

Note: The positive economic impacts are those for landholders, not those that accrue along the commercial supply chain. Note that the monetary value of camels mustered and sold by Aboriginal people and of damage by camels to airstrips were not quantified (NQ) in this study.

The climate change forecast for arid Australia out to 2030 is for a temperature increase of 1–1.2°C, higher frequency of hot days, a decline in rainfall of between 2–5%, higher evaporation rates, and higher frequency of droughts (CSIRO 2007). Under this scenario, even if camel populations remain static, the negative impacts of camels are likely to be exacerbated. Water will be a scarcer resource and camels will put more pressure on water resources on pastoral leases, in remote settlements, and in wetlands. As droughts increase in frequency so too will the frequency of camels moving en masse onto pastoral leases and into remote settlements in search of water as described in Case Study 8.1. Wetlands will become increasingly important as refugia in arid Australia as the frequency of droughts increases, and this will magnify the effects of feral camels on environmental values. The exotic disease risk associated with feral camels is also likely to increase if camels are brought into closer contact with stock as they seek out scarcer water resources.

The positive density/damage relationship established for camels and infrastructure on pastoral properties is likely to hold true for environmental variables and cultural/social variables as well. Therefore, irrespective of climate change, the magnitude of the negative impacts of feral camels will undoubtedly increase if the population is allowed to continue to increase. Furthermore, the likelihood that camels would be epidemiologically involved in the spread of exotic diseases (were there to be outbreaks of these diseases in Australia) is also very likely to increase with population density.

The positive density/damage relationship established for camels and infrastructure on pastoral properties indicates that the degree of damage increases significantly when camel densities exceed 0.3 camels/km^2. This suggests that there are real gains to be made in maintaining camel densities on pastoral leases at <0.3 camels/km^2. Figure 7.9 shows that the amount of damage tends to flatten out at densities between 0.1–0.2 camels/km^2, at levels of about $5000–6000 over two years. For most pastoralists, this may be a tolerable level of damage. According to Dörges and Heucke (2003), the long-term survival of environmentally and culturally important tree species like quandong, curly pod wattle, and bean tree is compromised even at 'low' densities of camels. While Dörges and Heucke (2003) did not provide a definition for 'low' density of camels, they did recommend that, in order to protect the vegetation resource in managed situations, densities of camels during dry times should not exceed 0.5 camels/ km^2 in woodland/shrubland habitats and 0.3 camels/km^2 in sandplain/sand dune habitats. Even in such situations, Dörges and Heucke (2003) recommended fencing off stands of highly preferred species in order to protect them. Thus it would seem that, in order to safeguard the survival of quandongs, curly pod wattles, and bean trees, camel densities need to be kept at or <0.3 camels/km^2. There is an obvious need to clarify this threshold for these and other highly palatable species. On the basis of our current understanding, we recommend that feral camels be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and plant species which are highly susceptible to camel browsing.

11.1 Recommendations

- The management of feral camels should focus on mitigation of negative impacts, not reduction in the number of camels per se. However, as there is a positive relationship between camel density and degree of damage, reducing camel density will often be fundamental to achieving damage mitigation.
- That on the basis of our current understanding, feral camels be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.
- There is a need to quantify the density/damage relationship for feral camels for response variables (particularly environmental variables) for which the relationship is not known across a range of environments and with particular emphasis on identifying the threshold density below which impacts are negligible.

12. References

Albrecht DE, Duguid AW, Coulson H, Harris MG and Latz PK. 2007. *Vascular plant checklist for the southern bioregions of the Northern Territory*, 2nd edn, Northern Territory Government.

Australian Pest Animal Strategy – a national strategy for the management of vertebrate pest animals in Australia. 2007. Natural Resources Ministerial Council, Canberra.

Baldock M and McLean A. 2005. *The economic cost and impact of the road toll on South Australia*. Centre for Automotive Safety Research, The University of Adelaide, South Australia.

Barker P and Brim Box J. 2008. *Central Australia Wetlands Monitoring Framework Parts I and II: water quality and aquatic fauna sampling*, Prepared for the Central Australian Water for Life Project. Greening Australia, NT.

Bayly IAE. 1999. Review of how indigenous people managed for water in desert regions of Australia. *Journal of the Royal Society of Western Australia* 82, pp. 17–25.

Box JB, Duguid A, Read R, Kimber RG, Knapton A, Davis J and Bowland AE. 2008. Central Australian waterbodies: the importance of permanence in a desert landscape. *Journal of Arid Environments* 72, pp. 1395–1413.

Braysher M. 1993. *Managing vertebrate pests: principles and strategies*. Australian Government Publishing Service, Canberra.

Brown A. 2004. *A review of camel diseases in central Australia*. Northern Territory Department of Primary Industry, Fisheries and Mines, Technical Bulletin 314, Alice Springs. Available: Technical Publications, Northern Territory Department of Primary Industry, Fisheries and Mines.

BTE. 2000. *Road crash cost in Australia*. Bureau of Transport Economics, Canberra.

Bureau of Meteorology. 2008. *Climate statistics for Australian locations*. Available from <http://www.Bom.gov.au/climate/averages/tables/cw_015527.All.shtml>

Copley PB, Baker LM, Nesbitt BJ and Foulkes JN. 2003. 'Mammals', in *A Biological Survey of the Anangu Pitjantjatjara Lands, South Australia, 1991–2001*, ed. AC Robinson, PB Copley, PD Canty, LM Baker and BJ Nesbitt. Department for Environment and Heritage, Adelaide.

CSIRO. 2007. *Climate change in Australia, technical report*. CSIRO. Available from <http://www.climatechangeinaustralia.gov.au/resources.php>

Davis JA, Harrington SA and Friend JA. 1993, Invertebrate communities of relict streams in the arid zone: the George Gill Range, Central Australia. *Australian Journal of Marine and Freshwater Research* 44, pp. 483–505.

Dörges B and Heucke J. 2003. *Demonstration of ecologically sustainable management of camels on aboriginal and pastoral land*, Final report on project number 200046, Natural Heritage Trust (Online). Available from <http://www.camelsaust.com.au/NHTreport2003.doc>

Drucker AG. 2008. *Economics of camel control in the central region of the Northern Territory*, DKCRC Research Report 52. Desert Knowledge CRC, Alice Springs.

Dufour A, Snozzi M, Koster W, Bartram J, Ronchi E and Fewtrell L (Eds). 2003. *Assessing microbial safety of drinking water: improving approaches and methods*. IWA Publishing, London.

Duguid A, Barnetson J, Clifford B, Pavey C, Albrecht D, Risler J and McNellie M. 2005. *Wetlands in the arid Northern Territory: a report to the Australian Government Department of the Environment and Heritage on the inventory and significance of wetlands in the arid NT*. Northern Territory Government Department of Natural Resources, Environment and the Arts, Alice Springs.

Edwards GP, Saalfeld K and Clifford B. 2004. Population trend of feral camels in the Northern Territory, Australia. *Wildlife Research* 31, pp. 509–517.

Edwards GP, McGregor M, Zeng B, Saalfeld WK, Vaarzon-Morel P and Duffy M. 2008. Synthesis and key recommendations. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 331–360. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Hart Q and Bomford M. 2006. *Australia's pest animals: new approaches to old problems*. Department of Agriculture, Fisheries and Forestry, Canberra.

Henzell R, Caple P and Wilson G. 1999. *Wildlife and exotic disease preparedness in Australia. Feral herbivores*. Australian Government Publishing Service, Canberra.

Herrick JE, Van Zee JW, Havstad KM, Burkett LM and Whitford WG. 2005. *Monitoring Manual for Grassland, Shrubland and Savannah Ecosystems*: Volume I – 'Quick Start'. USDA-ARS Jornada Experimental Range, Las Cruces, New Mexico.

Hone J. 2007. *Wildlife Damage Control*. CSIRO Publishing, Collingwood.

Koenig R. 2007. Camel scientists ask: What's sinking the ships of the desert? *Science* 318, pp. 1372–1373.

Latz P. 1995. *Bushfires and bushtucker: Aboriginal plant use in central Australia*. IAD Press, Alice Springs.

Manefield GW and Tinson AH. 1996. *Camels. A compendium*, The TG Hungerford Vade Museum Series for Domestic Animals, Series C, No 22. University of Sydney Post Graduate Foundation in Veterinary Science, Sydney.

McLeod R. 2004. *Counting the cost: Impact of invasive animals in Australia 2004*. Cooperative Research Centre for Pest Animal Control, Canberra.

Norris A and Low T. 2005. *Review of the management of feral animals and their impact on biodiversity in the rangelands: A resource to aid NRM planning*. Pest Animal Control CRC Report 2005, Pest Animal Control CRC, Canberra.

NPYWC. 2003. Ngayu - Lampa Mirrka*, Our food: Report on the research done to investigate the viability of establishing an Aboriginal Bush Food Collective on the NPY lands*. NPY Women's Council, Alice Springs.

NRMA. 2005. *Safety alert: drivers approach riskiest time for animal smashes – NSW*, Available from <http://www.nrma.com.au/about-us/media-releases/20050629-a.shtml>

NT News. 2006. 'Troubled year for trains'. 13 December, p. 4.

Peeters PJ, Jennings S, Carpenter RJ and Axford G. 2005. *Assessing the abundance and impacts of feral camels in the Great Victoria Desert*, A report to the Aboriginal Lands Integrated Natural Resource Management Group. Department for Environment and Heritage, South Australia.

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK, Edwards GP, Zeng B and Lamb D. 2008. A Multiple Criteria Decision Support Tool for feral camel management. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 287–330. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK and Zeng B. 2008. Review of non-commercial control methods for feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 185–220. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Sada DW and Vinyard GL. 2002. 'Anthropogenic changes in historical biogeography of Great Basin aquatic biota, in Great Basin Aquatic Systems History', pp. 277–293, Eds R Hershler, DB Madsen and D Currey, *Smithsonian Contributions to the Earth Sciences* No. 33.

Short J, Caughley G, Grice D and Brown B. 1988. The distribution and relative abundance of camels in Australia, *Journal of Arid Environments*, vol. 15, 91–97.

Solinst Canada Ltd. 2008, *User Guide for Solinst Levelogger Model 3001*. Software Version 3.2.3, Georgetown, Ontario.

Vaarzon-Morel P. 2008a. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008b. *Key stakeholder perceptions of feral camels: Aboriginal community survey*, DKCRC Research Report 49. Desert Knowledge CRC, Alice Springs.

Vintner A and Collins T. 2008. Lost in the desert for 135 years – and found alive, *TSN News*, Winter 2008.

Walsh FJ and Douglas J. In review. Harvester–trader exchanges: a critical element of sustainable bush harvest to 2006, in *Sustainable bush produce systems*, Working Paper, Desert Knowledge Cooperative Research Centre, Alice Springs.

Walsh FJ. In prep. ' "To hunt and to hold": Martu Aboriginal people's uses and knowledge of their country, with implications for co-management in Karlamilyi National Park and the Great Sandy Desert, Western Australia'. Schools of Social and Cultural Studies (Anthropology) and Plant Biology (Ecology), PhD thesis, The University of Western Australia, Perth.

Wernery U and Kaaden OR. 2004. Foot-and-mouth disease in camelids: a review, *Veterinary Journal* 168, pp. 134–142.

Wilson RT. 1984. *The camel.* Longman Group Ltd., London and New York.

Woinarski J, Pavey C, Kerrigan R, Cowie I and Wards S. (Eds.). 2007. *Lost from our landscape: Threatened species of the Northern Territory*. Northern Territory Government, Darwin.

Yu S. 2002. *Ngapa kunangkul* (Living water): an Indigenous view of groundwater. In: *Country: visions of land and people in Western Australia*, Eds A Gaynor, M Trinca and A Haebich, Perth, Western Australian Museum and Lotteries Commission of Western Australia.

Zeng B and Edwards GP. 2008a. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008b. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

13. Appendices

Appendix 7.1 The impacts of camels on water bodies in Central Australia: A preliminary assessment

Peter Barker[1], Jayne Brim Box[2], and Tracey Guest[3]

[1] Greening Australia NT, Alice Springs, NT.

[2] Biodiversity Conservation Unit, Department of Natural Resources, Environment, The Arts and Sport, Alice Springs, NT.

[3] Uluṟu–Kata Tjuṯa National Park, Natural and Cultural Resources, Yulara, NT.

Introduction

Arid water bodies have been called the 'precious jewels of the desert' because they not only provide reliable water for humans, livestock, and native terrestrial and aquatic animals, but because they are often biological hotspots and areas of high endemism (Box et al. 2008). Arid water bodies are also jewel-like in their fragility, and extinction rates for animals and plants that rely on arid waterbodies are often higher than rates in other arid land types (Sada & Vinyard 2002).

Many water bodies in central Australia are also precious because they have deep ceremonial, economic, and social significance for Aboriginal people. Historically, Aboriginal people had an encyclopaedic knowledge of all waters within their own traditional country and often a good knowledge of the waters in the countries of their neighbours. Aboriginal people also actively managed many water bodies or sites, and permanent waterbodies were of particular importance as they were essential for survival during severe droughts (Bayly 1999). Most, if not all, are still considered culturally significant.

Camels and other large feral herbivores can impact isolated waterbodies by trampling, grazing, fouling, muddying, destabilizing, and drinking. The environmental impacts of feral animals on waterbodies in other areas of Australia have been well documented (for a review see Norris & Low 2005). Camels, in part because of their large numbers, can potentially pose significant threats to central Australian water bodies.

Over the period January 2005 – July 2008, the environmental impacts of camels were noted or evaluated during fieldwork associated with several natural resource management projects undertaken by Greening Australia and landholders at various locations in central Australia. These observations were mainly in regards to the impacts of camels on isolated water bodies, both temporary and permanent, and/or the surrounding watershed. Impact assessments included mainly qualitative evaluations of how camels affected erosion processes, water levels, aquatic animals, aquatic and riparian plants, and water quality. In some cases quantitative assessments were made. This report is in two parts: (1) a synthesis of camel impacts on waterholes, based on observations made across central Australia; and (2) a preliminary assessment of camel impacts on the Petermann and Katiti Land Trusts.

1. The impacts of camels on waterholes in central Australia: general observations

Methods

The following observations were made over the period January 2005 – July 2008 across a number of Aboriginal land trusts and pastoral leases in central Australia, primarily by Peter Barker of Greening Australia, NT. These observations were made during fieldwork associated with the Water for Life program, and in the course of site evaluations and the construction of large camel exclusion fences under the Protecting Central Australian Rockholes project funded by the Australian Government. A range of water body types was visited including permanent spring-fed rockholes, semi-permanent alluvial waterholes, gnamma holes, and soakages.

Vegetation cover around waterholes

Camels and other large feral herbivores can cause significant damage to the vegetation around permanent and semi-permanent waterholes. When a large number of camels is present, a significant percentage (e.g. > 80%) of the ground cover near the waterhole is often destroyed by trampling. After rain events and/or if the soil moisture is sufficient, annual plants (often weed species) and some stunted perennials may be present, but in most cases these do not survive long after germination due to trampling. In areas less accessible to camels (e.g. those close to rock faces or in low traffic areas), perennial grasses and some unpalatable shrub and tree species may be present.

Sedimentation/erosion

Sedimentation of water bodies occurs when sites are devoid of vegetation and have camel pads leading to them. At some water bodies, up to eight pads were observed. These pads often change the hydrology of the surrounding landscape by channelling water to or away from the water bodies. Camel carcasses were excavated by hand in collaboration with Traditional Owners from beneath 1.5 m of sediments at some water bodies. Traditional Owners noted that some waterholes that were silted in due to camel impacts were historically over 2 m deep.

The emptying of waterholes by camels

Sites at which camel exclusion fences were constructed were visited repeatedly (e.g. 3 times per week) during the construction phase and then at periodic intervals to monitor fence performance. This provided the opportunity for the taking of basic measurements/calculations of water losses due to camels drinking. At one site an estimated 50 000 litres of water were removed by camels over a six-month period, after taking into consideration seepage and evaporation. This particular waterhole was at an isolated riverine site and was completely emptied by the camels over the observation period. This water loss was significant in that it represented over 50% of the standing free water available in this particular area.

Direct camel impacts on water

Many dead and dying camels were observed to have fallen into waterholes where they perished. Some waterholes had as many as 10 dead camels in them. Camel carcasses can cause major nutrient loading. In addition, because most waterholes are considered biologically and culturally significant, the presence of dead camels often caused major distress to Traditional Owners, who often expressed that waterholes were spoiled by rotting dead camels. In addition, camel manure contributes to water fouling (see Appendix 7.2), making water undrinkable for native animals or humans.

Camels 'padding' at water sites

After temporary waterholes have dried, camels often try to dig these sites out for more water. This process is called 'padding'. Padding is thought to be a major source of soil compaction, which may make it difficult for plants to recolonise or germinate at affected sites.

Browse line

A distinct browse line is often observed on palatable vegetation at waterholes visited by large numbers of camels. This line can often extend for several kilometres away from a waterhole. In addition to the browse line, small palatable trees are often completely defoliated by camels near waterholes, and there is very little recruitment of these species in affected areas.

2. A preliminary assessment of camel impacts on waterholes in the Petermann and Katiti Aboriginal Land Trusts

Methods

In May–June 2007, the authors were invited to participate in preliminary discussions with Traditional Owners, staff from Natural and Cultural Resources at Uluṟu–Kata Tjuṯa National Park (UKTNP), and the Central Land Council (CLC) regarding the status (i.e. ecological and cultural health) of 15 waterholes on the Petermann and Katiti Aboriginal Land trusts in the vicinity of UKTNP. At this meeting the Traditional Owners categorised these waterholes as 'good', 'not sure (of status)', or 'in need of help'. Shortly thereafter, the authors were invited to visit five of these water bodies that had been categorised as either 'not sure (of status)' or 'in need of help' to determine their ecological health, in collaboration with Traditional Owners and UKTNP staff. The five water bodies that were visited included the following wetland types: a small alluvial upland soakage/waterhole, a permanent spring, an isolated rockhole (or gnamma hole), and two isolated soakages.

Initial trips were made to all five water bodies in May and June 2007. Additional trips were made in November 2007 and in January and February 2008. In general, the following were assessed for each site either through direct observations, discussions with Park staff and/or Traditional Owners, or the collection of physical data:

1. whether camels were present in the area, had access to and were using the water body or surrounding area for drinking or grazing, and if camel impacts were noticeable either in the water body or the surrounding landscape
2. whether water was present (i.e. permanent or temporary sources), and whether camels were using the site as a water source
3. the overall state of water quality, including whether any obvious signs of enrichment or eutrophication were present
4. the condition of the surrounding watershed and/or countryside, including erosion, sedimentation of existing waterholes, browsing, or over-grazing by camels or other animals.

Results and discussion

Sedimentation, erosion and changes to hydrology

All of the waterholes studied were affected by sedimentation to some degree. Some were completely silted up, and water was only present when sediments were dug out. In one case the Traditional Owners indicated they did not want a waterhole cleaned out because of concerns that if water was present, camels would return and cause more damage. Other water bodies had only localised sedimentation, largely because they occurred at the top of catchments and were less accessible to camels.

Camels cause erosion because they destroy ground cover vegetation and make definitive pads to and from water places. At one site, a one-meter-wide camel pad led to a particular waterhole, and camel trampling and grazing probably contributed to the development of an erosion channel at the site. The presence of a number of dead ironwood (*Acacia estrophiolata*) and red gum (*Eucalyptus camaldulensis*) trees that now occurred a long way from the current hydrologic channel suggests that the hydrological pattern for this site had changed from a broad flood-out to a relatively narrow channel, thereby cutting off the water supply for the trees. Such changes to hydrologic patterns are not uncommon at waterholes in soft substrates that are heavily used by camels.

Emptying of water

Many of the waterholes that were assessed were clearly being emptied by camels. One particular waterhole is a good example of this and also of the associated impacts on native fauna. When the site was first visited in January 2008, the waterhole was partially filled with an estimated 6000 litres of water and contained thousands of tadpoles. About 30 camels were observed in the area at that time. Two days later, one of the authors (T. Guest) returned to find that this waterhole was dry. Although evaporation was undoubtedly responsible for some of the water loss, the expected amount of evaporation, based on January pan evaporation estimates for Yulara airport (Bureau of Meterology 2008), was much less than 6000 litres. It is suspected that camels drank this waterhole dry. Thousands of dead and dying tadpoles were found at this waterhole after it had been emptied of surface water. This accelerated draining of a temporary water body may have implications for local frog populations which may not be able to complete their life cycle under such circumstances. According to Joseph R Mendelson III (2008, Curator of Herpetology, Zoo Atlanta, pers. comm.), 'Waterholes are a limited resource in deserts, and local [frog] populations often show a high degree of fidelity to particular historical waterholes, with only limited amounts of risky cross-country emigrations.' However, this assertion needs to be tested.

Management

One waterhole had been fenced in 2000 by UKTNP staff and Traditional Owners. The fence consisted of cable strung between concreted poles. The fence excluded camels while allowing native wildlife (kangaroos, birds) to access the site (i.e. kangaroo and bird droppings were found inside the fence). Although there was evidence that camels had tried to penetrate the fence, they had not managed to break through. In other areas camels have been observed to kill themselves trying to get through fences for water. A permanent spring located about 20 kms from the site fenced in 2000 may have served as an alternate water source for camels in the area, thereby taking pressure off the fence.

Observed camel numbers

There were many camels in the areas visited. During the first two-day trip, seven groups of camels were seen, with the largest group consisting of around 200 camels. These visual observations were consistent with the high camel densities estimated for the area during an aerial survey conducted in 2001 (Edwards et al. 2004).

Acknowledgments

We thank and greatly appreciate the guidance, discussions with, and participation of the following Traditional Owners and Mutitjulu community members during our visits: Cassidy Uluṟu, Reggie Uluṟu, Steven Uluṟu, Johnny Jingo, Wangan No.1., Ashely Paddy, Lochlan Jingo, David Moneymoon, Robert Sevens, Richard Kulitja, Joyce Tjiliri, Wionna Palma, Selwyn Kurukringa, Pamala Ray, and Bessie Nipper. We thank Mirjana Jambrecina, Daisy Walkabout, Phillip Driften, Sam Steel, and Steve Anderson of Natural and Cultural Resources/UKTNP for their field and office help, insights, and support for this assessment. We thank Sean Moran, Andrew Drenen, and David Alexander of the Central Land Council for their support and guidance. This assessment was supported by the DKCRC camel project, UKTNP, Central Land Council, Greening Australia, and Biodiversity Conservation South (NRETAS).

Appendix 7.2 Camel usage and impacts at a permanent spring in central Australia: A case study.

Tracey Guest[1], Peter Barker[2], Jayne Brim Box[3], Mirjana Jambrecina[4], and Sean Moran[5]

[1, 4] Uluṟu–Kata Tjuṯa National Park, Natural and Cultural Resources, Yulara, NT, Australia

[2] Greening Australia NT, Alice Springs, NT, Australia

[3] Biodiversity Conservation Unit, Department of Natural Resources, Environment and the Arts, Alice Springs, NT, Australia

[5] Central Land Council, Mutitjulu, NT, Australia

Introduction

In May–June 2007, the authors were invited to participate in preliminary discussions with Traditional Owners, staff from Natural and Cultural Resources at Uluṟu–Kata Tjuṯa National Park (UKTNP), and the Central Land Council (CLC) regarding the status (i.e. ecological and cultural health) of 15 waterholes on the Petermann and Katiti Aboriginal Land trusts in the vicinity of UKTNP. At this meeting the Traditional Owners categorised these waterholes as 'good', 'not sure (of status)', or 'in need of help' Shortly thereafter, the authors were invited to visit five of these water bodies that had been categorised as either 'not sure (of status)' or 'in need of help' to determine their ecological health, in collaboration with Traditional Owners and UKTNP staff.

Here we report on the ecological health of one of these water bodies. Because of sensitivities regarding the location and name of the water body, we have not named it in this report. Instead we will refer to it simply as 'X'. X is a small, well-defined spring-fed rockhole and short spring run located on the Petermann Aboriginal Land Trust. It consists of a small pool at the spring head, and a series of small, seasonal shallow pools in a poorly-defined short spring run. Traditional Owners commented that, in regards to local water sites, X was the site most visited by community members, native wildlife, and camels. X is often used as a water source for people travelling through the area.

Traditional Owners suggested X's status was, 'needs help', primarily because they and UKTNP staff had noted heavy usage by camels on previous visits. In order to determine in more detail the impacts that camels were having on X, the following objectives were proposed, in consultation with Traditional Owners:

1. determine the overall water quality, including whether faecal contamination from camels was present.
2. determine if camels were using X as a water source.
3. collect information on the aquatic animals (including frogs) that occur in X to assess whether camels were impacting aquatic animal species occurrences.
4. determine whether camels had impacted the area immediately around X, by conducting a ground cover survey and assessing trampling, browsing, etc.

Methods

A total of ten trips were made to X from May 2007 to July 2008. A list of visitation dates and the data collected at each visit is presented in Table A7.2.1. Physical aspects of the site, including dimensions of the rockhole, downstream pools, and suspected flow paths, were recorded on multiple visits. On each visit, observations were recorded on whether camels or native wildlife were observed near the spring.

Table A7.2.1: Dates of site visits and data collected from X

Date of visit	Data collected
31 May 2007	Site visit with Traditional Owners. Aquatic invertebrates sampled.
04 June 2007	Microbial water sample collected. Aquatic invertebrates sampled.
28 June 2007	Physical measurements of site taken. Aquatic invertebrates sampled.
13 August 2007	Depth logger deployed.
20 November 2007	Data from depth logger retrieved. Microbial water sample collected. Aquatic invertebrates sampled. Ground cover sampled.
18 January 2008	Data from depth logger retrieved. Aquatic invertebrates sampled.
27 February 2008	Cameras installed. Data from depth logger retrieved. Aquatic invertebrates sampled.
28 February 2008	Cameras retrieved.
28 May 2008	Depth logger retrieved.
09 July 2008	Ground cover sampled.

Water quality

Water chemistry was assessed using a Horiba U-10 multi-parameter water quality meter. Conductivity, pH, turbidity, dissolved oxygen, temperature, and salinity levels were recorded at least once, and in most cases on multiple visits. Because camel dung was conspicuous around the spring, and X is commonly used as a source of drinking water by people travelling through the county, water samples were taken in June and in November 2007 for microbial analysis (Table A7.2.1).

Macro-invertebrates

Semi-quantitative collections of macro-invertebrates (and tadpoles, if present) were made on five separate visits (Table A7.2.1). Macro-invertebrates were collected using standard techniques (e.g. Davis et al. 1993). In addition, both day and night samples were collected, as previous sampling efforts in central Australia have shown that this is the most effective means of collecting a representative sample of macro-invertebrates present (Barker & Brim Box 2008). Specimens were preserved and later sorted and identified using available taxonomic keys. Samples are stored at Biodiversity Conservation Unit, Department of Natural Resources, Environment, The Arts and Sport, Alice Springs.

Vegetation and ground cover sampling

Surveys of the area or 'riparian zone' surrounding X were conducted on 20 November 2007 and on 9 July 2008. A line-point intercept method was used to determine vegetation, litter, rock, and soil cover and to interpret erosion processes and where water infiltration occurred (Herrick et al. 2005). A total of 92 (80 cm^2) points from 8 transects were sampled from an approximately 22 m x 8 m area immediately in front of the spring source that was considered the riparian zone.

Water level monitoring and surveillance cameras

To assess whether camels were drinking from X, a HOBO water level logger was deployed on 13 August 2007 (Table A7.2.1). The data logger recorded the barometric pressure, which was later used to estimate changes in water level over time. The data logger was programmed to record a water level every six minutes. Water temperature was also recorded at these times. The data logger was removed on 28 May 2008. In some cases the memory card on the logger filled before data could be downloaded. Therefore, there are a few gaps (e.g. 12–20 November 2007) in the otherwise continuous record.

To check if changes in water level depths corresponded to times when camels were actively drinking from X, two infra-red, motion-detecting surveillance cameras were deployed on the evening of 27 February 2008. Timers on the cameras were coordinated with the water level logger timer on site and immediately before deployment. A night trial was chosen because, based on some of the preliminary water level data, it was suspected that camels were drinking from X more often at night. The cameras were retrieved the following morning.

Data analysis for water level logger

Water level loggers measure absolute pressure (water pressure plus atmospheric pressure). In order to determine water column depth based on water pressure alone, several steps were needed to convert the data to water column depth. These steps are outlined below.

<u>Step 1. Compensate for atmospheric pressure.</u>

This step is needed because atmospheric pressure fluctuates during a 24-hour period. In this case the atmospheric pressure (recorded in 30-minute intervals) collected by the Bureau of Meteorology (BOM) from the Yulara airport was used. The following linear regression was used to compensate for the change in elevation between X (642 m) and Yulara (492 m):

Pressure (mbar) at site X = -0.113(elevation (m)) + 1011.52

<u>Step 2. Estimate atmospheric pressure for time periods not recorded at the Yulara airport.</u>

The water logger recorded absolute pressure in 6 minute intervals, but atmospheric pressure was recorded at the Yulara airport every 30 minutes. To estimate the atmospheric pressure at intervals not recorded by the BOM at Yulara, a linear interpolation was used to estimate the atmospheric pressure between every two time steps recorded at Yulara (e.g. 1:30 am and 2:00 am).

<u>Step 3. Determine water pressure and water column height.</u>

Estimated water pressure for each 6-minute reading was determined by subtracting the estimated air pressure (mbar) from the absolute pressure recorded on the logger. To determine the water column equivalent height for each reading, the following conversion was used (Solinst 2008):

One unit pressure (mbar) = 0.01022 water column equivalent (m)

<u>Step 4. Determine volume of water in X from water column height.</u>

Based on field measurements, it was assumed that X most closely approximated a cylinder. To convert from water column height to litres of water, the volume of water in X was first calculated for each water pressure reading. For example:

If the water column level (h) = 0.642 (m), then volume = $\pi r^2 h$, where,

r = radius of the opening of the rockhole, for X estimated to be 0.2 m,

h = 0.642 m, or estimated height of the water column.

These data (m^3) were then multiplied by 1000 to obtain estimated litres of water at each time step.

Results and discussion

Water quality

The results of the microbial analyses of water samples are in Table A7.2.2. On the first date (5 June 2007), two samples were taken: one from a pool that had formed directly below the spring [(*a*) in Table A7.2.2 below] and where camel dung was obvious, and one from the spring source [(*b*) in Table A7.2.2 below]. The third sample was taken from the spring source after moderate rains in November [(*c*) in Table A7.2.2 below].

Table A7.2.2: Faecal coliform results for water samples taken from X

Date	Time sampled	Temp (°C)	Coliform per 100 ml	*E. coli* per 100 ml	Plate count organisms	Drinking mode
5/6/2007 (*a*)	19:30	10.9	>2420	>2420	2940	no
5/6/2007 (*b*)	19:30	16.8	2420	0	1750	yes
20/11/2007 (*c*)	18:20	27.2	>2420	1986	>10 000	no

Drinking Mode was determined using guidelines developed for the Northern Territory.

Faecal contamination was detected on both dates that samples were taken. However, on the first date (5 June 2007) faecal coliforms were only found in the pool below the spring (Table A7.2.2). It is not surprising that faecal contamination was present in the lower pool in June 2007, as the water was green in that pool and camel dung was obvious. Faecal coliforms are thought to only live for a short time outside an animal's gut, and these results suggest that camels, and possibly other animals and birds, were visiting the waterhole at this time. In comparison, the water was clean in the spring source and considered drinkable based on water quality guidelines for the NT.

In November 2007, however, faecal contamination was detected in the spring source and the water would not have been considered drinkable. Interestingly, this faecal contamination was not obvious; the water was clear (i.e. turbidity was 2 NTU) and no camel dung was apparent in the rockhole.

Faecal coliforms include bacteria that originate in faeces (e.g. *Escherichia coli*) as well as bacteria (e.g. *Citobacter*) that are found in faeces but are also commonly found in water, soils, and wastewater. Faecal coliform counts are intended to indicate faecal contamination, and the presence of *E. coli* is used as an indicator or surrogate microorganism for other pathogens (e.g. protozoans) that may be present in a water body but are not measured (for a comprehensive treatment of microbial safety of drinking water see Dufour et al. 2003). Waterborne pathogenic diseases can lead to a wide variety of human health problems, including hepatitis A, ear infections, and gastroenteritis.

High faecal counts are potentially harmful to humans if they indicate other pathogens are present. In addition, high faecal counts can also be detrimental to overall water quality and animals that are found in those waters. For example, organic matter that may accompany or be the source of faecal coliforms can lead to reduced dissolved oxygen levels when this matter decomposes. Low dissolved oxygen levels can harm aquatic animals, especially those that are sensitive to changes in water quality. Organic matter is also often acidic and can lower the pH of water. Such changes in pH can adversely affect water quality and aquatic lifeforms.

Vegetation and ground cover sampling

The first vegetation survey (20 November 2007) was conducted following moderate rains in early and mid-November. Camels had apparently dispersed from X from 30 October –12 November, based on water level logger data (Figure A7.2.1) (no data were recorded from 12 November until the vegetation survey was conducted as the data logger memory card was full). The second survey (9 July 2008) was conducted following a dry period and associated heavy camel usage at X.

In November 2007 there was 11% herbaceous cover and 13% grass cover at the site (Table A7.2. 3). Camel dung was found at 51% of the points sampled (Table A7.2.3). In July 2008, during a period of suspected heavy use by camels, herbaceous plants, and/or grasses were found in only 5% of the points sampled, a 19% reduction from the November survey, while camel dung was found in almost 80% of the area sampled. Shrubs in the rocks above the waterhole were observed to be heavily browsed in July 2008, and in some cases branches were broken off. Only one non-native plant (a grass) was found during the November 2007 survey.

These findings are consistent with other anecdotal observations made at the site. In February 2008 little ground vegetation was obvious at the site, and the small pools that normally occurred below the spring source were dry and filled with sediment and camel dung. If camels were to be excluded from this site in the future (e.g. through fencing), additional line-point intercept surveys could be used to evaluate changes and recovery of ground cover and vegetation.

Table A7.2.3: Results of line-point intercept survey conducted in the weeks following moderate rains in November 2007, and during a dry period with heavy camel use in July 2008

Cover type	Total % pts containing cover type (November 2007)	Total % pts containing cover type (July 2008)
Bare soil/rock	93	47
Camel dung	51	78
Herbaceous	11	1
Grasses	13	4
Sedges/Rushes	0	0
Lower shrubs	0	0
Upper shrubs	2	1
Trees	0	0

Note: Multiple hits were possible for each point taken and so figures sum to more than 100% for each survey.

Macro-invertebrates

Very few macro-invertebrates were found in X. The highest species richness recorded was three: mosquito larvae, non-biting midge larvae, and dragonfly larvae were the only macro-invertebrates found. On three sampling occasions no macro-invertebrates were found.

Mosquito larvae and some types of non-biting midge larvae are, in general, tolerant of poor water quality and stagnant conditions. It is not surprising that the macro-invertebrate fauna of X could be considered depauperate, as large daily water fluctuations are undoubtedly problematic for species that need at least some habitat stability. However, to find no macro-invertebrates in a naturally occurring waterhole is unusual for central Australia, especially in a waterhole where the overall water quality (e.g. freshness or low dissolved ions) could be considered good. At other sites in central Australia, macro-invertebrate species richness generally ranged between 4–64 species per site (Box et al. 2008).

Water level monitoring and surveillance cameras

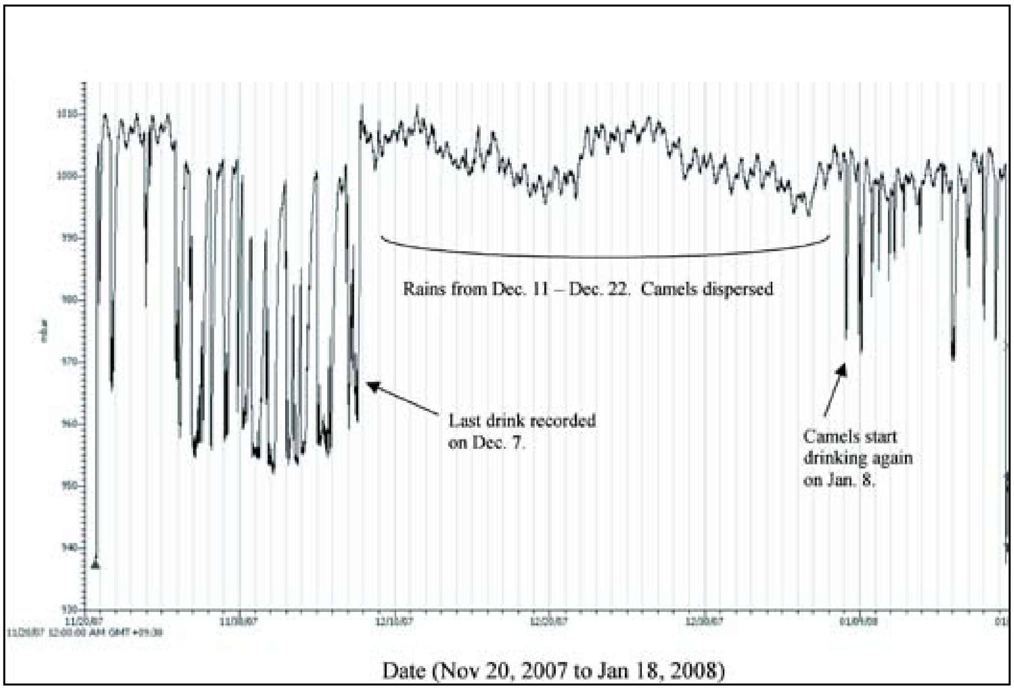
About 64 000 water level readings were recorded over the 9.5-month period the logger was deployed. There were two instances where the logger memory reached capacity (i.e. between 12 November 2007 at 5 am and 20 November 2007 at 6:39 pm [9 days], and from 19 February 2008 at 4:32 am and 27 February 2008 at 7:32 pm [9 days]).

Based on physical measurements, it was estimated that X held ~120 litres of water when full. Because of debris and the contours of the rockhole, it is impossible to know if the data logger was resting on the absolute bottom of the rockhole, or how accurate our calculations are in regards to estimating the total volume of X. In addition, although one of the aims of this project was to obtain estimates of how much an individual camel could drink in one sitting, it became obvious that the total volume of X was too small to accurately make these estimates.

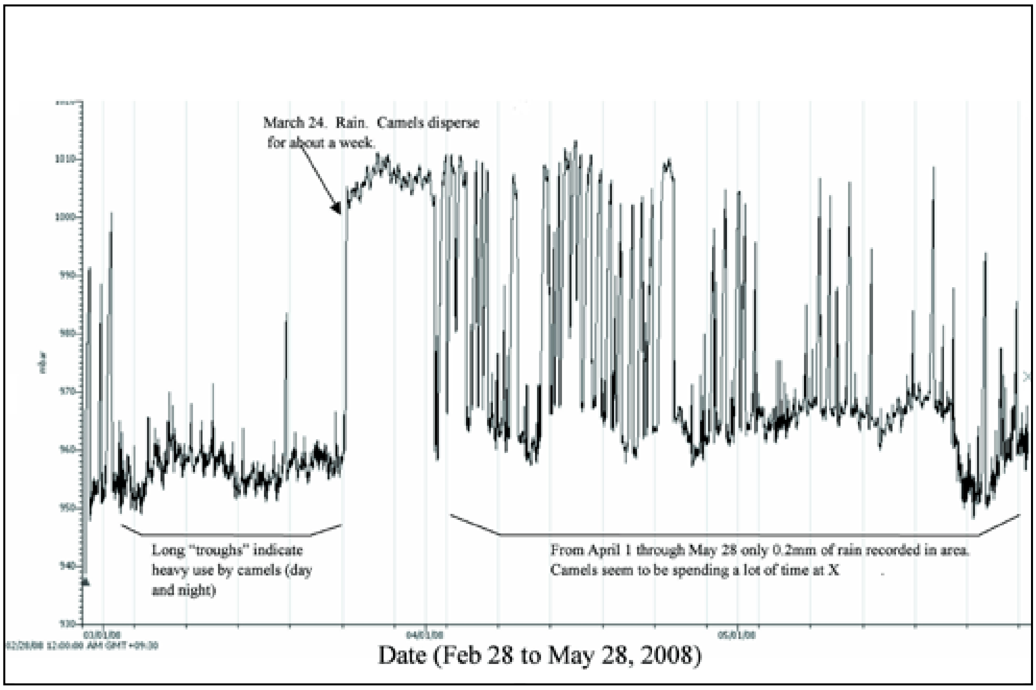
Water levels varied considerably over the period of record. The lowest levels (~3 litres) were recorded in September 2007 and January 2008. The highest level (~91 litres) was recorded in December 2007. Although small fluctuations were probably due to changes in barometric pressure and/or native animals drinking, and in some cases may have been due to people re-filling their water supplies, there are no other large feral or domestic herbivores in the area that could remove large volumes of water. Therefore, the large fluctuations in water levels recorded were assumed to be caused by camels drinking the water. To test this assertion, surveillance cameras were used for a 12-hour trial period (see below).

Figure A7.2.1 illustrates how water levels varied over two extensive periods during the study. Changes in water levels varied by month, diurnally, and before and after rain events. In general, camels appeared to use X more often during low rainfall periods, and dispersed from X in the days immediately before a rain event, for weeks at a time. It is probable that as less permanent sources of water dried, they returned to permanent waterholes like X.

The average monthly amount of water in X was significantly correlated ($p < 0.05$) with the amount of monthly rainfall (Figure A7.2.2). There could be two reasons for this. First, recharge rates into X are probably higher after rain events, especially if some of the groundwater recharge is from stored surface water. If these recharge rates are exceptionally high then even if camels were drinking, recharge may be high enough to replace water as it is being removed by camels. This scenario seems unlikely given the small size of X, estimates of how slowly it refills (see below), and how quickly camels are able to draw down the waterhole. Second, camels may move away from X during and after rain events in search of food because water is no longer a limiting factor.



(a)



(b)

Figure A7.2.1: Examples of long-term water usage patterns by camels at X

Note: (a) 20 November 2007 – 19 January 2008, (b) 28 February 2008 – 28 May 2008. In (a), it appears that camels used X until the afternoon of December 7. A small amount of rain fell on 11 December (< 1mm) and on 12 December over 20 mm of rain fell in the area. By then, camels were no longer drinking from X. In (b) camels used X almost continuously in early March, until rains on 24 March. Camels appeared to disperse for about a week after that rain event.

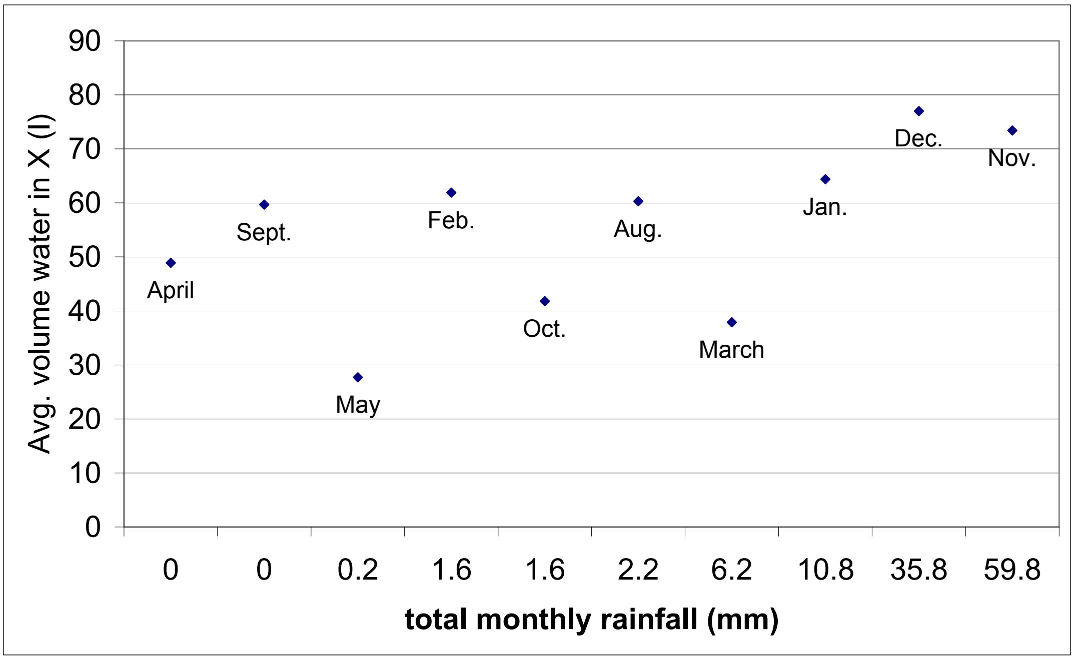


Figure A7.2.2: Average monthly water volume in X

Note: Total monthly rainfall was significantly positively correlated ($p < 0.05$) with the volume of water in X. In general the greater the monthly rainfall, the less camels used X as a source of water.

Camels also appeared to spend more time at X at night than during the day. The volume of water in X was significantly less during the night than during the day for each month sampled (two sample t-test assuming unequal variances. Note: a large number of samples were taken each month) (Figure A7.2.3).

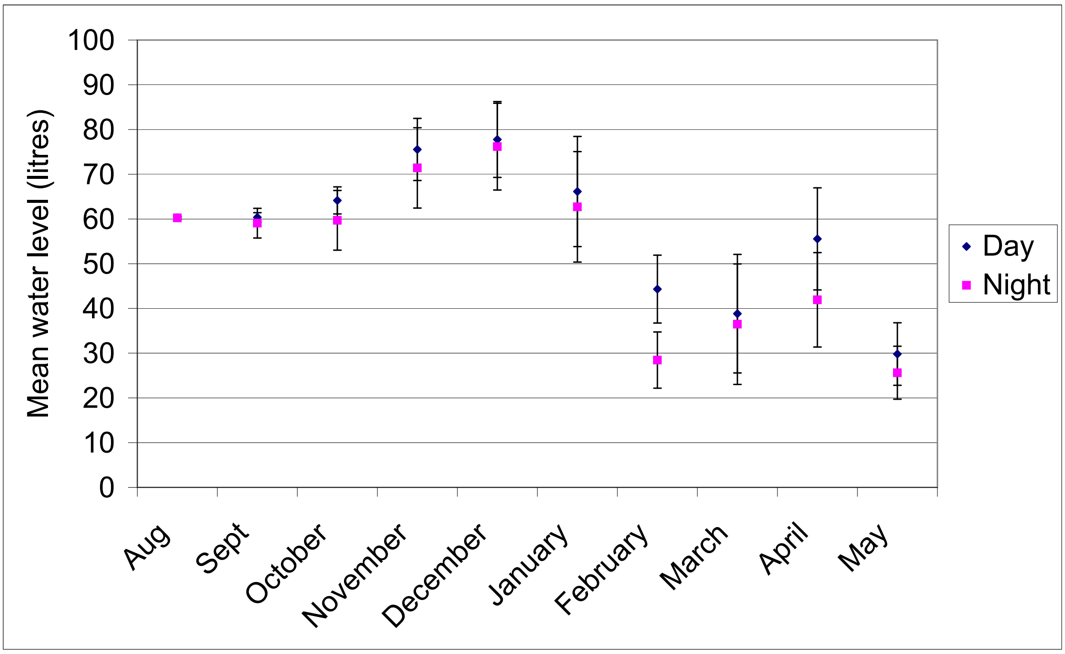


Figure A7.2.3: The mean monthly water levels (with SD) recorded

Note: Significantly more water ($p < 0.05$) was in X during the day than night periods, suggesting that X was used more heavily by camels at night.

At least 10 camels were present when the authors arrived on the evening of 27 February to install the cameras at X. X was near empty at this time. The camels were scared off by the arrival of people, allowing X to slowly re-fill. The depth recorder was re-deployed at 6.54 pm, following which the research team departed (at about 7.15 pm). Over 11 000 images were recorded on the surveillance cameras during the subsequent 12-hour period. Almost all of these pictures were of camels standing or drinking at X (Figure A7.2.4). At least one dingo visited twice during the night.

Based on recorded images, camels returned to X at about 8.20 pm. Between 6.54 and 8.20 pm, X had re-filled about 19 litres (Figure A7.2.5). Camels started drinking from X at about 8.36 pm. Between 8.42 and 8.48 pm, about 14 litres of water had been removed. The amount of water in X remained low all night (Figure A7.2.5), most probably because of camels drinking it. After people arrived the next morning at about 6.55 am the camels departed, allowing X to again slowly re-fill. It is estimated that X recharged at a rate of about 10 litres per hour, based on data logger measurements and physical measurements on site. The recharge rate, however, will undoubtedly fluctuate with time of year and rainfall.

The apparent ability of camels to keep the water level in X at low levels for extended periods (Figure A7.2.5) may have adverse effects on native wildlife that relies on this water. Not only may small mammals, macropods, and birds be unable to reach deep into the waterhole to obtain water, the low water levels maintained by camels prevent the overflow that usually forms small accessible pools below the spring source at this site.

Figure A7.2.4: Photos taken by surveillance camera on 27–28 February 2008

Note: The image at 10.00 pm shows a camel biting another camel to prevent it from drinking. A dingo visited the waterhole twice, once before camels arrived and once while they were present. About 11 000 images were taken in the 12-hour trial.

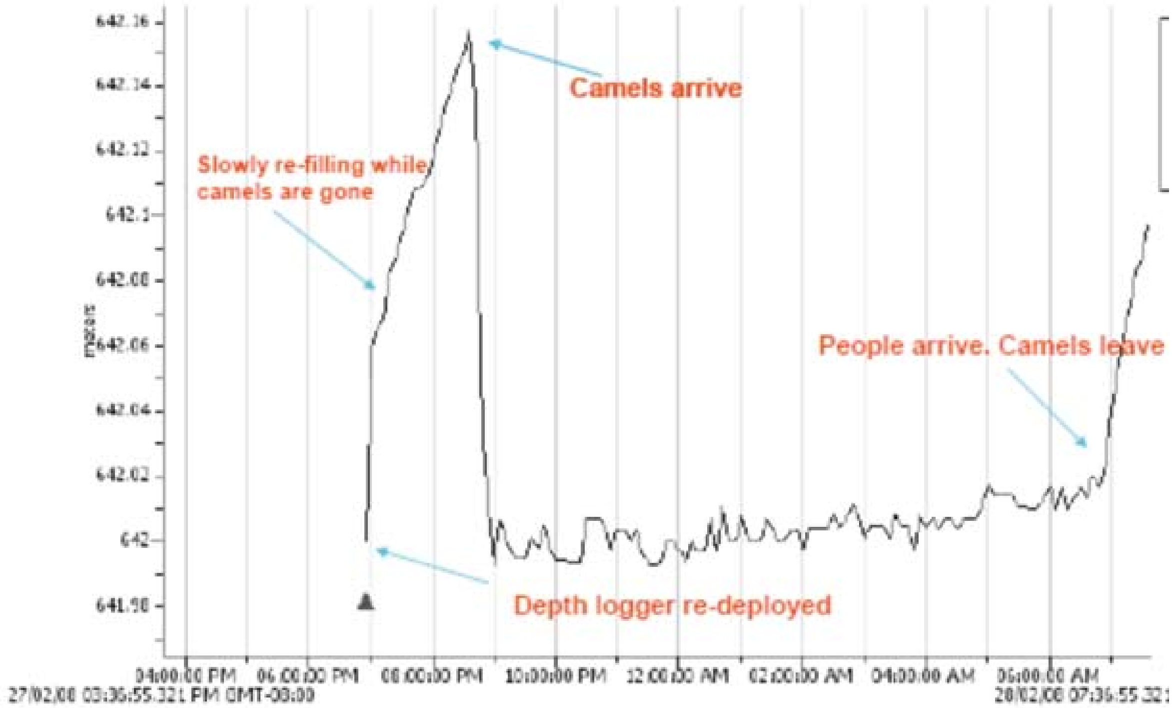


Figure A7.2.5: Changes in water levels before and after camels visit X on 27–28 February 2008

Note: Between 8.36 pm and 8.42 pm the water level starts to drop. By 9.00 pm about 25 litres has been removed. Water levels are kept low all night by camels drinking. After people arrive at 6.55 am the water level starts to rise, and by 7.42 am the water level had risen about 12 litres (i.e. recharged).

Conclusions

It is apparent that camels have multiple significant impacts on X. Camels appear to use X most heavily in periods when rainfall is scant, and more at night than during the day. However, in long periods with little or no rainfall, it appears that camels use X heavily during the day and night, and there is little chance for X to re-fill. Consequently, small pools that form when X is full, and can be readily accessed by native wildlife, are dry and filled with soil and dung during periods of heavy camel use. This lack of access to an otherwise permanent waterhole may have negative impacts on native animal species that rely on this water. In addition, the low number of macro-invertebrates present during the study period suggests that the aquatic fauna is also negatively impacted by the presence of camels.

Not surprisingly, the vegetation surrounding X was found to be heavily impacted by camels. Shrubs near X showed signs of heavy browsing, and the ground cover became mainly denuded of vegetation due to camel browsing and trampling during dry periods. This could lead to long-term alternations in drainage patterns and erosion of the site. Follow-up vegetation and ground cover surveys are needed to better assess these impacts.

X was and is a traditional source of drinking water for people travelling through the country. Preliminary microbial analysis indicates that at certain periods X is not suitable for drinking, even if the water itself looks ‘clean’ or clear. The faecal contamination evident was most probably due to camel use of the waterhole. These results have been discussed with Traditional Owners, but further microbial analyses may be needed for longer-term assessments.

Acknowledgments

We thank and greatly appreciate the guidance, discussions with, and participation of the following Traditional Owners and Mutitjulu community members during our visits; Cassidy Uluṟu, Reggie Uluṟu, Steven Uluṟu, Johnny Jingo, Wangan No.1., Ashely Paddy, Lochlan Jingo, David Moneymoon, Robert

Sevens, Rene and Richard Kulitja, Joyce Tjiliri, Wionna Palma, Selwyn Kurukringa, Pamala Ray, and Bessie Nipper. We thank Daisy Walkabout, Phillip Driften, Sam Steel, Niall Stephen, Amber Forbes, and Steve Anderson of UKTNP for their field and office help, insights, and support for this assessment. We especially thank Rene and Richard Kulitja for their help and insights regarding rockhole X. We thank Andrew Drenen and David Alexander of the Central Land Council for their support and guidance. This assessment was supported by the DKCRC camel project, UKTNP, Central Land Council, Greening Australia, and Biodiversity Conservation South (NRETAS).

Chapter 8:
Review of non-commercial control methods for feral camels in Australia

WK Saalfeld

B Zeng

Contributing author information

Keith Saalfeld: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia.

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Contents

Tables

Figures and graphs

List of shortened forms

ALT	Aboriginal Land Trust
APAS	*Australian Pest Animal Strategy*
APY	Anangu Pitjantjatjara Yankunytjatjara
CAT	Centre for Appropriate Technology
CDEP	Community Development Employment Project
CLC	Central Land Council
FAAST	Feral Animal Aerial Shooter Training
GIS	Geographic Information System
GPS	Global Positioning System
IPA	Indigenous Protected Area
NRM	Natural Resource Management
SLR	Self-loading rifles
SSCAW	Senate Select Committee on Animal Welfare
UKTNP	Uluru–Kata Tjuta National Park
VPC	Vertebrate Pests Committee
VRD	Victoria River District

Acknowledgements

This report is Chapter 8 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of Desert Knowledge CRC or its participants.

We would like to thank Mr. Phil Gee from Rural Solutions SA, Mr David Oag from the Department of Primary Industries and Resources SA, Mr Kym Schwartzkopff from the Department of Natural Resources, Environment, The Arts and Sport NT and Mr Phil Duffield from the Sporting Shooters Association of Australia NT for their valuable insights into both procedures and costing for helicopter and ground shooting operations for feral camels, and Dr Tony Pople for his review of the chapter and many valued suggestions to improve the content.

Chapter 8: Review of non-commercial control methods for feral camels in Australia

1. Summary

Current management of feral camels falls far short of an integrated management approach, with limited integration of different control methods or across jurisdictions (Edwards et al. 2004, Norris & Low 2005) and, to date, having had little effect on population growth or in mitigating camel impacts.

A range of control methods, both commercial and non-commercial, are available for the management of feral camels, and most have been implemented to some extent. This chapter reviews non-commercial control methods which can be applied to mitigate the negative impacts of feral camels.

To date non-commercial control has primarily consisted of aerial platform (helicopter) shooting, ground-based shooting, and exclusion fencing. Chemical (poison), biological, and fertility controls are not currently in use, although a review undertaken for this project (Lapidge et al. 2008) has identified a number of potential avenues for further consideration.

Of the three non-commercial methods in current use, aerial shooting is the most widely implemented by management agencies. The majority of ground-based shooting is opportunistic in nature and implemented individually by pastoralists rather than by management agencies. Fencing has been limited to a number of waterholes of both cultural and conservation significance in central Australia.

Aerial shooting has been identified as the non-commercial control method with the greatest applicability (Edwards et al. 2004, Norris & Low 2005) to broadscale feral camel management. The cost range reflects the availability of animals at different densities. Although the detailed nature of the cost density relationship is unknown for camels, indicative costs are \$20–\$30 per animal at high density (densities greater than 0.3 animals/km^2); \$40–\$100 per animal for densities in the range 0.3–0.1 animals/km^2; and a cost per animal greater than \$100 for densities less than 0.1 animals/km^2.

The limitations of ground-based shooting compared with aerial shooting include restricted access to animals and reduced ability to remove large quantities of animals. Ground-based shooting has limited applicabilty for broadscale population reduction and will primarily fill a long-term management role of maintaining low density populations through opportunistic shooting integrated with other activities.

The high cost of fencing, particularly for areas greater than a few hectares, and the fact that fencing does not affect population size and growth, greatly limits the applicability of fencing in managing the impacts of feral camels. Fencing is primarily applicable to the protection of high value cultural and conservation assets where the total exclusion of feral camels is mandatory to prevent any damage to the assets. Fencing is not considered a broadscale management tool.

1.1 Recommendations

- That aerial shooting from helicopters is recognised as the optimal control action to achieve large population density reductions over broadscale areas, particularly in short time frames, and the only available control action that can be used in very remote or inaccessible areas.
- That aerial shooting from helicopters be based on specific targets and outcomes and that to achieve this objective, removed and final population densities must be known, requiring pre- and post-control population monitoring.
- That any proposed camel management program, particularly involving aerial shooting, must be fully funded and adequately resourced to meet the proposed outcomes, including all monitoring requirements.

- That it is recognised that effective management of camels and their impacts will involve the integration of all available control methods, both non-commercial and commercial, and that the development of scale-dependent, multiple outcome management plans integrated into the national framework will be key to the effective management of feral camel impacts in Australia.
- That it is recognised that ground-based shooting has limited applicabilty for broadscale population reduction and will primarily fill a long-term management role of maintenance of low density populations through opportunistic shooting integrated with other activities.
- That it is recognised that exclusion fencing is not a broadscale level management tool. Fencing is likely to be most effective when applied at the local scale to protect high value assets.
- That the following techniques are investigated further for the chemical, biological and fertility control of camels:
    - Low concentration delivery of nitrite or 1080 in raised water troughs. This may be made more specific if delivered at salt lakes where fresh water is more desirable for camels and species diversity is lower.
    - Delivery of sodium or potassium nitrite via a camel-specific feeding trough or raised salt lick at natural congregation points. Potassium chloride or 1080 may act synergistically with nitrite, which would lower the dose required and shorten the time to death.
    - A combination of potassium chloride with a diuretic, with and without a nephrotoxic agent such as banamine and phenylbutazone, should be examined further as it may prove uniquely toxic to camels.
    - Camelpox is worthy of further investigation, particularly in reference to its spread in more natural nomadic camel populations within the species range and the humaneness of the virus. Regardless, camelpox is unlikely to be the ‘calicivirus’ of camels in Australia, and would be principally introduced to limit population recruiment (following Lapidge et al. 2008).
    - An immunocontraceptive vaccine technology that is orally active and has a species-specific immunogen is favoured for fertility control. Research into a feral pig anti-fertility vaccine that can be used as a platform from which to undertake similar research in camelids holds the greatest hope for this in the immediate future but requires funding for extension of the work into camels.
    - Three other novel approaches to manipulating fertility warrant attention: phage panned peptide technology, the Talwar protein, and antigen delivery systems such as bacterial ghosts.

2. Current feral camel management context

Feral camel management is currently carried out in what can only be described as an ‘ad hoc’ approach (Edwards et al. 2004, Norris & Low 2005), with limited cross-jurisdictional coordination to date (Norris & Low 2005) and having little impact on populations overall (Edwards et al. 2004, Ward 2007).

Based on current distribution and abundance, camels are not considered a major problem in either New South Wales (NSW) or Queensland (Qld) at present, and little or no coordinated government management is being undertaken in these jurisdictions apart from maintenance of the existing dog fence. In Western Australia (WA), South Australia (SA), and the Northern Territory (NT), where camels are recognised as a significant feral animal, there has been a limited amount of government management, primarily aerial surveys to determine distribution and abundance, opportunistic culling programs, commercial harvest, and fencing off of waterholes (Norris & Low 2005). Additionally, pastoral managers across all jurisdictions have undertaken limited control of feral camels on their properties, primarily opportunistic shooting but with some coordinated government actions (Norris & Low 2005, Gee & Greenfield 2007, Zeng & Edwards 2008a).

On the basis that the camel population is doubling every nine years (McLeod & Pople 2008) and a current population estimate of about one million animals (Saalfeld & Edwards 2008), management activities need to remove at least 80 000 animals annually to maintain the current population.

Given that the assessment of current feral camel negative impacts (Edwards, Zeng & Saalfeld 2008) indicates an urgent requirement for reduction of these impacts in certain locations, it is likely that substantially more than the estimated minimum of 80 000 camels will need to be removed annually for a period of years to maintain current population levels if current population densities and resulting impact are to be reduced to acceptable levels.

The current limited market for the commercial utilisation of feral camels (Ellard & Seidel 2000, Warfield & Tume 2000, Edwards et al. 2004, Norris & Low 2005) and the projected lengthy time frame to develop the commercial utilisation market (Zeng & McGregor 2008) means that a substantial requirement for non-commercial control methods for the management of feral camels exists and will continue to exist for some time.

At present, commercial utilisation removes 5000–6000 feral camels annually across the Australian distribution (Zeng & McGregor 2008), leaving a shortfall of a minimum of 75 000 animals needing to be removed annually to maintain current population levels. Available reporting puts the current non-commercial removal at between 10 000 to 20 000 animals annually covering all land tenures (Figures 8.1 & 8.2) resulting in a shortfall of a minimum of 55 000 animals needing to be removed annually to maintain current population levels and potentially substantially more than this to achieve desired management outcomes (Edwards, Zeng & Saalfeld 2008, Drucker 2008). Currently, this shortfall can only be addressed through non-commercial control methods. In the medium to longer-term, commercial utilisation may play an expanded role in the management of feral camels if markets can be expanded (Zeng & McGregor 2008).

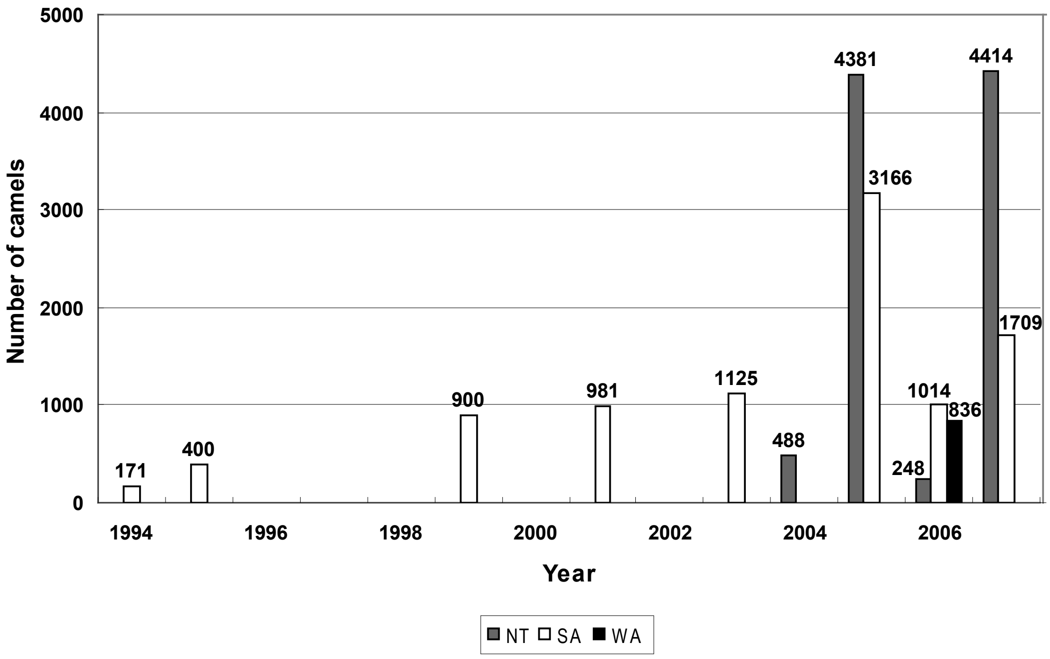


Figure 8.1: Camels removed via non-commercial control in the NT, SA, and WA from available records

Source: (Ward & Burrows 2007, Gee & Greenfield 2007, Oag 2008, S Eldridge 2007, Consultant, Desert Wildlife Services, pers. comm., Kym Schwartzkopff 2007, Wildlife Officer, NRETAS, pers. comm.).

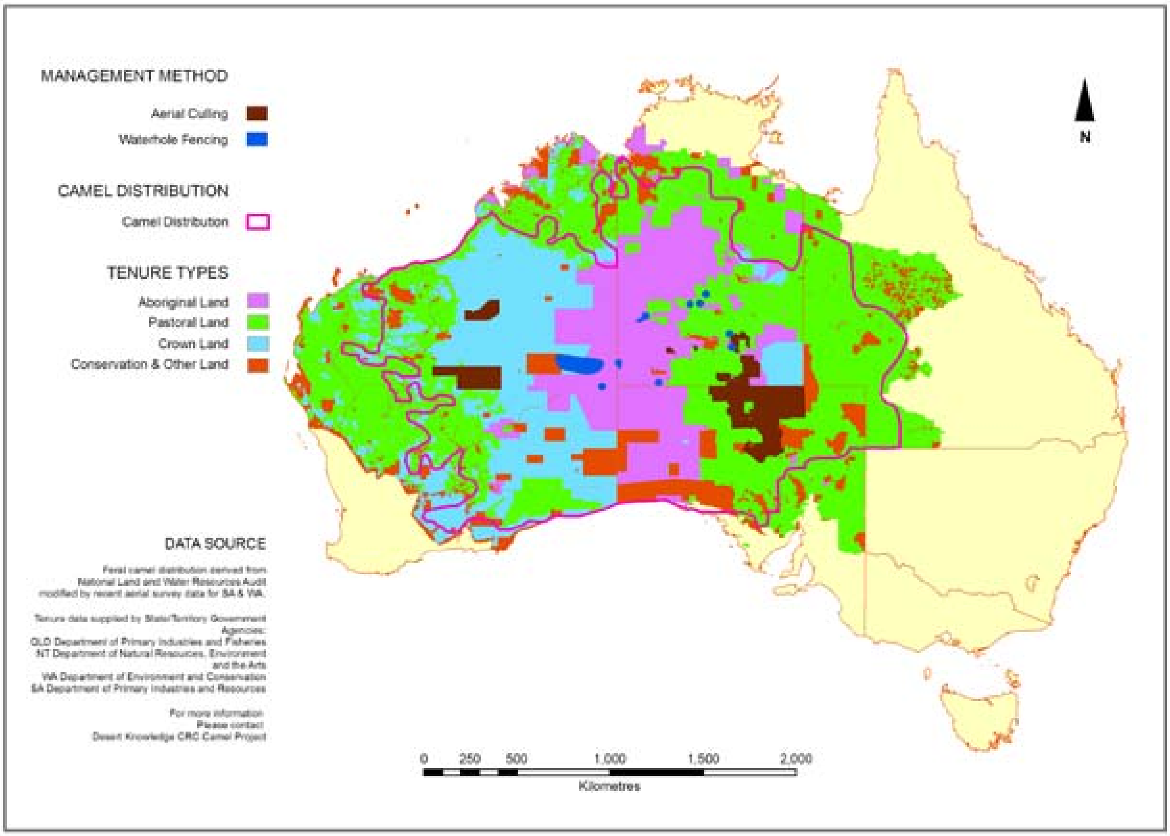


Figure 8.2: Locations of government-managed aerial culling operations and waterhole fencing projects for feral camels since 2001

Gee and Greenfield (2007) state that 72.5% of pastoralists in the South Australian Arid Lands NRM Region opportunistically cull camels on their properties by shooting them from vehicles. Approximately one-third of these properties have reportedly removed more than 100 camels over the last five years (Gee & Greenfield 2007). Pastoralists in both the NT and WA also remove camels through ground-based shooting for non-commercial purposes; however, available records are insufficient to estimate numbers.

In order to meet a minimum management outcome of keeping the current feral camel population stable, a near order-of-magnitude increase in the effort invested in non-commercial control methods is immediately required. This near order-of-magnitude increase in the effort reflects the requirement to increase non-commercial removal from the current level of 10 000 to 20 000 annually to at least 75 000 as determined above. Associated with this would be the requirement for a near order-of-magnitude increase in the level of funds expended on non-commercial control methods.

In this report we review non-commercial control methods which can be applied to mitigate the negative impacts of feral camels.

2.1 Legal status

Primary responsibility for the management of feral animals and the prevention of cruelty to animals lies with individual state and territory governments (SSCAW 1991, Braysher 1993, Dobbie et al. 1993). Individual landholders are responsible for the management of feral animals on their lands, and state and territory governments have the legislative capacity to require landholders to manage feral animals on their lands (Braysher 1993). The Australian Government is responsible for feral animal management on lands it manages, in the scope of animal import and export and exotic disease prevention and control (Braysher 1993, Dobbie et al. 1993).

A detailed review of all Commonwealth, state and territory legislation that has any role in the declaration and management of feral camels in Australia has been undertaken and is reported in Carey, O'Donnell, Ainsworth, Garnett, Haritos, Williams, Edwards, McGregor and Zeng (2008), and in Carey, O'Donnell, Ainsworth, Garnett, Haritos and Williams (2008).

The legislation review (Carey, O'Donnell, Ainsworth, Garnett, Haritos and Williams 2008) clearly identifies a range of Commonwealth and individual state and territory legislation that rigidly regulates all of the potential control methods, either commercial or non-commercial, that may be used in the management of feral camels.

2.2 Collaboration between jurisdictions

Norris and Low (2005) considered that current management of feral camels is largely ad hoc and that a strategic approach had yet to developed and implemented. They define a strategic approach as management which aims to prevent damage rather than dealing with damage that has already occurred (Norris & Low 2005), and state that camels are fast becoming a lost opportunity for strategic control due to rapidly increasing numbers.

Braysher (1993) identifies the core components of a strategic pest management plan as:

- define the problem
- define the objectives, performance criteria, and criteria for failure
- identify and evaluate available management actions
- implement management actions
- monitor and evaluate implementation against objectives.

The need for a strategic approach to the management of all of Australia's vertebrate pest animals, including the feral camel, has been clearly recognised by the Commonwealth and the individual states and territories through the development of the *Australian Pest Animal Strategy* (APAS) (2007).

Developed by the Vertebrate Pests Committee (VPC) of the Natural Resource Management Ministerial Council – an Australasian committee with membership of each state and territory, the Australian Government, New Zealand, CSIRO, and the Invasive Animals CRC – the APAS seeks to address the undesirable economic, environmental, and social impacts of vertebrate animals (*Australian Pest Animal Strategy* 2007). The goals of the APAS and the associated objectives, actions, and outcomes clearly recognise the need for and provide mechanisms to achieve a strategic approach to the management of vertebrate pest animals across Australia. Integral to this, and recognised in objective 1.2 of the APAS 'to ensure nationally consistent pest animal management approaches are in place at all scales of management', is the need for coordination and collaboration between all jurisdictions.

Recognition of the need for collaboration and coordination of feral camel management across both jurisdictions and stakeholder groups was one of the major outcomes of the Feral Camel Action Plan Workshop (Edwards 2005). The recommendations and associated actions and research reported in the workshop outcomes are consistent with the objectives and actions contained within the APAS.

The APAS and the Feral Camel Action Plan Workshop identify a range of actions to achieve collaboration and coordination of pest animal (including camel) management across Australia. Actions include:

- Establish an implementation group to oversee delivery of the *Australian Pest Animal Strategy*. By extension this would require establishing a national group to oversee the development and implementation of feral camel management at the national scale. This requirement has been potentially addressed through the establishment of the Steering Committee for the 'Cross-jurisdictional management of feral camels to protect NRM and cultural values' project.

- Establish the position of Coordinator, *Australian Pest Animal Strategy*. The extension of this to feral camel management would be the establishment of a coordinator for the delivery/implementation of the recommendations of the 'Cross-jurisdictional management of feral camels to protect NRM and cultural values' project. This is consistent with the program for the delivery of national coordination in the Australian Weeds Strategy through the Weeds of National Significance Program, which includes a coordinator for individual weed species.
- Improve the consistency and effectiveness of pest animal management legislation across Australia. A review of all Commonwealth, state and territory legislation that has any role in the declaration and management of feral camels in Australia was undertaken by the 'Cross-jurisdictional management of feral camels to protect NRM and cultural values' project to identify impediments to a coordinated and integrated national approach (Carey, O'Donnell, Ainsworth, Garnett, Haritos, Williams, Edwards, McGregor and Zeng 2008; Carey, O'Donnell, Ainsworth, Garnett, Haritos and Williams 2008).
- Develop integrated pest animal management plans that are consistent with the principals of the APAS at national, state, territory, regional, and property levels. The 'Cross-jurisdictional management of feral camels to protect NRM and cultural values' project will provide a framework and tools to facilitate the management of feral camels and their impacts at a range of scales.
- Develop nationally consistent codes of practice and standard operating procedures for pest animal management. Nationally consistent codes of practice and standard operating procedures have already been developed for a number of vertebrate pest animals (Sharp & Saunders 2004, Australian Government 2004), and will be developed for all vertebrate pest species (APAS 2007), including the feral camel.

Given the significant emphasis placed on the collaboration and coordination of pest animal, including feral camel, management across Australia, implementation of the above actions is clearly a priority in the development and implementation of management programs for feral camels.

2.3 Availability of resources for feral camel management

Holznagel and Saalfeld (2002) and Saalfeld et al. (2006) indentified the greatest limitation on successfully implementing a control program for donkeys and horses in the Victoria River District of the NT as a failure to recognise and plan for adequate resourcing to achieve the programs target outcomes. Inadequate resourcing is almost invariably a consequence of funding limitations. The majority of feral animal management programs are dependent upon federal and state/territory government funding, and this funding is generally sought by government and non-government management agencies in a competitive process for finite funds. Broadscale feral animal management (i.e. that occurring over large areas; typically >10 000 km^2) is invariably extremely expensive, with program costs of hundreds of thousands to millions of dollars annually (Drucker 2008), amounts which can easily exceed total amounts available for feral animal management from funding agencies. In this circumstance programs often have to be reduced to meet funding constraints.

Adequate resourcing to undertake management will be a core requirement of any integrated management program for feral camels in Australia. To address resource requirements, an audit of available resources should be undertaken covering all jurisdictions. This process should allow for the identification of potential critical areas of resource shortfall which could compromise program delivery.

2.4 Current non-commercial control methods

The suite of non-commercial control methods that are potentially available for use in the management of feral camels consists of:

- aerial platform (helicopter) shooting
- ground shooting
- fencing to prevent access
- baiting/poisoning
- biological control
- fertility control.

Of the above methods, only the first three are in current use and are discussed in detail herein. The final three methods are considered in a ‘Review of Chemical, Biological and Fertility Control Options for the Camel in Australia’, which was undertaken by the Invasive Animals Cooperative Research Centre (Lapidge et al. 2008) and is reported here (section 6.1).

The criteria used to determine which method, or combination of methods, of control are used for a specific management program or management area are highly varied and dependent on a range of factors. This combination of factors used in determining appropriate control methodology is considered in detail in Saalfeld et al. (2008). In summary, the key factors are:

- feral camel density
- land tenure and perceptions/requirements of the landholder
- access to the animals
- access to infrastructure to support control methods
- conservation/natural resource/cultural values impacted by feral camels.

Dobbie et al. (1993), in discussing methods of control for feral horses state, ‘No single method is likely to offer effective control’ and it is reasonable to expect the same to be true for feral camels.

3. Aerial culling

Aerial platform (helicopter) shooting has long been recognised as the only practical method of controlling a number of large vertebrate feral animals, including camels, across large-scale regions, in inaccessible areas, or to achieve rapid density reductions (SSCAW 1991, Dobbie et al. 1993, Edwards et al. 2004, Norris & Low 2005). Norris and Low (2005) identify aerial shooting from helicopters as ‘probably one of the best control techniques for large feral herbivores in the rangelands’.

Significant opposition to the use of aerial platform shooting for control of feral animals exists, particularly among animal welfare organisations worldwide based on perceptions that it is cruel and inhumane (SSCAW 1991, Norris & Low 2005). However, there is a limited recognition by some of these organisations that there are circumstances where aerial platform shooting is the only viable mechanism to achieve control (SSCAW 1991).

This study (Vaarzon-Morel 2008a, 2008b) has indicated that there is widespread and substantial opposition to aerial shooting of feral camels ‘to waste’ exists in Aboriginal communities across the camels range in Australia. This opposition also encompasses ground-based shooting ‘to waste’ and derives primarily from the Aboriginal cultural perspective that camels are a part of the environment and hence have both a role to play in the environment and also serve as a resource to be used (Vaarzon-Morel 2008a). It is important to note that Aboriginal people do not oppose the shooting of camels per se; it is the issue of wastefulness that they are mostly concerned with.

At present the criteria used to determine whether on not aerial platform shooting of feral camels is undertaken generally comes down to four factors:

1. whether the landholder(s) wishes to use commercial or non-commercial control methods
2. the accessibility of the animals
3. the density of animals to be controlled
4. the level and speed of density reduction required.

Given the broad distribution of the feral camel across Australia's rangelands, with highly variable density at both the local and the broadscale (Axford et. al 2002, Edwards et al. 2004, Peeters et al. 2005, Lethbridge 2007, Ward 2007), and the wide range of ground accessibility from easily accessible to inaccessible (SSCAW 1991, Edwards et al. 2004), aerial platform (helicopter) shooting of feral camels will undoubtedly play a major role in their management into the foreseeable future.

3.1 Description of methods

Aerial platform (helicopter) shooting involves the use of a helicopter flying at low-level altitude and low velocity to position a marksman relative to the target animals so as to have a clear and unimpeded shot to obtain a humane kill. Both the helicopter pilot and marksman have to have undertaken appropriate specific training and received recognised accreditation before engaging in aerial shooting operations (SSCAW 1991).

A Code of Practice for the control of camels and a Standard Operating Procedure for the aerial platform (helicopter) shooting of feral camels are under development. These documents are expected to closely align with the existing *Model Code of Practice for the Humane Control of Feral Horses* and *Standard Operating Procedure for the Aerial Shooting of Feral Horses* (Sharp & Saunders 2004, Australian Government 2004).

Using the *Standard Operating Procedure for the Aerial Shooting of Feral Horses* as a model, a proposed draft operating procedure has been developed for feral camels and is included in Appendix 8.1.

In addition to using the helicopter as a shooting platform, the use of a single engine, fixed high-wing aircraft (e.g. Cessna 172, 182) as a spotter aircraft to locate groups of animals and direct the helicopter to them is strongly recommended. While this is not essential at high animal densities when groups of animals can be quickly located by the helicopter at low altitude with minimal search time, it can significantly increase operational efficiency at lower animal densities by minimising the search time of the helicopter. The spotter aircraft must operate at sufficient altitude above the operational altitude of the helicopter and with sufficient lateral clearance to ensure safe operations. Pilots of both aircraft should maintain constant radio contact (preferably on a dedicated frequency to ensure clear communications), and should maintain regular visual contact.

3.2 Cost and effectiveness

While helicopter shooting may be the only practical method for the control of feral camels across large-scale regions, in inaccessible areas, or to achieve rapid density reductions, the cost of helicopter shooting is highly variable dependent upon density. When animal densities are high it can be a cost-effective way to quickly reduce animal numbers; however, at lower densities the cost per animal can become prohibitive (Norris & Low 2005).

The cost of two recent aerial control operations for feral camels, one in WA in 2006 (Ward & Burrows 2007) and one in SA and the NT in 2007 (Oag 2008; David Oag 2007, Pastoral Inspector, SA Department of Primary Industries and Resources, pers. comm.; Kym Schwartzkopff 2007, Wildlife Officer, NRETAS, pers. comm.), are presented in Table 8.1. Cost per animal for each of these and other aerial control operations is summarised in Table 8.2. Note that, although these operations were focused on feral camels, other large herbivore pests were also shot where the opportunity arose.

Table 8.1: Total cost for the control of feral camels using helicopter shooting

Helicopter shooting operation (Reference)	Operational component	Component cost $	Component amount	Total cost $
WA 2006 (Ward & Burrows 2007)	Helicopter and aircraft		5 days	45 650
	Other		5 days	33 350
	Total		**5 days**	**79 000**
SA 2007 (Oag 2008, David Oag, pers. comm.)	Helicopter (Robinson R22)	$375/hr (GST inc)	8 hrs/day	3000
	Fuel (Avgas)	$2/ltr (GST inc)	40 ltrs/hr	640
	Ammunition	$0.80/round (GST inc)	3 rounds/animal (250 animals/day)	600
	Marksmen	$300/day	2	600
	Onground support	$300/day		300
	Station accommodation	$80/day (camp allowance)		80
	Aerial support (spotter plane)	$200/hr	8 hrs/day	1600
	Ground support by stations	$100/day		100
			total per day	**6920**
	Oct07		**3 days**	**20 760**
	Nov07		**9 days**	**62 280**
	Total		**12 days**	**83 040**
NT 2007 (Kym Schwartzkopff pers. comm.)	Helicopter (Robinson R44) + 1 marksman		2 days	25 085
	Total		**2 days**	**25 085**

Note: data derived from two recent helicopter shooting operations (Ward & Burrows 2007, Oag 2008).

Table 8.2: Cost per animal for the control of feral camels using helicopter shooting

Helicopter shooting operation (Reference)	Location	No. days	Area (km^2)	Number of animals/number of camels killed	Density reduction (animals/km^2)	Total cost $	Cost per animal/camel $
WA 2006 (Ward & Burrows 2007)	Lorna Glen region	5	13 965	1416/836	0.11	79 000.00	55.79/94.50
SA 2007 (Oag 2008, David Oag pers. comm.)	Simpson Desert	3	29 792	300/300	0.01	20 760.00	69.20/69.20
	Marla Oodnadatta Region	9	52 750	2079/1709	0.03	62 280.00	26.96/36.44
SA 2006 (David Oag 2007 pers. comm.)	Rangelands Action Project	N/A	30 125	1248/1014	0.03	20 624.00	16.53/20.34
SA 2005 (David Oag 2007 pers. comm.)	Rangelands Action Project	N/A	50 574	3553/3166	0.06	59 700.00	16.80/18.86
SA 2001 (David Oag 2007 pers. comm.)	Rangelands Action Project	N/A	77 805	2096/981	0.01	71 864.00	34.29/73.26
NT 2007 (Kym Schwartzkopff 2007 pers. comm.)	Haasts Bluff	1	1798	483/483	0.27	7355.77	15.23/15.23
	Loves Creek	<1	3670	440/111	0.03	10 788.00	24.52/97.19
	Loves Creek	<1	3670	566/310	0.08	8523.60	15.06/27.50
	Lilla Creek, New Crown, Andado	2	19 905	394/258	0.06	9400.40	23.86/36.44
				862/862		15 685.00	18.20/18.20

Note: data derived from two recent helicopter shooting operations (Ward & Burrows 2007, Oag 2008) plus available records from earlier shoots (David Oag 2007, Pastoral Inspector, SA Department of Primary Industries and Resources, pers. comm. and Kym Schwartzkopff 2007, Wildlife Officer, NRETAS, pers. comm.)

On the basis of the information contained in Table 8.2, helicopter shooting costs per animal range from \$15.06 up to \$69.20, and costs per animal for camels alone range from \$15.23 up to \$97.19. Except for the 2006 shoot in WA, essential data that are lacking from this cost estimate analysis are the starting population and/or density for each of the areas covered and hence the actual proportional reduction in density achieved. It is well established that the relationship between cost per animal killed and animal density is not linear (Choquenot 1988a, Boulton & Freeland 1991, Dobbie et al. 1993) for large vertebrate feral animals; the relationship is usually an exponential decline in the cost of removal with increasing density, but the actual form is unknown for feral camels. The above data are inadequate to determine this relationship for feral camels.

Dobbie et al. (1993) estimated the cost per head for feral horse control in 1987 and concluded that the values were consistent with those obtained for donkeys by Choquenot (1988a). The values Dobbie et al. (1993) estimated are presented here (Figure 8.3) and converted to 2007 dollars using Consumer Price Index extrapolation ($\$_n = \$_{n-t} * (CPI_n / CPI_{n-t})$ where $\$_n$ = current value, $\$_{n-t}$ = previous value, CPI_n = current CPI value and CPI_{n-t} = previous CPI value).

From Tables 8.2 and Figure 8.3 it is apparent that, on the basis of past helicopter shooting operations for feral camel control, management agencies have been prepared to spend in the range of \$15–\$100 per animal for control. The relationship between costs of control and density for feral horses (Figure 8.3) suggests camel densities were > 0.3 animals/km^2 for as much as 50% of aerial shooting operations documented in Table 8.2 and between 0.1 and 0.3 animals/km^2 for the remainder. This supports the proposition that management agencies have not been prepared to fund broadscale aerial shooting at densities < 0.1 animals/km^2. At these densities, where cost per head increases substantially (Choquenot 1988a), it would appear that most management agencies do not consider broadscale aerial shooting cost effective. Given the lack of any clear density impact relationship for feral camels prior to this study, this can only be categorised as a simple economic decision rather than a cost/benefit determination.

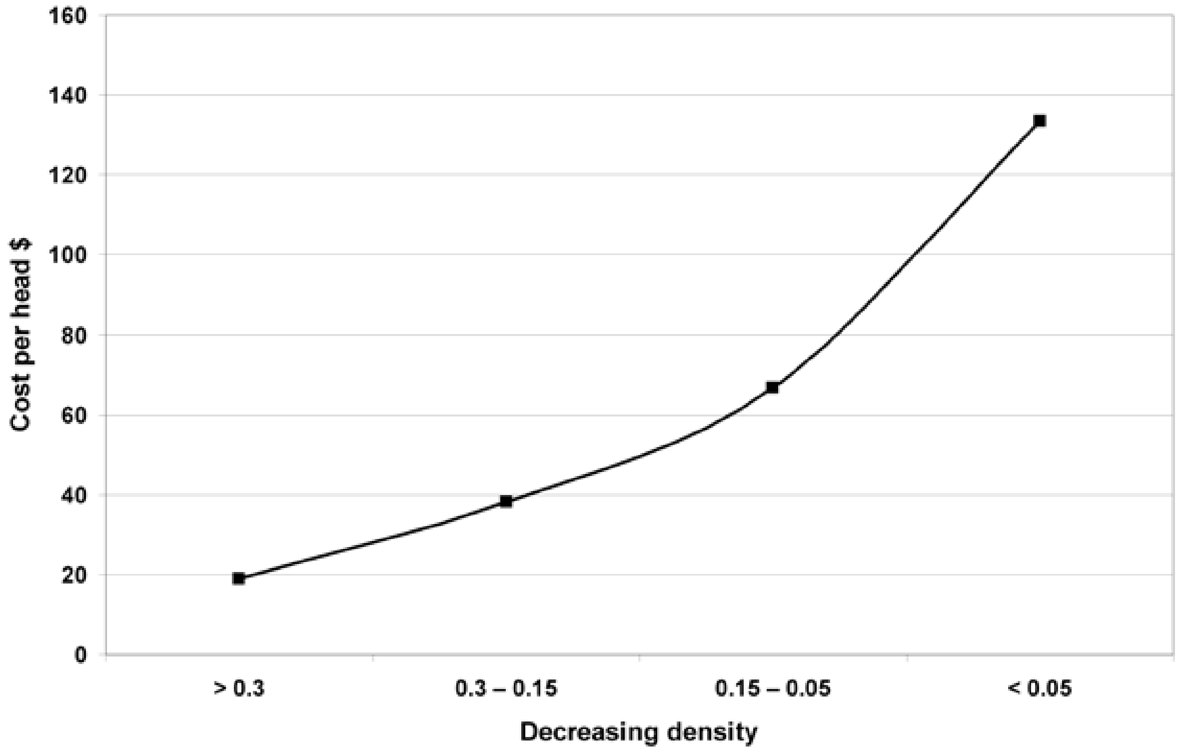


Figure 8.3: Cost per head for helicopter shooting of feral horses showing increasing costs at decreasing densities

Source: Dobbie et al. 1993 converted to 2007 dollar values (CPI_{1987} = 82.6, CPI_{2007} = 157.5)

The major determinant of the minimum cost per animal is the maximum number of animals that can be killed from a single helicopter in one day of operation. Available information (David Oag 2007, Pastoral Inspector, SA Department of Primary Industries and Resources, pers. comm., Kym Schwartzkopff 2007, Wildlife Officer, NRETAS, pers. comm.) suggests that the maximum number of animals that can be killed from a single helicopter in one day of operation is 500–750, depending on density and distribution. Taking into account daily operational costs (Table 8.2) gives an absolute minimum cost per head of $9.23–$13.84.

The actual effectiveness of aerial shooting in managing populations of feral animals across large areas is surprisingly poorly documented. Population reductions of up to 50% in areas of control by aerial shooting have been reported for a number of broadscale aerial control operations (Choquenot 1988b, Saalfeld 2002, Ward & Burrows 2007). However, little or no reporting of the actual impact of these population reductions on conservation or production values has occurred. Additionally, for a number of these population reductions achieved through a broadscale aerial shooting program, a failure to implement ongoing management has resulted in rapid population recovery to pre-control levels (Choquenot 1988b, Saalfeld 2002, Ward & Burrows 2007).

A measure of the effectiveness of broadscale aerial control (helicopter shooting) of feral animals is provided by the NT management of donkeys and horses throughout the Victoria River District (VRD) of the NT (Saalfeld 2002, Holznagel & Saalfeld 2002). The program was implemented in 1999 and covered an area of 120 000 km^2. At that time the donkey population was estimated at 93 000 ± 12 000 animals and management was to be achieved through the declaration of a feral animal control zone covering the area and the issuing of notices to landholders requiring them to remove specific numbers of animals (to achieve an overall density of approximately 0.25 animals/km^2). Control notices totalled 58 000 animals to be removed over a period of three years. In 2001, an aerial survey of the control area gave a population estimate of 103 000 donkeys, while at the same time 58 000 donkeys had been removed (primarily by helicopter shooting) between 1999 and the end of 2001; the removal of 58 000 donkeys over the three-year period had seen an approximate 10% increase in the commencement population. That is, despite the removal of more than 60% of the estimated 1999 population between 1999 and 2001, the population in 2001 was still 10% more than it had been in 1999 (Saalfeld 2002, Holznagel & Saalfeld 2002). This was because allowing three years to achieve the required removal had not taken into account annual recruitment of donkeys (estimated at 25% per annum), and the removal required in the control notices needed to be accomplished in the first year to achieve the target outcome of a reduction in density to 0.25 animals/km^2 (Saalfeld 2002, Holznagel & Saalfeld 2002).

The VRD program is ongoing and it was estimated that 140 000 donkeys had been removed by the end of 2005, for an actual total population reduction of 40 000 donkeys on the 1999 population estimate (Saalfeld et al. 2007). While this program does not appear very successful in terms of efficaciously meeting population reduction targets, the program was highly successful in other areas. It was the first NT Government feral animal program funded primarily by landholders; there was, and is, strong landholder ownership and commitment to ongoing management; and the program was integrated across land tenures. Another strength of the program was that it was subject to internal review, which identified key failings of inadequate resources, lack of compliance, and lack of initial commitment to the program, which were subsequently addressed (Saalfeld et al. 2006). The single most important resource inadequacy was a lack of appropriately qualified and licensed marksmen to undertake aerial shooting operations, followed by lack of aircraft, and lack of qualified pilots (Holznagel & Saalfeld 2002).

For camels, the aerial shooting program most closely approximating the VRD program above has been the SA annual cull of camels associated with the Rangelands Action Project. This cull has taken place annually since 2005 (Table 8.2, David Oag 2007, Pastoral Inspector, SA Department of Primary Industries and Resources, pers. comm.), but has limited facility for comparison with the VRD project to determine efficiency, as the SA cull is not undertaken on the basis of known commencement densities, required off-take, and known target densities. While it does provide details of cost per head for aerial shooting of camels, the value of this information is limited since camel densities are unknown.

3.3 Summary

Aerial platform (helicopter) shooting will almost certainly be the most extensively used method of control for camel management in the immediate future. Aerial shooting is the only method of control that has the capacity to provide access to feral camels across much of the range of the camel in Australia (Saalfeld et al. 2008), subject to a range of non-logistical constraints including landholder and public acceptance (Zeng & Edwards 2008a, Zeng & Edwards 2008b, Vaarzon-Morel 2008a). Further, aerial shooting is the only method of control that is capable of achieving a rapid reduction in feral camel density across a large area.

Although the detailed nature of the cost density relationship is unknown for camels, indicative costs are \$20–\$30 per animal at high density (densities greater than 0.3 animals/km2); \$40–\$100 per animal for densities in the range 0.3–0.1 animals/km2; and a cost per animal greater than \$100 for densities less than 0.1 animals/km2.

While the cost per head for aerial shooting is greater than that for other methods of control and increases substantially as density decreases, the efficacy of this method of control for broadscale management of feral camels guarantees its ongoing role in the management of feral camels in Australia.

The VRD donkey and horse control program (Holznagel & Saalfeld 2002, Saalfeld et al. 2006) has clearly highlighted under-resourcing as the greatest impediment to the successful implementation of a broadscale aerial shooting program, with the most important resource shortfall identified being appropriately qualified and licensed marksmen to undertake aerial shooting operations, followed by lack of aircraft and qualified pilots. Ensuring that adequate resources are available and committed to any aerial control program is probably the single most important factor in achieving the program's target outcomes, and to this end, it is essential to plan aerial control programs as one component of an integrated management approach for feral camels across their range.

4. Ground shooting

As with aerial shooting, ground shooting of feral camels has been carried out across the camel's distribution, but has generally been uncoordinated between landholders or across tenure types and has been carried out opportunistically rather than as planned management.

Ground shooting can be time consuming and labour intensive (Norris & Low 2005), is impractical in rugged or relatively inaccessible terrain (Dobbie et al. 1993, Norris & Low 2005), and injured animals cannot be easily followed to ensure a humane death (Dobbie et al. 1993, Norris & Low 2005). It appears to be optimal when assets of value need protecting (Norris & Low 2005) and where the area of operation is easily accessible, clearly defined, and able to be covered effectively on the ground.

Ground shooting is carried out primarily by pastoral landholders in an opportunistic manner incorporated into other pastoral property activities such as fence line and bore inspection activities. Recreational hunting for feral animals is commonly undertaken on private lands with the blessing of the landholder (Norris & Low 2005). However, the distribution of feral camels in arid rangelands on primarily public (government managed), pastoral, and Aboriginal lands results in little recreational shooting of feral camels. As with aerial shooting 'to waste', Aboriginal communities are generally opposed to ground shooting 'to waste' (Vaarzon-Morel 2008a). As such, recreational ground shooting is generally not condoned on Aboriginal lands, but ground shooting for pet meating is sanctioned on some communities as it is non-wasteful (Zeng & McGregor 2008). Recreational shooting is not permitted on public (government managed) lands in the NT, WA or SA (Carey, O'Donnell, Ainsworth, Garnett, Haritos, Williams, Edwards, McGregor and Zeng 2008) and pastoral enterprises generally prefer to carry out shooting operations under their own management to control access. Ground shooting on public lands is carried out almost exclusively by government officers, particularly on parks and reserves.

Ground shooting of feral camels has occurred in SA, WA, and the NT. However, records of numbers of animals removed through ground-based activities are extremely poor. As previously reported, Gee & Greenfield (2007) provided an estimate of opportunistic culling by pastoralists in the SA Arid Lands NRM Region. Similarly, Ward et al. (2005) reported that culling of camels by pastoralists for sale to the pet meat industry was prevalent in the pastoral area in WA covered by the 2005 survey, but that record keeping was highly variable, ranging from no records to meticulous data (Ward et al. 2005). In the NT, Mulga Park and Curtin Springs stations shot to waste approximately 4500 camels (using ground-based shooters) during the 2006–07 summer and the months that followed following an influx of camels from neighbouring lands (Edwards, Zeng & Saalfeld 2008).

4.1 Description of methods

Ground shooting of large vertebrate feral animals generally involves the shooting of the target animal from a stationary vehicle by a marksman. While there are generally no legislative requirements governing the skill or capabilities of the marksman other than the requirements of the appropriate jurisdiction's Firearms and Animal Welfare legislation, Model Codes of Practice for Humane Control and Standard Operating Procedures for ground-based shooting have been prepared for a number of species (Sharp & Saunders 2004, Australian Government 2004) and should be followed. Any government-managed program will require that all appropriate Codes of Practice and Standard Operating Procedures are followed for all management activities.

A Code of Practice for the control of camels and a Standard Operating Procedure for the ground shooting of feral camels are under development. These documents are expected to closely align with the existing *Model Code of Practice for the Humane Control of Feral Horses* and *Standard Operating Procedure for the Ground Shooting of Feral Horses* (Sharp & Saunders 2004, Australian Government 2004).

Using the *Standard Operating Procedure for the Ground Shooting of Feral Horses* as a model, a proposed draft operating procedure has been developed for feral camels and is included in Appendix 8.2.

4.2 Cost and effectiveness

Almost all non-commercial ground shooting of camels occurring currently is carried out by pastoralists and is opportunistic in nature and directly associated with other property management activities. In this circumstance, estimation of the cost of control is difficult and to some extent irrelevant to the control taking place (but see Edwards, Zeng & Saalfeld 2008). Data are available for commercial ground-shooting operations (Zeng & McGregor 2008) and are used here as the basis to extrapolate cost and effectiveness of non-commercial ground shooting of feral camels.

Best available estimates for ground shooting indicate that daily harvest rates of up 100 animals per day per shooter are achievable when densities are high (P. Duffield, Conservation and Pest Management, Sporting Shooters Association of Australia, pers. comm.). On this basis and using cost estimates associated with commercial (pet meat) operations (Zeng & McGregor 2008), a cost per animal of $7.20 is estimated (100 animals per day per shooter/$440 per day per shooter/$120 per day per vehicle/$1.60 per animal ammunition). While this compares favourably with the cost per animal of aerial control (estimated at around $20–$30 per head at densities greater than 0.3 animals/km^2), the limitations of ground shooting (access and volume) severely restrict the applicability of any broadscale ground shooting program.

4.3 Summary

Ground shooting for non-commercial purposes is of limited applicability in managing the impacts of feral camels when compared with aerial platform (helicopter) shooting. Best estimates (above) give ground shooting only one-fifth the capacity of aerial shooting in areas where both can be undertaken. A consequence of taking five times as long to achieve the same result means that recruitment has a major impact on the capacity to achieve population targets in acceptable timeframes with ground shooting. Opportunistic ground shooting by pastoralists appears to be the most viable application for this method of control, and in this context ground shooting is most likely to play a role in long-term management of feral camel populations once high density populations have been reduced by other control methods.

5. Physical barriers

Fencing has been the most common method used to exclude feral animals from an area (Norris & Low 2005), with the best known fence being the dingo fence, stretching 5614 kilometres and covering three states (Qld, NSW, and SA) to separate southern and eastern sheep grazing lands from cattle and dingo country (Norris & Low 2005).

A number of different types of fence have been used to purposely exclude feral herbivores: conventional stock fencing, electric fencing, and purpose-built fences (Norris & Low 2005). Fences are typically used to break up areas into manageable blocks for control (similar to paddocks used for herd management on pastoral land), to exclude animals from water points, and to protect important areas. Exclusion fencing is being increasingly used to protect areas of high conservation value or to create refuges for native fauna (Norris & Low 2005). Sites of important cultural significance for Aboriginal people that are negatively affected by feral animals, including feral camels, may be best protected by exclusion fencing to prevent any access by feral animals, particularly where the density of animals required to have an impact is unknown.

Exclusion fencing to prevent feral camels accessing important cultural sites on Aboriginal land, primarily important waterholes, has been used in SA, WA, and NT (Figure 8.2).

Northern Territory

Katiti ALT

A program to protect two culturally important rockholes on the Katiti Aboriginal Land Trust (ALT) from camels – Kulpitjata and Putji – began in the late 1990s or early 2000s. These fences were built by A<u>n</u>angu rangers from Ulu<u>r</u>u–Kata Tju<u>t</u>a National Park (UKTNP) for the purpose of excluding camels. They were constructed from heavy duty cable wire with bore casing for posts. Although the fence at Kulpitjata was completed, it was destroyed by camels not long after and is now sitting in a state of disrepair. The Putji fence may still be intact.

The Central Land Council (CLC) has submitted an application for Indigenous Protected Area (IPA) project money with the long-term aim of IPA declaration for the Petermann and Katiti land trusts. If successful, the initial focus of the project will be protection of culturally significant rockholes, springs, and waterholes on these land trusts. This will likely include further work at Kulpitjata, as well as at new sites, such as other culturally important sites that are being heavily affected by camels.

Santa Teresa

The CLC received a Community Water Grant in 2006 to fence three culturally and biologically important springs – Hayes, Salt, and Brumby Springs – in the Allambarinja Range on the Santa Teresa ALT. The fence at Hayes Springs was completed in mid-2006 and work commenced on fencing Salt Springs in November, and was completed by the end of 2007. Camel-proof fencing, designed by the Centre for Appropriate Technology in collaboration with Greening Australia, was erected at these sites. The design includes the use of bore casing as posts and heavy duty wire cable. This is a collaborative project involving CLC Land Management, Greening Australia, and Traditional Owners, and employs CDEP workers from Santa Teresa. Water quality and macro-invertebrate monitoring is being established by NT Department of Natural Resources, Environment, The Arts and Sport at two of the springs with the involvement of older children from Ltyentye Apurte School.

There have been problems with cattle and camels putting pressure on the fence before the summer rains. There has been no alternative water source provided for the camels, cattle, and horses in this area of the land trust so it is likely that the pressure on the fence will continue. Impacts will likely increase at other springs in the area that are not going to be fenced as part of this program.

Nyirripi

Nyirrpi community also received Community Water Grant funding in 2006, assisted by Greening Australia. It is aiming to fence up to 16 rockholes, gnamma holes[1] and springs on the Lake Mackay and Yunkanjini ALTs, prioritised according to their cultural significance. Work commenced on this project in 2007 when permit clearance was been gained from the CLC. Camel-proof fences or 'spider' structures (see below) will be erected at these sites, depending on the most suitable method.

Docker River

An initial project in 2003/04 involved CLC Land Management and senior men covering rockholes with heavy-duty mesh attached to mulga logs as weights. Docker River Council then gained funding in 2005 from the Community Heritage Grants program for further rockhole protection work. CLC contributed a vehicle and a project officer to coordinate the program, while the community paid for materials and wages for A<u>n</u>angu participants out of the grant. Four senior men and up to 11 young men were involved in the work. Three rockholes/soaks to the south of Docker River and one to the east were fenced off using steel rail fence (stockyard fencing) concreted into the ground.

Ahakeye ALT

Community Water Grant funding was received by Charles Darwin University and Greening Australia in 2006 to fence off Anningie waterhole on the Ahakeye ALT. Fencing of this site commenced in 2007.

Pastoral country

Greening Australia has received funding to fence off Mudhut Swamp on Stirling pastoral lease and Spring Creek on Coniston pastoral lease in collaboration with lessees of these stations. While the primary purpose of these fences is to exclude cattle, camels also occur on both stations. The option exists to add an electric line to the fences if camels prove to be a problem. This is also the case for Yaninji Rockhole on the section of Ahakeye ALT that is managed as a grazing lease.

Greening Australia and the manager of the Garden pastoral lease are also planning to fence off a number of springs in Mordor Pound, though they have not yet applied for funding for this project. These springs are being affected by cattle, camels, and other feral animals.

1 Holes made by Aboriginal people for the collection of water.

Western Australia

Wanarn and Patjarr

Ngaanyatjarra Land Management received a small grant in 2004 for Patjarr Community to design and produce ‘spider’ structures (see below) to protect rockholes from camels. These structures were placed over three rockholes at Tikatika, a site near the community. Further funding was then acquired for both Wanarn and Patjarr communities to construct more spiders. However, all of the construction was undertaken in Wanarn because it happened to have a community project officer who could supervise the welding. A further 15 spiders were placed over rockholes during 2006, between the Gibson Desert Nature Reserve and the Rawlinson Range. Two or three rockholes in the vicinity of Patjarr community were covered by wire mesh held down by rocks prior to the invention of the Patjarr Spider.

Warakurna

Two rockholes in the vicinity of Warakurna have been covered by structures that apparently have successfully kept camels out, while still enabling wildlife to drink. Both are heavy-duty wire mesh structures raised 0.6–0.9 m off the ground. One was constructed by Bureau of Meterology staff and the other by the Warakurna school.

Blackstone

A 100 m x 100 m steel rail fence was erected around an important waterhole to the south of Blackstone community.

Punmu and Parnngurr

Community members have expressed an interest in fencing off a number of significant springs and rockholes in the vicinity of Punmu and Parnngurr communities in the Great Sandy Desert. Camels occur in high densities in this region and many important waterholes and springs are being heavily affected. It is possible that an application for a Community Water Grant will be submitted by the WA Rangelands NRM Coordinator to fund the fencing. Martu traditional owners have also expressed concern about camel impacts in other parts of their country, in particular in the Percival Lakes to the north of Punmu.

South Australia

A<u>n</u>angu Pitjantjatjara Yankunytjatjara (APY) Lands

APY Land Management has been fencing off important rockholes and waterholes from camels over the past few years. They have found that fencing waterholes only serves to increase the pressure on unfenced sites nearby. Their new strategy involves re-commissioning old bores on the Lands to provide an alternative water supply to the rockholes and waterholes. Their evidence suggests that camels prefer to drink from troughs and where these are provided little or no damage occurs to waterholes nearby. They still plan to fence off a certain number of significant sites that are particularly significant and/or vulnerable to camel impacts.

Appropriate use of fencing may help conserve areas of high conservation or cultural value by excluding the feral animals (Norris & Low 2005) and can also provide opportunity and time for other actions (Pickard 2006). However, while fencing can effectively exclude feral camels, it does not necessarily reduce their population number or even their impacts. Fencing simply shifts the point of impact to other, presumably less important, areas. In some instances, an asset enclosed by a poorly designed fence may still be affected by camels. For example, a rockhole enclosed by a poorly situated fence can still become silted up through sediment mobilisation as a result of camels congregating at the barrier fence knowing that there is water nearby. All things considered, fencing is best considered as a strategic small-scale management tool to protect valuable assets.

5.1 Description of methods

A number of designs for exclusion fencing for camels have been developed. Dörges and Heucke (1995, 2003) claimed success with a design based on modified cattle fencing, and the Centre for Appropriate Technology in collaboration with Greening Australia have designed a camel-exclusion fence using substantially heavier and more robust materials than used in stock fencing (Barker & Elliat 2007). A third design involves the use of 'spider' structures, where the waterhole is covered by a structure to prevent the camels being able to enter the waterhole but still giving them access to the water to drink.

The design by Dörges and Heucke (1995, 2003) involved a standard cattle fence (three line barbed wire) extended to a height of at least 1.6 metres with the addition of a fourth top wire. The top wire is made visible by adding light reflecting objects that hang on short lengths of plain wire (5–15 cm) tied to the top barbed wire, with the objects able to swing freely below. Dörges and Heucke (1995, 2003) found empty beer cans were very effective in the role of reflecting object, being both visible and, on windy days, audible. On the basis of these findings, any highly reflective, light weight metallic object in the size range of a standard beer can would make a suitable reflecting object for this fence design. While this fence is reported to be more effective than a standard cattle fence at controlling or managing camel movement, it is unlikely to be any stronger than a standard cattle fence at resisting damage from camels that attempt to penetrate or become entangled in the fence, hence the requirement for inspection and maintenance is likely to be as high as for standard cattle fencing.

The more robust design by the Centre for Appropriate Technology is fully detailed in the Centre's *Bush Tech* #35 publication (Barker & Elliat 2007). The design is intended to protect waterholes and is based on a solid cable fence capable of keeping camels out but allowing native wildlife access. The design is considerably heavier than standard cattle fencing, using bore casing for posts (100 mm diameter and a minimum 3 mm wall thickness) and 8 mm galvanised cable. The fence is designed to be resistant to damage from camels attempting to penetrate it and hence requires less maintenance than standard cattle fencing, but it does need periodic inspection for any damage that may result from very high continual pressure.

As reported above, the 'spider' design has been trialled at a number of locations. The design consists of a central hub, typically an old wheel rim, with eight legs attached to brackets welded to the hub. The legs can be chained for cross-bracing and tin sheeting can be added to reduce evaporation from the waterhole. The design is reported in *The Camel Book* (Tangentyere Landcare 2006) and, as stated, is intended to prevent camels entering the waterhole and becoming trapped and dying therein. It is not designed to stop the camels drinking at the waterhole and does not limit access to the immediate area of the waterhole. Hence this design is not suitable where the objective is to prevent camels from accessing the area of the waterhole and its surrounds.

Bertram et al. (2007) consider a number of fence designs for the management of camel movement. They report that camels are observant, easily taught, and have good memories (Bertram et al. 2007), and that for a fence to become an effective deterrent to camel movement it should be constructed so that it is easily seen and remembered. Bertram et al. (2007) advise that the use of barbed wire should be limited, since the reaction by camels to the adverse stimulus of barbed wire is often the opposite of what is desired – they jump further forward into the fence rather than move away from it. In addition to the design of Dörges and Heucke (1995, 2003) they describe the use of both electric fences and cable fences.

Electric fence designs considered by Bertram et al. (2007) included custom-built electric fences or modification of an existing fence. They advise that the use of electric wires can increase the memorable and deterrent aspects of a fence and that the use of energisers of sufficient capacity and an effective fence design are essential for an electric fence to be effective (Bertram et al. 2007). For custom-built electric fences they consider two plain wires (one energised) or four plain wires (two energised) as options. Four plain wire, with two wires energised, electric fences have been found to effectively control camel movement where internal fences have a lot of pressure, while where camels are familiar with electric wires and there is low pressure, a single electric wire is adequate (Bertram et al. 2007). For modification of an existing fence, Bertram et al. (2007) advise either an energised plain top wire or an energised wire offset on outriggers on the side from which camel pressure is expected, although they report that outriggers have not been proven effective for feral camels. As with the design of Dörges and Heucke (1995), while an electric fence is expected to be more effective than a standard cattle fence at controlling/managing camel movement, it is unlikely to be any stronger than a standard cattle fence at resisting damage from camels that attempt to penetrate or become entangled in the fence. Hence, the requirement for inspection and maintenance is likely to be as high as for standard cattle fencing.

The cable fence design reported by Bertram et al. (2007) used recycled heavy duty materials: 100 mm bore casings up to 4 m above ground and sunk 1.5 m into the ground, with 20 mm steel cable loosely strung 80 cm and 100 cm above the ground. Bertram et al. (2007) indicate that this design was developed and used by the joint management of UKTNP to control feral camel movement and successfully kept camels out of sensitive areas.

5.2 Cost and effectiveness

Costs associated with the different designs of fencing to prevent feral camels from accessing areas of high conservation or cultural value are variable depending upon the specific design of fencing used. Table 8.3 provides costing associated with a number of different designs for ‘camel proof’ fencing. The cost of fencing is very dependent on terrain and remoteness, and the figures in Table 8.3 are at best a guide to the potential cost. It should be clearly recognised that costs could be significantly higher for areas in difficult terrain or that are very remote.

Table 8.3: Cost per 100 metre and per kilometre for camel proof fencing.

Fence	Cost per 100 m $	Cost per km $
Cattle fence[1]	500 – 1000	1000 – 10 000
Electric fence[2]	1000	6000
Dörges & Heucke[3]	750 – 1500	1500 – 15 000
CAT camel fence[2]	3000 – 5000	30 000 – 50 000
Patjarr Spider (per spider)	500	

Note: standard[4] cattle fencing, for electric[5] fencing, for cattle fencing modified as per Dörges and Heucke (1995, 2003), for Centre for Appropriate Technology (CAT) camel proof, fence and for Patjarr Spider.

[1] PGC Fencing Contractors 2008, Alice Springs, pers. comm.

[2] Peter Barker 2007, Greening Australia, pers. comm.

[3] 150% cost of cattle fence

[4] 3-strand barbed wire

[5] 2-strand barbed and single-strand plain electric wire

Using Table 8.3 as a guide, the cost of protecting either a waterhole or specific area of conservation/cultural significance will vary considerably depending on the area to be fenced and the type of fence chosen to accomplish the task. Figure 8.4 provides a comparison of estimated costing for different size areas and fencing types.

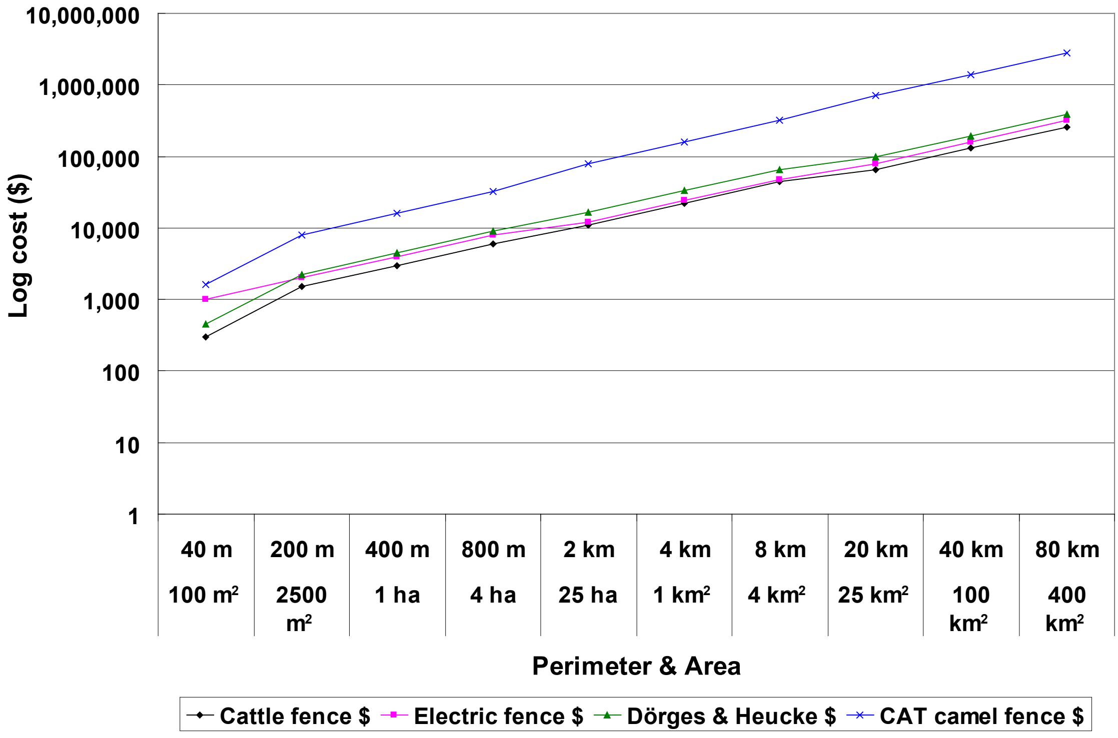


Figure 8.4: Cost of protecting different sized areas using different fence designs

Note: Costs are based on a square protection area and using the mid-point of each price range from Table 8.3 for fences less than 20 km length and first quarter of the price range for fences 20 km or more in length.

Figure 8.4 clearly demonstrates the dramatic increase in cost as area increases for each fence design. This makes it imperative that the specific outcome to be accomplished by fencing and the design required to achieve are unambiguously identified in the initial stages of developing any fencing proposal for the management of feral camels.

As indicated in Section 5.1, the effectiveness of the different designs in managing feral camel movement or preventing their access to specific sites/areas is very much dependent upon the design of fence. For the designs in Table 8.3, ranking from least to most effective is predicted to be the cattle fence, electric fence, Dörges and Heucke fence and finally the CAT camel fence. The Dörges and Heucke, design is ranked higher than the electric fence on the basis that for feral camels that have never encountered a fence, the visual component of the Dörges and Heucke design is likely to be more effective initially than the aversion effect of the electric fence, which is more effective as a learned response.

A number of theoretical fencing case studies have been modelled below to determine potential cost: total exclusion of camels from a waterhole, fencing of a small wetland to reduce camel impact, fencing of a community to exclude camels, boundary fencing of a pastoral property to restrict camel entry (one side and complete), and fencing the entire outer boundary of the pastoral area within the camel's distribution.

Waterhole

- Area of waterhole 13 m^2.
- Camels excluded from accessing waterhole out to 10 m from waterhole to limit camel degradation of surrounds and prevent silting of waterhole by camel generated erosion.
- Area of exclusion 460 m^2 (circular) or 576 m^2 (rectangular).
- Perimeter of exclusion 75 m (circular) or 96 m (rectangular).

- For total exclusion use CAT design fence.
- Fence cost $3000 (circular) or $3840 (rectangular).
- Ongoing maintenance should be minimal.

Wetland

- Area of wetland 25 ha.
- Camels restricted from accessing wetland and edge of wetland.
- Area of exclusion 25 ha (circular and rectangular).
- Perimeter of exclusion 1.77 km (circular) or 2 km (rectangular).
- For restricted access use Dörges & Heucke design fence (electric fence not considered suitable due to potential impact on native wildlife trying to access wetland; entire fence loses electrification and hence effectiveness if fence broken).
- Fence cost $14 602 (circular) or $16 500 (rectangular).
- Total exclusion fence (CAT design) would cost $70 800 (circular) or $80 000 (rectangular).
- Ongoing maintenance likely to be significant but would need to amount to 2–3 times the original fence cost before total cost would approach that of the total exclusion fence.

Community

- Area of community and airport for camel exclusion: 600 ha.
- Perimeter of community and airport for camel exclusion: 10.5 km.
- Immediate location of community and infrastructure reduces fence monitoring and maintenance as an issue.
- Restricted access electric fence design best to use for this purpose given potential effectiveness in keeping camels and other wildlife out of the community and airport.
- Fence cost $63 000.
- Require two access points through airport fence and four access points through community fence. Heavy duty cattle grids are suitable to prevent camels crossing access point.
- Six cattle grids cost $4000 each; total $24 000.
- Total fence cost $87 000.
- Equivalent total exclusion fence (CAT design) would cost $444 000.
- Ongoing maintenance likely to be significant but would need to amount to 4–5 times the original fence cost before total cost would approach that of the total exclusion fence. Expectation that fence monitoring and maintenance would be included in community general maintenance program.

Pastoral property

- Area of property 3 000 km^2.
- Perimeter of property 260 km (100 + 30 + 100 + 30 km sides).
- Lengths of fence are 100 km for a single side adjoining feral camel country and 260 km for entire property boundary.
- For restricted access on boundary use Dörges & Heucke design fence (electric fence considered less suitable due to entire fence or substantial length of fence losing electrification and hence effectiveness if fence broken).

- For single side 100 km length with one access point: fence cost $487 500, cattle grid cost $4000; total cost $491 500.
- For complete property boundary with four access points: fence cost $1 267 500, cattle grid cost $16 000; total cost $1 283 500.
- The above pricing is the cost to construct the fence from new. If existing fence is in place and is able to be modified, then cost will be considerably less, approximately one quarter the cost above, i.e. $121 875 for single 100 km boundary and $316 875 for entire boundary, assuming access points already in place.
- Monitoring and maintenance of the fence should be included with normal property fence maintenance.

Outer boundary of entire pastoral area abutting core camel distribution

- Length of boundary 11 000 km approximately.
- Cattle fence cost $35 750 000.
- Electric fence cost $66 000 000.
- Dörges & Heucke fence cost $53 625 000 for new fence and $13 406 250 to modify existing cattle fence, assuming entire boundary is already fenced.
- Total exclusion fence (CAT design): $330 000 000.

The theoretical case studies above give some idea of the potential costs associated with fencing specific small sites up to small communities and pastoral properties. As previously indicated, costs increase substantially as area increases and the actual effectiveness of any of the fence designs at either excluding or restricting camel access to the sites is poorly documented at best (Dörges & Heucke 1995, 2003, Barker & Elliat 2007, Bertram et al. 2007). Based on the available reports, the Centre for Appropriate Technology design is effective at excluding feral camels from sites but costs are extremely high compared with other fence designs, approaching an order of magnitude greater for very large areas.

5.3 Summary

Fencing to exclude or restrict feral camel access to particular sites or areas of conservation or cultural significance for Aboriginal people appears both feasible and economical provided that the area is not too large. Fencing costs range between $3000 to $16 500 for areas of 400 m^2 – 25 ha depending upon the fence design selected and the total area. For larger areas, fencing costs increase substantially and have to be weighed against the cost and effectiveness of alternative management methods.

It is important to stress that fencing does not have any impact on camel population numbers or population growth. There will be a requirement to actually reduce feral camel numbers in order to mitigate landscape level impacts across much of the camel's range. This can only be achieved with alternative control measures. Invariably, failure to control population growth will eventually result in population pressures on fencing that result in unacceptable levels of damage and maintenance costs.

6. Potential non-commercial control methods

6.1 Achilles Heel: Potential for the chemical, biological, or fertility control of feral camels

An extensive review of potential methods of chemical, fertility, and biological control for the camel in Australia was undertaken for this project by the Invasive Animals Cooperative Research Centre and is reported here (Lapidge et al. 2008). Additionally, the review provides suggestions for potential landscape delivery options for any new control methods.

The review provided a series of conclusions and recommendations for each of the considered options and these are given below. The review recommended ‘that the following techniques be investigated further, at least initially with camel stakeholder groups, animal welfare groups, the Australian Pesticide and Veterinary Medicine Authority, and the Australian public’.

- Low concentration delivery of nitrite or 1080 in raised water troughs. This may be made more specific if delivered at salt lakes where fresh water is more desirable for camels and species diversity is lower.
- Delivery of sodium or potassium nitrite via a camel specific feeding trough or raised salt lick at natural congregation points. Potassium chloride or 1080 may act synergistically with nitrite, which would lower the dose required and shorten the time to death.
- A combination of potassium chloride with a diuretic, with and without a nephrotoxic agent such as banamine and phenylbutazone, should be examined further as it may prove uniquely toxic to camels.
- Camelpox is worthy of further investigation, particularly in reference to its spread in more natural nomadic camel populations within the species range and the humaneness of the virus. Regardless, camelpox is unlikely to be the ‘calicivirus’ of camels in Australia, and would be principally introduced to limit population recruiment.
- An immunocontraceptive vaccine technology that is orally active and has a species-specific immunogen is favoured for fertility control. Research into a feral pig anti-fertility vaccine that can be used as a platform from which to undertake similar research in camelids holds the greatest hope for this in the immediate future but requires funding for extension of the work into camels.
- Three other novel approaches to manipulating fertility warrant attention: phage panned peptide technology, the Talwar protein, and antigen delivery systems such as bacterial ghosts” (Lapidge et al. 2008).

Lapidge et al. (2008) further recommended that a balanced research and development approach be taken rather than focusing on a single management tool, and that any future research program should have short-, medium-, and long-term products to provide incremental improvements in managing the camel population in Australia. Finally, they identified that any research must be publically acceptable and humane (Lapidge et al. 2008).

7. Recommendations

- That aerial shooting from helicopters is recognised as the optimal control action to achieve large population density reductions over broadscale areas, particularly in short time frames, and the only available control action that can be used in very remote or inaccessible areas.
- That aerial shooting from helicopters be based on specific targets and outcomes and that to achieve this objective, removed and final population densities must be known, requiring pre- and post-control population monitoring.
- That any proposed camel management program, particularly involving aerial shooting, must be fully funded and adequately resourced to meet the proposed outcomes, including all monitoring requirements.
- That it is recognised that effective management of camels and their impacts will involve the integration of all available control methods, both non-commercial and commercial, and that the development of scale-dependent, multiple outcome management plans integrated into the national framework will be key to the effective management of feral camel impacts in Australia.
- That it is recognised that ground-based shooting has limited applicabilty for broadscale population reduction and will primarily fill a long-term management role of maintenance of low density populations through opportunistic shooting integrated with other activities.

- That it is recognised that exclusion fencing is not a broadscale level management tool. Fencing is likely to be most effective when applied at the local scale to protect high value assets.
- That the following techniques are investigated further for the chemical, biological and fertility control of camels:
    - Low concentration delivery of nitrite or 1080 in raised water troughs. This may be made more specific if delivered at salt lakes where fresh water is more desirable for camels and species diversity is lower.
    - Delivery of sodium or potassium nitrite via a camel-specific feeding trough or raised salt lick at natural congregation points. Potassium chloride or 1080 may act synergistically with nitrite, which would lower the dose required and shorten the time to death.
    - A combination of potassium chloride with a diuretic, with and without a nephrotoxic agent such as banamine and phenylbutazone, should be examined further as it may prove uniquely toxic to camels.
    - Camelpox is worthy of further investigation, particularly in reference to its spread in more natural nomadic camel populations within the species range and the humaneness of the virus. Regardless, camelpox is unlikely to be the 'calicivirus' of camels in Australia, and would be principally introduced to limit population recruiment.
    - An immunocontraceptive vaccine technology that is orally active and has a species-specific immunogen is favoured for fertility control. Research into a feral pig anti-fertility vaccine that can be used as a platform from which to undertake similar research in camelids holds the greatest hope for this in the immediate future but requires funding for extension of the work into camels.
    - Three other novel approaches to manipulating fertility warrant attention: phage panned peptide technology, the Talwar protein, and antigen delivery systems such as bacterial ghosts (Lapidge et al. 2008).

8. References

Australian Government. 2004. *Development of a model code of practice and standard operating procedures for the humane capture, handling or destruction of feral animals in Australia.* PDF files, listed at http://www.environment.gov.au/biodiversity/invasive/publications/humane-control/

Australian Pest Animal Strategy – a national strategy for the management of vertebrate pest animals in Australia. 2007. Natural Resources Ministerial Council, Canberra.

Axford G, Holden C and Farroway L. 2002. *Aerial Survey of Camels and Other Large Feral Animals in the Simpson Desert Region of South Australia*, Department for Environment and Heritage, South Australia.

Barker P and Elliat R. 2007. Bush Tech #35: *Protecting your Water Places*, Centre for Appropriate Technology, Alice Springs.

Braysher M. 1993. *Managing Vertebrate Pests: Principals and Strategies*, Bureau of Resource Sciences, Commonwealth of Australia.

Bertram J, Williams O, Gill B, Coventry J and Sidel P. 2007. *Camel Control Using Alternative Fencing*, Agnote No. 16, Department of Primary Industry, Fisheries and Mines, Northern Territory.

Boulton WJ and Freeland WJ. 1991. 'Models for the Control of Feral Water Buffalo (Bubalus bubalis) using Constant Levels of Offtake and Effort', *Wildlife Research*, vol. 18, pp. 63–73.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H, Williams G, Edwards GP, McGregor M and Zeng B. 2008. Review of legislation and regulations relating to feral camel management (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 125–132. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H and Williams G. 2008. *Review of legislation and regulations relating to feral camel management*, DKCRC Research Report 50. Desert Knowledge CRC, Alice Springs.

Choquenot D. 1988a. 'Feral donkeys in northern Australia: population dynamics and cost of control', MSc Thesis, Canberra College of Advanced Education, Canberra.

Choquenot D. 1988b. *The1988 VRD Feral Animal Survey*. A consultancy report to the Conservation Commission of the Northern Territory, Conservation Commission of the Northern Territory, Darwin.

Dobbie WR, Berman DMcK and Braysher M. 1993. *Managing Vertebrate Pests: Feral Horses*, Bureau of Resource Sciences, Commonwealth of Australia

Dörges B and Heucke J. 1995. 'Ecology, social organisation and behaviour of the feral dromedary Camelus dromedaries (L. 1758) in central Australia', Unpublished Report (translated from two PhD theses, submitted 1995), University of Braunschweig, Braunschweig, Germany.

Dörges B and Heucke J. 2003. *Demonstration of ecologically sustainable management of Camels on Aboriginal and pastoral land*, Final report on NHT Project No. 200046, Natural Heritage Trust, Canberra, Australia.

Drucker AG. 2008. Economics of feral camel control in the central region of the Northern Territory (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 283–286. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards G. 2005. *Outcomes and recommendations of the Feral Camel Action Plan Workshop, 13–14 April 2005, Alice Springs*, Department of Natural Resources, Environment and the Arts, Northern Territory, Australia.

Edwards GP, Saalfeld K and Clifford B. 2004. Population trend of camels in the Northern Territory, Australia, *Wildlife Research*, vol. 31, pp. 509–511.

Edwards GP, Zeng B and Saalfeld WK. 2008. Evaluation of the impacts of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 133–182. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Ellard K and Seidel P. 2000. *Development of a Sustainable Camel Industry*. RIRDC Publication No 99/118, Rural Industries Research and Development Corporation, Canberra.

Gee P and Greenfield B. 2007. 'SA Arid Lands Feral Camel Management Plan', DRAFT, South Australia Arid Lands Natural Resource Management Board, South Australia.

Holznagel N and Saalfeld K. 2002. *End of Year Operational Report of the Victoria River District Pest Declaration 2001*, Technical Report, Department of Infrastructure, Planning and Environment, Northern Territory.

Lapidge SJ, Eason CT and Humphrys ST. 2008. *A review of chemical, biological and fertility control options for the camel in Australia*, DKCRC Research Report 51. Desert Knowledge CRC, Alice Springs.

Lethbridge Mark R. 2007. '2007 camel survey of South Australia and Western Australia', Draft Final Report, Flinders University, Adelaide S.A.

McLeod SR and Pople AR. 2008. *Modelling management options for management of feral camels in central Australia*, DKCRC Research Report 48. Desert Knowledge CRC, Alice Springs.

Norris A and Low T. 2005. *Review of the management of feral animals and their impact on biodiversity in the Rangelands: A resource to aid NRM planning*. Pest Animal Control CRC Report 2005, Pest Animal Control CRC, Canberra.

Oag D. 2008. 'Large feral animal control program in the Marla Oodnadatta Region'. November 2007, Draft Report, Department of Primary Industries and Resources, South Australia.

Peeters PJ, Jennings S Carpenter R. and Axford G. 2005. *Assessing the abundance and impacts of feral camels in the Great Victoria Desert*, A report to the Aboriginal Lands Integrated Natural Resource Management Group, Department for Environment and Heritage, South Australia.

Pickard J. 2006. Fences for biodiversity conservation in the arid zone: some lessons from history, in *The 14th Biennial conference of Australian Rangelands Society*, Renmark, Australia.

Saalfeld WK. 2002. *Aerial Survey of Donkey and Horse Populations in the Victoria River District, 2001*, Technical Report, Parks and Wildlife Commission of the Northern Territory, Northern Territory.

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK, Edwards GP, Zeng B and Lamb D. 2008. A Multiple Criteria Decision Support Tool for feral camel management. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 287–330. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld K, Walters A and Hooper D. 2007. *Aerial Survey of Donkey and Horse Populations in the Victoria River District*, 2006, Technical Report, Department of Natural Resources, Environment and the Arts, Northern Territory.

Saalfeld K, Walters A and Delaney R. 2006. 25 years of standing still: trends in feral equid control (Victoria River District, NT), in *Proceedings of 19th Scientific Meeting, Australasian Wildlife Management Society*, Auckland, New Zealand, December 2006.

Senate Select Committee on Animal Welfare. 1991. *Culling of Large Feral Animals in the Northern Teritory*. Report by the Senate Select Committee on Animal Welfare, Commonwealth of Australia.

Sharp T and Saunders G. 2004. Model code of practice for the humane control of feral horses, in *Development of a model code of practice and standard operating procedures for the humane capture, handling or destruction of feral animals in Australia*, Final report for the Australian Government Department of Environment and Heritage, Department of Environment and Heritage, Canberra.

SSCAW——see Senate Select Committee on Animal Welfare

Tangentyere Landcare. 2006. *The Camel Book*, Reprinted by the DKCRC 'Cross-jurisdictional Management of Feral Camels' project, with support from the Australian Government.

Vaarzon-Morel P. 2008a. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008b. *Key stakeholder perceptions of feral camels: Aboriginal community survey*, DKCRC Research Report 49. Desert Knowledge CRC, Alice Springs.

Ward BG, Ward CG and Liddelow GL. 2005. 'Camel Populations in Central Western Australia Determined from Aerial Surveys', Draft Report, Department of Environment and Conservation, Western Australia.

Ward B. 2007. 'Feral Camel Distribution and Abundance of the Warburton central Ranges and Northern Great Victoria Desert', Unpublished Report. Department of Environment and Conservation, Western Australia.

Ward B and Burrows N. 2007. 'Evaluating the effectiveness of an operation to cull feral camels in the Western Little Sandy Desert', Unpublished Report, Department of Environment and Conservation, Western Australia.

Warfield B and Tume L. 2000. *Market Analysis and Plan for the Camel Industry*, RIRDC Publication No 00/9, Rural Industries Research and Development Corporation, Canberra.

Zeng B and Edwards GP. 2008a. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008b. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

9. Appendices

Appendix 8.1: Draft Standard Operating Procedure for the Aerial Shooting of Feral Camels

Adapted from the *Standard Operating Procedure for the Aerial Shooting of Feral Horses* (Sharp & Saunders 2004)

Application

- Shooting should only be used in a strategic manner as part of a coordinated program designed to achieve sustained effective control.
- Aerial shooting is a cost-effective method where camel density is high. Costs increase greatly as camel numbers decrease.
- Aerial shooting is used to control feral camels in remote, inaccessible, or rugged terrain where camels cannot be caught, when there is no viable market for them, or when a rapid reduction in density is required.
- In areas of heavy cover (e.g. vegetated creek lines and closed woodlands), effectiveness is limited since camels may be concealed and difficult to locate from the air.
- The optimal period for aerial shooting is during dry seasons or droughts when many groups of camels are forced to congregate around remaining areas of water and feed. Shooting during drought reduces the number of camels that would otherwise die slowly of hunger or thirst.
- For safety reasons, shooting from a helicopter cannot be undertaken in adverse weather conditions (e.g. strong wind, rain, low cloud).
- Shooting of feral camels should only be performed by competent, trained personnel who have been tested and accredited for suitability to the task and marksmanship and who hold the appropriate licences [e.g. in NSW shooters must complete the Feral Animal Aerial Shooter Training (FAAST) course].
- Helicopter pilots must hold the appropriate licences and permits and be skilled and experienced in aerial shooting operations.
- Helicopter operators must have approval from the Civil Aviation Safety Authority to undertake aerial shooting operations.
- Aerial shooting should comply with all relevant Federal and State/Territory legislation, policy, and guidelines.
- Storage, use, and transportation of firearms and ammunition must comply with relevant legislative requirements.

Animal welfare considerations

Impact on target animals

- Humaneness of aerial shooting depends on the skill and judgement of both the shooter and the pilot. If properly carried out, it can be a humane method of killing feral camels. On the other hand, if inexpertly carried out, shooting can result in wounding which may cause considerable pain and suffering.
- Aerial shooting should not be carried out if the nature of the terrain reduces accuracy, resulting in too many wounding shots, and prevents the humane and prompt dispatch of wounded animals.
- Shooting must be conducted in a manner which maximises its effect, thus causing rapid death. This requires the use of appropriate firearms and ammunition.
- Only head (brain) or chest (heart-lung) shots must be used. Shooting at other parts of the body is unacceptable.

- With aerial shooting, chest shots are preferred over head shots. The heart and lungs are the largest vital area and an accurate shot is more achievable, particularly within the range of unusual angles encountered when shooting from above. Wounding in the chest/shoulder area, if not lethal, is likely to severely restrict an animal's ability to move and will facilitate the placement of follow-up lethal shots. However, compared with an accurate head shot, a chest shot does not render the animal instantaneously insensible. Although shots to the head are more likely to cause instantaneous loss of consciousness, there is a high risk of missing a smaller, moving target area.
- Death from a shot to the chest is due to massive tissue damage and haemorrhage from major blood vessels. Insensibility will occur after an interval ranging from a few seconds to a minute or more. If a shot stops the heart functioning, the animal will lose consciousness very rapidly. Correctly placed head shots cause brain function to cease and insensibility is immediate.
- The shooter must be certain that each animal is dead before another is targeted. Wounded camels must be located and killed as quickly and humanely as possible with further shot(s) directed at the chest or head. If left, wounded animals can suffer from the disabling effects of the injury, from sickness due to infection of the wound, and from pain created by the wound.
- Helicopter shooting operations do not always result in a clean kill for all animals; therefore prompt follow-up procedures are essential to ensure that all wounded animals are killed. This can be achieved by:
  - Flying the helicopter back to wounded animals so that further shot(s) can be placed into the vital areas of the animal.
  - Using a deliberate policy of 'overkill' whereby numerous rounds are used per animal instead of a single shot. Since it is very difficult to assess if an animal is dead from a distance it is essential that after the initial shot, another one or more shots be fired into the chest or head to ensure a quick death.
  - Using a ground crew of several individuals walking or on all-terrain vehicles to locate and humanely kill any wounded animals in areas that are accessible.

  The cost of ammunition and extra flying time must not deter shooters from applying the appropriate follow-up procedures.
- To minimise the animal welfare implications of leaving dependent calves to die a slow death from starvation it is preferable not to undertake aerial shooting programs when cows have dependent young at foot. Calving is concentrated over winter and spring. Apart from the welfare implications, control at times of calving may be less effective as females are usually more cryptic and tend to leave the group to give birth in isolated and/or sheltered locations.
- If lactating cows are shot, efforts should be made to find dependent calves and kill them quickly and humanely.

Impact on non-target animals

- Shooting is relatively target specific and does not usually impact on other species. However, there is always a risk of injuring or killing non-target animals, including livestock, if shots are taken before an animal has been positively identified.

Health and safety considerations

- The potentially hazardous nature of aerial shooting requires that safety protocols be strictly followed. Each team member must be aware of and trained in all aspects of helicopter and firearm safety.
- Shooting from a helicopter can be hazardous, particularly in areas of rugged topography. The combination of low-level flight, close proximity to obstacles (trees, rocks, wires) and the use of firearms make this task extremely hazardous.

- It is essential that ejected firearm shells do not interfere with the safe operations of the helicopter. It may be necessary to fit a deflector plate to the firearm to ensure shells are ejected safely.
- Firearm users must strictly observe all relevant safety guidelines relating to firearm ownership, possession, and use.
- When not in use, firearms must be securely stored in a compartment that meets state legal requirements. Ammunition must be stored in a locked container separate from firearms.
- Adequate hearing protection should be worn by the shooter and others in the immediate vicinity of the shooter. Repeated exposure to firearm noise can cause irreversible hearing damage.
- Safety glasses are recommended to protect the eyes from gases, metal fragments, and other particles.

Equipment required

Firearms and ammunition

- Self-loading rifles (SLR) with large magazine capacity such as the M14, M1A, L1A1, or Heckler and Koch M19 in .308 calibre are suitable. They should be fitted with a spot on/aim-point/red dot scope. Soft- or hollow-point ammunition with heavy projectiles no smaller than 150 grain should be used.
- Shotguns are NOT recommended for use on feral camels. If they must be used in an emergency situation, rifled slugs are to be used as ammunition.
- To provide a backup in case of firearm/ammunition malfunction, at least two weapons should be carried by shooters at all times.
- The accuracy and precision of firearms should be tested against inanimate targets prior to the commencement of any shooting operation.

Aircraft

- Turbine-powered helicopters are preferred (e.g. Bell Jetrangers, Hughes 500, Kawasaki, etc.)
- It is recommended that GPS (global positioning systems) and computer mapping equipment such as GIS (geographic information systems) are used to assist in the accurate recording of information (e.g. where animals are shot) and to eliminate the risk of shooting in off-target areas.

Other equipment:

- Flight helmet (with intercom)
- Fire-resistant flight suit
- Safety harness
- Other personal protective equipment including lace-up boots, gloves, and appropriate eye and hearing protection
- Survival kit (including a first-aid kit)
- Emergency locating beacon
- Lockable firearm box
- Lockable ammunition box.

Procedures

- Target camels should be mustered away from watercourses before being shot, as wounded animals will be difficult to locate if they go down in water.
- Once a target is sighted and has been positively identified, the pilot should position the helicopter as close as is safe to the target animal to permit the shooter the best opportunity for a humane kill.
- The pilot should aim to provide a shooting platform that is as stable as possible. Shooting from a moving platform can significantly detract from the shooter's accuracy.

- A feral camel should only be shot at when:
    - it can be clearly seen and recognised
    - it is within the effective range of the firearm and ammunition being used and
    - a humane kill is probable. If in doubt, do NOT shoot.
- Camels nearly always trot in single file and their head does not move a great deal as they travel. In a line of running animals, always shoot the animals at the tail end first and then move forward until all animals in the line have been shot.
- In most aerial shooting situations the shooter should aim at the chest, to destroy the heart, lungs and major blood vessels. The following aiming point is recommended:

    Chest shot (this is the preferred point of aim for aerial shooting)

    Side view

    - The firearm is aimed at the centre of a line encircling the minimum girth of the animal's chest, immediately behind the forelegs.
    - The shot should be taken slightly to the rear of the shoulder blade (scapula). This angle is taken because the scapula and humerus provide partial protection of the heart from a direct side-on shot.
- Shots to the head should only be attempted at short ranges and in ideal conditions. The brain is a relatively small target that is well protected by bone. Only the slightest misplacement of the bullet can result in non-lethal and debilitating wounds, such as a broken jaw. Aiming points for head shots are as follows:

    Head shots

    Temporal position (side view)

    - This shot is occasionally used where a second shot needs to be delivered to an injured animal that is lying on its side.
    - The camel is shot from the side so that the bullet enters the skull midway between the eye and the base of the ear. The bullet should be directed horizontally.

    Frontal position (front view)

    - This position is occasionally used when an animal faces the shooter.
    - The firearm should be directed at the point of intersection of diagonal lines taken from the base of each ear to the opposite eye aiming at the spine.
- If an animal is wounded by an initial shot but not killed, a 'fly back' procedure should be adhered to immediately where the wounded animal is located and additional shot(s) are administered to ensure a quick death. Any wounded animal in a group should be killed immediately before any further animals are targeted and shot.
- After a group of animals has been shot, it is essential that the pilot fly back over it to search for animals that still may be alive.
- When shooting feral camels, all animals should receive multiple shots to the vital areas to ensure a rapid death. Animals may appear to be dead but may only be temporarily unconscious.
- Records should be kept of numbers and locations of animals killed, hours flown, ammunition used, and details of fly-back procedures.

Appendix 8.2: Draft Standard Operating Procedure for the Ground Shooting of Feral Camels

Adapted from the *Standard Operating Procedure for the Ground Shooting of Feral Horses* (Sharp & Saunders 2004)

Application

- Shooting should only be used in a strategic manner as part of a coordinated program designed to achieve sustained effective control.
- Ground shooting is time consuming and labour intensive, and is therefore not considered an effective method for large-scale control.
- Ground shooting as a means of population control is not suitable in inaccessible, wooded, or rough terrain where sighting of target animals and accurate shooting is difficult or when wounded animals cannot easily be followed up and killed.
- The optimal period for ground shooting is during dry seasons or droughts when many groups of camels are forced to congregate around areas with water and feed. Shooting during drought reduces the number of camels that would otherwise die slowly of hunger or thirst.
- Sporadic shooting from the ground may teach camels to avoid certain areas, making overall control difficult.
- Shooting of feral camels should only be performed by skilled operators who have the necessary experience with firearms and who hold the appropriate licences and accreditation.
- Storage and transportation of firearms and ammunition must comply with relevant legislative requirements.

Animal welfare considerations

Impact on target animals

- The humaneness of shooting as a control technique depends almost entirely on the skill and judgment of the shooter. If properly carried out, it can be a humane method of destroying feral camels. On the other hand, if inexpertly carried out, shooting can result in wounding which may cause considerable pain and suffering.
- Shooting must be conducted with the appropriate firearms and ammunition and in a manner which aims to cause immediate insensibility and painless death.
- Shooters should not shoot at an animal unless it is clearly visible and they are confident of killing it with a single shot.
- Only head (brain) or chest (heart-lung) shots must be used. Shots to the head are preferred over chest shots as they are more likely to cause instantaneous loss of consciousness. Chest shots do not render animals instantaneously insensible and are likely to result in a higher incidence of wounding. Shooting at other parts of the body is unacceptable.
- Group flight response is a limiting factor for humane and instantaneous killing of camels.
- If possible, all camels in a group should be killed before any further groups are targeted.
- Wounded camels must be located and killed as quickly and humanely as possible with a second shot, preferably directed to the head. If left, wounded animals can escape and suffer from pain and the disabling effects of the injury.
- Culling programs should be timed to minimise the risk of orphaning dependent calves or causing abortion when females are in late pregnancy.

- If lactating females are inadvertently shot, efforts should be made to find dependent young and kill them quickly and humanely with a shot to the brain.

Impact on non-target animals

- Shooting is relatively target specific and does not usually impact on other species. However, there is always a risk of injuring or killing non-target animals, including livestock, if shots are taken only at movement, colour, shape, or sound. Only shoot at the target animal once it has been positively identified and never shoot over the top of hills or ridges.

Health and safety considerations

- All participants in the culling program should stand well behind the shooter when an animal is being shot. The line of fire must be chosen to prevent accidents or injury from stray bullets or ricochets.
- Firearm users must strictly observe all relevant safety guidelines relating to firearm ownership, possession, and use.
- Firearms must be securely stored in a compartment that meets state legal requirements. Ammunition must be stored in a locked container separate from firearms.
- Adequate hearing protection should be worn by the shooter and others in the immediate vicinity of the shooter. Repeated exposure to firearm noise can cause irreversible hearing damage.
- Safety glasses are recommended to protect the eyes from gases, metal fragments, and other particles.
- Care must be taken when handling feral camel carcasses as they may carry diseases such as meliodosis, ringworm, and dermatophilosis that can affect humans and other animals. Routinely wash hands and other skin surfaces after handling carcasses. Carcasses can be heavy, so care must be taken when lifting/dragging.

Equipment required

Firearms and ammunition

- Large calibre, high powered, centre-fire, bolt action or semi-automatic rifles (at least equal to .308 performance), fitted with a telescopic sight should be used. Hollow-point or soft-nosed ammunition, minimum 165 grain, should be used.
- Shotguns are NOT recommended for use on feral camels. If they must be used in an emergency situation, rifled slugs are to be used as ammunition.
- The accuracy and precision of firearms should be tested against inanimate targets prior to the commencement of any shooting operation.

Other equipment:

- lockable firearm box
- lockable ammunition box
- personal protective equipment (hearing and eye protection)
- first-aid kit.
- Appropriate maps identifying access trails and land tenure.

Procedures

- Camels must NOT be shot from a moving vehicle or other moving platform as this can significantly detract from the shooter's accuracy.
- The shooter must be in a firm, safe and stable position before taking a shot.

- The objective is to fire at the closest range practicable in order to reduce the risk of non-lethal wounding. Accuracy with a single shot is important to achieve an immediate and, therefore, humane death.
- A camel should only be shot at when:
    - It is stationary and can be clearly seen and recognised
    - It is within the effective range of the firearm and ammunition being used
    - A humane kill is probable. If in doubt, do NOT shoot.
- Ensure there are no other camels behind the target animal that may be wounded by the shot passing through the target.
- Although camels are large animals, the vital areas targeted for clean killing are small. Shooters should be adequately skilled that is, be able to consistently shoot a group of not less than 3 shots within a 10 cm target at 100 metres. Shooters should also be able to accurately judge distance, wind direction and speed, and have thorough knowledge of the firearm and ammunition being used.
- The shooter must aim either at the head, to destroy the major centres at the back of the brain near the spinal cord, or at the chest, to destroy the heart, lungs, and great blood vessels. This can be achieved by one of the following methods:

    Head shots

    Frontal position (front view)

    - The firearm should be directed at the point of intersection of diagonal lines taken from the base of each ear to the opposite eye. The bullet should be directed horizontally.

    Temporal position (side view)

    - The camel is shot from the side so that the bullet enters the skull midway between the eye and the base of the ear. The bullet should be directed horizontally.

    Chest Shots

    Side view

    - The firearm is aimed horizontally at the centre of a line encircling the minimum girth of the animal's chest, immediately behind the forelegs. The shot should be taken slightly behind and below the shoulder at the point immediately behind the elbow.
- Shooting of individuals should stop when the flight response of the herd limits further accurate shooting.
- Bulls should be shot first. This tends to confuse the remaining camels, slows their retreat and increases the chances of culling them.
- The target animals in a group should be checked to ensure they are dead before moving on to the next group of animals. *Always approach the animal from the dorsal (or spinal) side to prevent injury from kicking legs.* Death of shot animals can be confirmed by observing the following:
    - Absence of rhythmic, respiratory movements
    - Absence of eye protection reflex (corneal reflex) or 'blink'
    - A fixed, glazed expression in the eyes
    - Loss of colour in mucous membranes (become mottled and pale without refill after pressure is applied).
- If death cannot be verified, a second shot to the head should be taken immediately.

Chapter 9:
Review of commercial options for management of feral camels

B Zeng

M McGregor

Contents

Contributing author information

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Murray McGregor: Desert Knowledge Cooperative Research Centre and Curtin University of Technology, PO Box 3971, Alice Springs, Northern Territory 0871, Australia

Tables

Figures and graphs

List of shortened forms

APY	Anangu Pitjantjatjara Yankunytjatjara
AQIS	Australian Quarantine Inspection Service
CACIA	Central Australian Camel Industry Association
CDA	Community Development Advisor
CDU	Charles Darwin University
CLC	Central Land Council
DBERD	Department of Business, Economic and Regional Development
DPI&F	Department of Primary Industry and Fisheries (Queensland Government)
DPIFM	Department of Primary Industry, Fisheries and Mines
FAOSTAT	Food and Agriculture Organization of the United Nations (FAO) Databases
FOB	Free on Board
ILC	Indigenous Land Corporation
MBI	Market Based Instrument
MCDST	Multiple Criteria Decision Support Tool
NRETAS	Natural Resources, Environment, The Arts and Sport
NRM	Natural Resource Management
NTCA	Northern Territory Cattlemen’s Association
PFIAA	Pet Food Industry Association of Australia
RIRDC	Rural Industries Research and Development Corporation
SAAL NRM	SA Arid Lands Natural Resources Management
UAE	United Arab Emirates
UK	United Kingdom

Acknowledgements

This report is Chapter 9 of the final report for the project ‘Cross-jurisdictional management of feral camels to protect NRM and cultural values’. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of DKCRC or its participants.

We are grateful for the support provided to us by a number of organisations, government agencies, and industry participants. In particular we would like to acknowledge Peter Seidel of the Central Australian Camel Industry Association (CACIA) for providing valuable information about the camel industry in Australia and for linking the researchers to relevant industry participants. We would also like to thank Garry Dann, Jim Craig, and Alex Knight for supplying the information that allowed us to develop the case studies. Thanks are also due to Theresa Nano for her contribution to our information collection. We would like to acknowledge the pet food processors who took part in our survey of their use of camel meat. Finally, we would like to thank Glenn Edwards, Phil Gee, John Pitt, and Keith Saalfeld for their valuable comments and suggestions.

Chapter 9: Review of commercial options for management of feral camels

1. Summary

Feral camels have potential commercial uses. A camel industry has been emerging in Australia over the last 20 years, but it is still very small. This chapter reviews the potential for the commercial utilisation of feral camels in Australia and discusses the implications for feral camel management arising as a consequence. Recommendations are made that aim to encourage the development of a strategic management approach to feral camel control within an emerging camel industry.

1.1 Conclusions

Internationally, there is a significant camel industry based on meat, live animals, and by-products. In Australia, by contrast, the industry has struggled to gain momentum because it has been based on the ad-hoc harvest of a feral animal herd that is located in very remote parts of the country and a long distance from domestic markets, let alone international markets. The lack of appropriately located and accredited processing abattoirs has also been a significant obstruction for the industry. The harvesting of feral camels started in the late 1980s, and by 2007 it was estimated that the Australian camel industry harvested around 5000–6000 camels per annum: 3600–4600 for pet meat, fewer than 400 for live export, and 1000 for mainly domestic human consumption. The camel industry in Australia is still very small when compared internationally. However, the size of the feral camel resource of approximately one million animals makes the Australian herd the fifth largest in the world behind Somalia, Sudan, Ethiopia, and Mauritania.

There is potentially a large market for camel products, and a well-developed camel industry could provide an important management tool for the control of feral camels and their impacts and provide much-needed employment and economic activity in desert Australia. Although the current number of camels removed is small, commercial utilisation could potentially remove enough animals to have a significant localised impact on the levels of damage being caused at present and form part of a wider management program to arrest the continued growth in the feral population. However, a flourishing camel industry alone can not bring down the camel population in the short term, as the industry will take some time to develop. Therefore, commercial utilisation is potentially an effective tool for managing feral camels and their impacts in targeted areas rather than across their whole range and as part of a more substantial integrated management approach.

Of the commercial uses investigated in this research, the slaughtering of feral camels for pet meat seems likely to make the greatest contribution to managing camel impacts in the short term, followed by a meat industry for human consumption and live export. Pet meating is attractive as it involves minimal capital infrastructure to develop and could quickly provide livelihoods for Aboriginal people. However, the contribution from commercial activities will depend on the development of secure markets that are prepared to pay the real costs of harvesting and transport.

The industry at present is not organised and lacks some key components to allow it to develop. The key missing elements are the lack of suitable capital infrastructure for harvesting, transporting and processing animals; incomplete information on potential markets including meat for human consumption and pet meat; no collective vision on how the industry should develop; and a lack of dialogue and consultation with land owners.

In many Aboriginal communities there has been considerable discussion about the development of the camel industry and the use of feral camels (e.g. for pet meat). This has contributed to a perception that feral camels are a resource rather than a pest in remote desert settlements (Gee & Greenfield 2007). Aboriginal people and pastoralists are keen to take up opportunities presented by the commercial utilisation of camels and see it as an opportunity for local economic development, employment, capacity building, and empowerment (refer to Zeng & Edwards 2008a, Vaarzon-Morel 2008a). They generally would like to be directly involved in the industry rather than see economic benefits go to external businesses.

The camel industry in Australia must have a unique structure because commercial utilisation would also form part of a national strategy to mitigate negative impacts by controlling feral camels. Commercial utilisation must be integrated into the comprehensive feral camel management strategy. There is clearly a market failure in play at present that has allowed camel numbers to increase in an uncontrolled manner, as society has not factored in the non-market impacts of feral camels on Australia's natural and cultural resources. A Market Based Instrument (MBI) approach is currently being trialled in South Australia and may prove to be an effective way of dealing with this market failure. However, this approach should be limited to situations where the commercial extraction of feral camels is a strategic component of a wider cross-jurisdictional feral camel management plan and not as a subsidy for the establishment of a new industry.

The farming of camels could support a sustainable alternative pastoral industry but would not contribute to the management of feral camels, because camel farming will establish and maintain a permanent domesticated population of camels. Given that this will need to occur to ensure a sustainable industry in the long-term, appropriate regulatory structures must ensure that domesticated animals are contained so they cannot return to the feral herd and are traceable through electronic tagging in the same way as cattle.

Live camel export, meat for human consumption, and pet meat are the major commercial enterprises that would contribute directly to feral camel management. While there should be a focus on continuing to enlarge the international market, the domestic market must also be considered. Other commercial uses for feral camels – such as the production of milk, skin, and game meat, the development of camel tourism and camel farms, and their use for undertaking weed control – would contribute very little to reducing the impacts of feral camels. However, the multiple use of camels would increase the economic viability of a camel industry

1.2 Recommendations

- The commercial utilisation of feral camels can, and should, be integrated into a national feral camel management strategy. Commercial utilisation will have localised impact on feral camel numbers (and their negative impacts), but such utilisation needs to be seen as part of a comprehensive feral camel management strategy aimed at significantly reducing the negative impacts of the species.
- Harvesting for commercial utilisation should focus on two regions. These are the tri-state border region (SA, NT, and WA) and the Alice Springs region.
- There is a need to develop critical capital infrastructure, particularly export-accredited abattoirs to support the development of commercial activities in the two target regions. While this should be funded by the private sector, governments have a role in correcting an existing market failure (where the market does not account for the environmental, cultural, and social costs associated with a feral camel herd).
- A Market Based Instrument (MBI) approach should be trialled across tenures and jurisdictional boundaries, but MBIs should only be used to encourage the reduction in feral camel impact and should not be seen as a subsidy for the establishment of a new industry.
- The commercial utilisation of feral camels provides an opportunity for local economic development, employment, capacity building, and empowerment. Aboriginal people and pastoralists suffering from the impact of camels must be consulted fully on the management approaches adopted on the land that they manage. Such consultation should involve the sharing of information on the costs and benefits of all options, including commercial options, so people can make informed decisions.

- Any future operations on Aboriginal land (and other areas) should attempt to increase the involvement of local people. An effective business model that supports broader and deeper local participation should be encouraged and supported by governments. Such a model should include direct commercial utilisation of camels but also, in the longer term, environmental management initiatives such as Aboriginal Ranger Groups and should be supported by training, including mentoring in business management.
- A national peak body should be established to coordinate the camel industry's development. The role of the peak body would be to speak for the commercial industry; advise government on the needs of the industry in terms of legislation and regulation, capital infrastructure, training, market development, and research based on an industry strategic plan; research potential markets for camel products; facilitate communication, information sharing, and cooperation among the industry participants; and develop a dialogue between the industry, land managers, and government.

2. Introduction

There are two species of camels significantly commercially used in the world: one-humped Dromedary (*Camelus dromedarius*) and two-humped Bactrian (*Camelus bactrianus*). In this chapter, when speaking in general terms, the term 'camel' refers to both species. In the Australian context, the term 'camel' refers to the one-humped Dromedary camel.

In many countries in the Middle East, Asia, and Africa, camels (both species) have been commercially exploited for hundreds of years. However, this utilisation has been based on farmed camels, and has never been linked to the control of a feral population. The industry in these countries is often built around a structured value chain that includes farming, trading, transport, slaughtering, processing, and marketing to final consumers. A wide range of products are traded: live animals for racing and beasts of burden, meat, milk, hides, and components of medicinal products. In Australia, the commercial utilisation of camels (Dromedary camels) is different as it is based on a wild harvest of feral camels; it is often seen as a management option for controlling the feral camel population rather than an integrated industry such as the beef or sheep industry with their associated infrastructure. As a result, the commercial utilisation of camels in Australia is disjointed and lacks a cohesive strategy, which means that it remains a niche activity. There have been numerous attempts to develop both a live-export trade and a meat industry based on feral camels, but these have failed to generate enough capital to make the industry sustainable in the long-term. This chapter reviews the possible commercial uses of camels and discusses the implications for the management of feral camels and their impacts in Australia.

3. Camel products and uses

3.1 Meat

Camels are used as a source of meat for both humans and pets. Comparisons of camel meat with other meats show that camel steak has protein levels similar to beef and has significantly less fat than lamb and chicken which have eight times more fat, and pork chops which have 14 times more fat than a camel steak. Camel steak also contains less cholesterol: 61mg of cholesterol per 100 g of uncooked camel meat compared with 70 mg, 130 mg, and 100 mg for beef, lamb chops and chicken meat respectively (Table 9.1).

Table 9.1: Comparison of camel and other meats

	per 100 grams uncooked mass			
	Energy (KJ)	**Protein (g)**	**Fat (g)**	**Cholesterol (mg)**
Lean camel steak	420	20.7	1.8	61
Lean beef steak	600	21.0	12.0	70
Lamb chop	840	12.0	15.0	130
Chicken meat	710	19.0	15.0	100

Source: CACIA 2006

Camel meat has a similar flavour and texture to that of beef but with a comparatively higher moisture content (Ellard & Seidel 2000). However, there is a difference in the percentages of protein, water, fat, and ash of meat from various parts of the body. The age of the animal also affects the composition of the meat. Camels younger than five years have less protein, fat, and ash than older camels. Nevertheless, these relatively small differences in protein are comparable with the protein content of beef whether it is from a bull, cow, or steer. The fat and ash content of camel meat is lower than that of beef (Table 9.2).

Table 9.2: Comparison of the basic nutritional value of camel and beef

	Water (%)	Protein (%)	Fat (%)	Ash (%)
Beef: bull	76.4	20.9	1.2	1.05
Beef: cow	75.5	21.2	4.0	1.02
Beef: steer	73.0	20.4	4.9	0.97
Camel >5 yrs	76.2	22.0	1.0	0.86
Camel <5 yrs	78.2	20.1	0.9	0.76

Source: Ellard & Seidel 2000

Camel meat is a high quality product in terms of nutrition and is seen as a valid alternative to beef both for human consumption and for pet food.

3.2 Milk

The camel has been used for milk production in Africa for hundreds of years. There has recently been significant interest in camel dairy products in South East Asian countries as a result of reports that camel milk is a good source of protein and vitamin C, and is much more nutritious and has more therapeutic value than the milk of any other animal (Inayat & Farooq 2005). It has been reported that camels produce milk comparable in quality and taste to that of cattle (Table 9.3).

Table 9.3: Composition of camel milk compared with other livestock

	Moisture (%)	Non fat solids (%)	Fat (%)	Lactose (%)	Protein (%)	Ash (%)
Camel	86.3–87.6	7.0–10.7 8.9–14.3	2.9–5.4 2.9–5.5	3.3–5.8 2.9–5.8	3.0–3.9 2.5–4.5	0.6–0.8 0.35–0.95
Cattle	86.1	8.5	5.4	4.6	3.2	0.7
Goat	87.1–88.2	7.8–8.8	4.0–4.5	3.6–4.2	2.9–3.7	0.8
Sheep	79.5–82.0	11.6–12.0	6.9–8.9	4.3–4.7	5.6–6.7	0.9–1.0
Human	88.0–88.4	8.3–8.9	3.3–4.7	6.8–6.9	1.1–1.3	-

Source: Yagil 1982; Wilson 1984; Khanna et al. 1993

While slightly saltier than cow's milk, camel milk is highly nutritious. Produced by animals that can live in some of the toughest environments, it has three times the vitamin C as cow's milk and is also known to be rich in iron, unsaturated fatty acids, and B vitamins.

Camel milk stays fresh much longer than cow's milk. In times of drought, camels continue to lactate long after goats, sheep, and cows have stopped. A lactating camel can produce 4–12 l of milk a day, but may, under intensive conditions, produce between 15–20 l per animal per day (Haddad 2006). Research indicates that camels, intensively managed in the same way as dairy cows, produce a high quality product.

3.3 Medicine

Camel milk, meat and urine have been used for medicinal purposes in many countries. The medicinal properties of camel products were known to Arab physicians centuries ago (Haddad 2006). Early in the sixteenth century one of most well-known medicinal encyclopaedias in China recorded in detail the medicinal value of camel products (Li 1596). This traditional knowledge has been respected, improved, and applied in modern medical practice. A large number of studies have been conducted into the medicinal value of camel products.

It is thought that camel milk and urine contain the diuretic and liver-strengthening properties of the wild herbs they prefer to eat, such as rosemary, thyme, wormwood, and southernwood (Haddad 2006). Camel milk has been used to cure diseases caused by chronic imbalance of the liver, such as jaundice, oedema, and swelling of the belly (Haddad 2006). Recent research reveals that raw camel milk contains insulin-like proteins that can bypass the stomach and be absorbed intact (Agrawal et al. 2005). This characteristic of camel milk could be exploited to help control diabetes in isolated Aboriginal settlements and perhaps to develop pharmaceutical products. Scientists in Israel and Sweden are currently investigating camel milk and its potential benefits to the pharmaceutical industry. Other research indicates that camel milk has a positive effect on children with severe food allergies. The effects are rapid and long lasting, although much research still needs to be done on the healing effects of the milk (Shabo et al. 2005). In India, camel milk is used therapeutically against oedema, jaundice, problems of the spleen, tuberculosis, asthma, anaemia, tuberculosis, and haemorrhoids (piles), and also used for improvement of bone formation (Yagil 1982). In Russia and Kazakhstan, doctors often prescribe camel milk to convalescing patients (Haddad 2006).

Camel meat has been used since the late sixteenth century in traditional Chinese medicine. Camel meat is used to improve resistance to disease, to strengthen the muscles and bones, to moisten the skin, and to relieve internal pain. The fat extracted from the camel's hump is used to effectively relieve pain and swelling (Li 1596; Encyclopedia 1990). Many Chinese restaurants serve, or plan to serve, their customers camel meat. Although camel meat is not commonly consumed in many parts of China, people are increasingly interested in tasting the meat (Liu 2006). In Australia, the National Heart Foundation has endorsed camel meat (Ellard & Seidel 2000).

Camel urine is also used as a medicine in some countries. It was a standard prescription in Arabic medicine and still remains a staple of Bedouin natural remedies, as a diuretic, snuff, and delousing hair wash; it has also been endorsed by mainstream modern medicine (Haddad 2006).

The active constituents of these camel products are unknown despite the fact that many parts and products of the camel are currently being used for medicinal purposes. If an industry is to develop around these products in Australia, then more research is needed into these medicinal properties, the usefulness of camel products in the management of chronic diseases such as diabetes, and the size of potential markets in Australia and internationally.

3.4 Other products and uses

Camel hides, hair, and wool can also be utilised commercially. Camel hides are used for making footwear, fashion accessories, luggage, garments, and bed covers. The average skin size of a six-year-old Australian camel ranges between 1.6 and 2.8 m^2. Skin thickness varies from 2.5 mm at the belly to 6 mm at the ridge. The camel leather has a high tensile strength (MacNamara et al. 2003).

The production of wool and hair by adult camels ranges from 1 kg (El-Amin 1979) to 5 kg (Keikin 1976). Wool is shed at the end of winter. If the wool is not gathered, the animal rubs itself against trees and bushes until the wool is shed. Camel wool is used for making padded cloth, quilts, and as a mattress filler. In addition to wool, Dromedary camels produce long hair that can be shorn and used for making clothes, tents, carpets, robes, saddle-girths, and blankets (El-Amin 1979).

Camels are used for tourism worldwide, especially in desert areas. In Australia there are about 50 camel tourism operations (see Edwards, Zeng & Saalfeld 2008), the most famous example being the camel ride offered at Cable Beach near Broome in Western Australia. Camel trekking and riding are the most common forms of camel tourism, but camels are also used in camel races such as the annual Alice Springs camel race. While camels do contribute to tourism, the number used is very small.

Camels are used also for other purposes such as ploughing, transporting people and materials, dung for fuel, removal of woody weeds, as props in film and video production, and racing.

4. Commercial utilisation of camels – international perspective

Camels (both Dromedary and Bactrian camels) are used commercially in many countries, primarily as a source of meat, milk, medicinal products, leather, and wool. The international camel industry is based on farmed, not feral animals.

The global population of domestic camels is relatively stable, at around 22 million, with only 5% of them being Bactrian camels. In 2007, the largest herds existed in the African nations of Somalia, Sudan, Ethiopia, Mauritania, Kenya, Chad, Mali, and Niger and the subcontinent countries of Pakistan and India, for a population of 18.8 million, with the other 3.2 million distributed across 36 other countries (Table 9.4).

Table 9.4: World camel stocks

Countries	2000	2001	2002	2003	2004	2005	2006	2007
Somalia	7 001 600	7 078 600	7 156 000	7 200 000	7 210 000	7 230 000	7 000 000	7 000 000
Sudan	3 108 000	3 203 000	3 342 000	3 503 000	3 724 000	3 908 000	3 700 000	3 700 000
Ethiopia	2 190 000	2 222 000	2 254 000	2 286 000	2 291 000	2 324 000	2 358 000	2 300 000
Mauritania	1 356 000	1 411 000	1 467 000	1 511 000	1 556 000	1 603 000	1 603 000	1 600 000
Kenya	824 800	819 100	889 200	895 100	1 193 600	931 300	1 057 900	1060000
Pakistan	775 000	767 000	758 000	751 000	743 000	736 000	738 000	900 000
Chad	720 000	725 000	725 000	730 000	735 000	740 000	745 000	749 500
India	759 000	714 000	672 000	632 000	632 000	632 000	632 000	632 000
Mali	467 000	467 000	470 000	470 000	472 000	472 000	474 000	476 000
Niger	410 000	415 000	421 000	427 000	433 000	439 000	427 000	430 000
Other	3 214 086	3 160 175	3 056 035	3 106 667	3 164 046	3 159 971	3 158 909	3 161 932
World total	**20 825 486**	**20 981 875**	**21 210 235**	**21 511 767**	**22 153 646**	**22 175 271**	**21 893 809**	**22 009 432**
Africa	17 049 378	17 319 372	17 697 672	18 012 894	18 632 992	18 647 511	18 374 748	18 304 243
Asia	3 764 108	3 650 503	3 500 563	3 486 273	3 513 262	3 520 356	3 511 972	3 698 004
Europe	12 000	12 000	12 000	12 600	7392	7404	7089	7185

Source: FAOSTAT 2008

Australia is the only country in the world with a large feral camel population. Its population of one million (refer to Saalfeld & Edwards 2008) is approximately 4.3% of the world total (23 million including both domestic and feral population) and is the fifth largest population in the world behind Somalia, Sudan, Ethiopia, and Mauritania. The Australian camel population is believed to be doubling about every nine years (refer to Saalfeld & Edwards 2008).

4.1 Meat production

Camel meat is not eaten everywhere; however, it is an important meat source in Middle Eastern and some South-East Asian countries (Yagil 1982). Internationally, there is a significant camel meat industry, but only a very small amount is recorded as internationally traded (Foster et al. 2005). Between 2000 and 2007 the number of camels slaughtered annually remained constant at around 1.4–1.5 million (Table 9.5), although these figures appear to be estimates rather than based on accurate data as all numbers have been rounded apart from the 'other' category.

Table 9.5: World camel slaughter figures

Countries	2000	2001	2002	2003	2004	2005	2006	2007
Somalia	230 000	245 000	240 000	260 000	262 000	263 000	260 000	260 000
Sudan	133 000	178 000	185 000	195 000	194 000	235 000	215 000	200 000
Saudi Arabia	181 000	182 000	182 000	184 000	194 000	193 000	186 000	186 000
Mauritania	112 000	117 000	122 000	127 000	130 000	134 000	134 000	134 000
Egypt	130 000	170 000	150 000	126 000	130 000	130 000	130 000	130 000
United Arab Emirates	72 606	76 950	81 210	85 480	85 500	85 500	86 000	86 000
Ethiopia	77 000	78 000	79 000	81 000	81 000	82 000	82 500	80 000
China	67 000	85 000	69 000	65 000	65 600	65 400	68 000	70 000
Kenya	66 000	66 000	66 000	66 000	95 000	85 000	66 000	66 000
Mali	46 000	46 000	47 000	47 000	47 200	47 200	47 400	47 600
Other	253 525	252 220	241 151	234 290	254 839	258 186	250 717	251 899
World Total	**1 368 131**	**1 496 170**	**1 462 361**	**1 470 770**	**1 539 139**	**1 578 286**	**1 525 617**	**1 511 499**
Africa	905 500	1 013 702	1 001 677	1 016 553	1 058 471	1 097 240	1 056 393	1 036 922
Asia	461 266	481 333	459 774	453 217	479 668	479 914	468 475	473827
Europe	1365	1135	910	1000	1000	1132	749	750

Source: FAOSTAT 2008

4.2 Global trade in live camels

There is significant global trade in live camels (Foster et al. 2005). While it is hard to obtain accurate information, the following Food and Agriculture Organisation of the United Nations (FAO) data (Figure 9.1, Figure 9.2) show that since 1990, global trade in live camels has oscillated considerably, with an average annual number traded of 80 000 head for an average annual value of approximately US$28 million. Since the late 1990s, the world trade in live camels has been declining at a rate of approximately 8% per year.

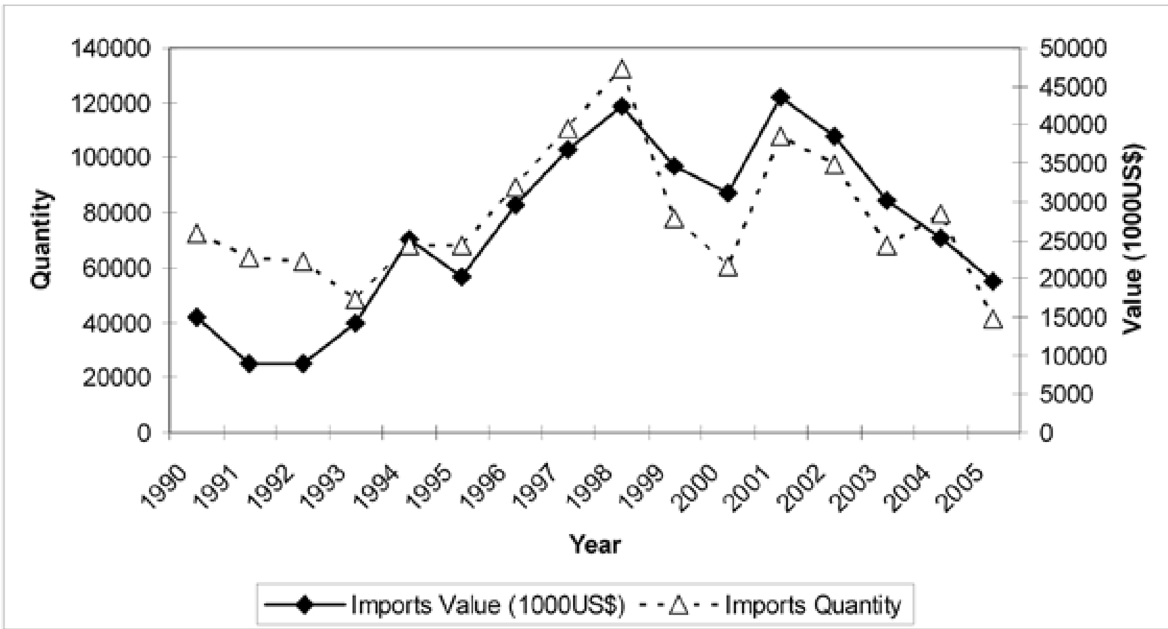


Figure 9.1: Live camel imports in the world

Source: FAOSTAT 2008

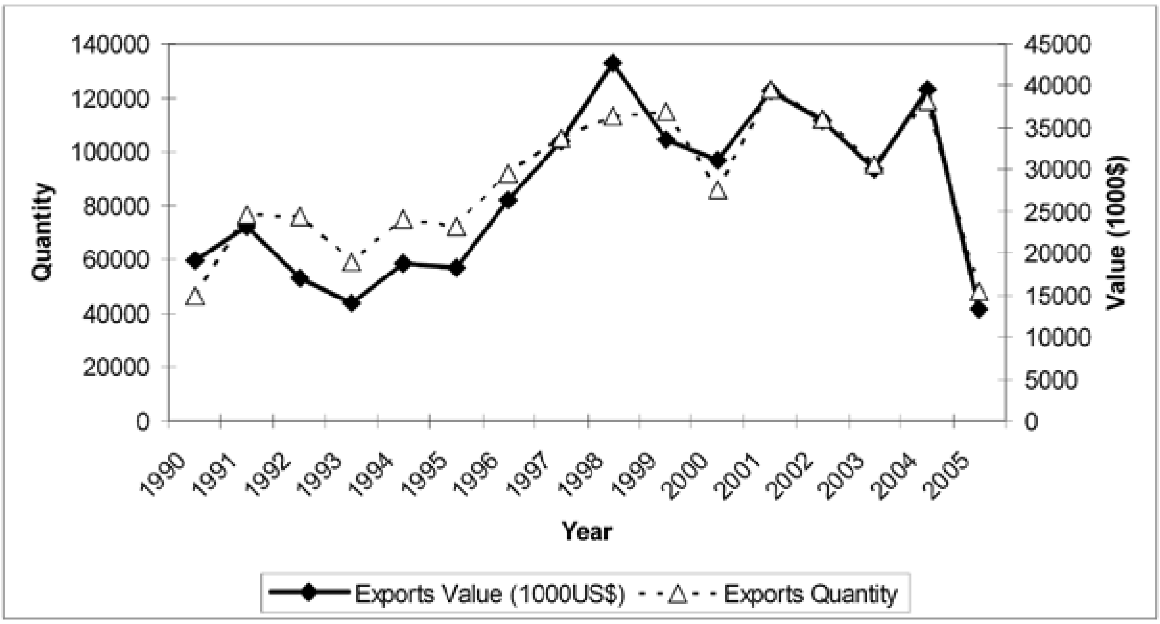


Figure 9.2: Live camel exports in the world

Source: FAOSTAT 2008

The Arab nations of Egypt, Saudi Arabia, Qatar, the United Arab Emirates, and Oman were the world's largest importers of live camels in 2000–2005, accounting for more than 90% of total world imports (Table 9.6).

Sudan was the world's largest exporter of live animals from 2000 to 2005 (Table 9.7). In this period the country's live camel exports varied from ~22 000 to ~97 000 head per annum, accounting for approximately 53–68% of total international live camel exports. Other key exporting nations recorded by FAOSTAT between 2000 and 2005 were Qatar, United Arab Emirates, Oman, Saudi Arabia, and Djibouti (Table 9.7) with Mauritania (Goulding et al. 2007) and Ethiopia (Ethiopian News Agency 2008) beginning to export large numbers.

Recent reports suggest that the international trade in live camels has started to recover, with the second largest live animal exporting company in Ethiopia, SAAFI Trading and Agro Industry PLC, predicting it would export 20 000 camels worth US$6 million abroad in 2008. This is a 50% increase on its previous year's export figures, and they continue to expect an average price of US$300 per head. It is interesting to note that the company requested the Ethiopian government strengthen its control over contraband trade, which, it said, is disabling the exporter's competitive capacity in the global market (Ethiopian News Agency 2008).

Table 9.6: World live camel imports 2000–05

Countries	2000		2001		2002		2003		2004		2005	
	Imports quantity (head)	Imports value (1000US$)	Imports quantity (head)	Imports value (1000US$)	Imports quantity (head)	Imports value (1000US$)	Imports quantity (head)	Imports value (1000US$)	Imports quantity (head)	Imports value (1000US$)	Imports quantity (head)	Imports value (1000US$)
Egypt	61 354	12 185	99 651	26 861	77 284	20 617	48 867	10 625	39 711	7745	45 456	9549
Saudi Arabia	25 160	8 700	10 785	3650	20 600	8500	25 762	7200	10 160	3226	-	-
Qatar	417	299	10 331	6984	4568	1823	541	218	8281	4240	8695	4801
Oman	-	-	-	-	5327	3768	8114	5867	5072	8422	-	-
Other	398	354	1347	973	178	45	1284	461	7857	4739	746	387
World Total	**87 329**	**21 538**	**122 114**	**38 468**	**107 957**	**34 753**	**84 568**	**24 371**	**71 081**	**28 372**	**54 897**	**14 737**
Africa	61 354	12 234	99 651	26 997	77 284	20 617	50 081	11 074	40 692	8388	45 456	9549
Asia	25 975	9304	22 463	11 471	30 673	14 136	34 487	13 297	30 389	19 984	9441	5188

Source: FAOSTAT 2008

Table 9.7: World live camel exports 2000–05

Countries	2000		2001		2002		2003		2004		2005	
	Exports quantity (head)	Exports value (1000US$)	Exports quantity (head)	Exports value (1000US$)	Exports quantity (head)	Exports value (1000US$)	Exports quantity (head)	Exports value (1000US$)	Exports quantity (head)	Exports value (1000US$)	Exports quantity (head)	Exports value (1000US$)
Sudan	61 400	12 186	97 441	26 200	50 896	13 500	60 949	12 255	84 545	15 268	22 296	4561
Qatar	13	10	1223	1789	5	3			12 441	3829	10 863	7564
United Arab Emirates	-	-	5305	4400	6443	4360	8114	5860	8865	11 050	-	-
Oman	-	-	-	-	436	375	4166	6222	5007	3393	-	-
Saudi Arabia	591	360	7765	2800	3322	1150	194	66	4059	1167	-	-
Djibouti	-	-	2110	670	25 248	6780	15 900	3900	4049	840	3376	609
Mali	-	-	-	-	41	13	1817	1094	1636	1163	1636	1163
Chad	2986	1550	1478	770	1500	780	1500	800	1500	800	1500	800
Somalia	25 161	10 000	4610	2000	20 600	8500	950	400	981	574	1000	600
Other	6613	3524	2359	937	3027	565	65	8	39	28	1005	256
World Total	**96 764**	**27 630**	**122 291**	**39 566**	**111 518**	**36 026**	**93 655**	**30 605**	**123 122**	**38 112**	**41 676**	**15 553**
Africa	95 192	26 740	105 639	29 640	98 307	29 577	81 181	18 457	92 711	18 645	30 653	7880
Asia	1572	890	16 652	9926	13 211	6449	12 474	12 148	30 411	19 467	11 023	7673

Source: FAOSTAT 2008

4.3 Other products

In Africa and the Middle East, camel milk is an important dairy product. The annual production of camel milk is around 5.4 million tonnes (Fletcher 2006). The major demand for camel milk comes from countries in the region from the Sahara to Mongolia. The demand in Europe is currently small but the FAO has recently predicted that camel milk could appear on European supermarket shelves one day (Fletcher 2006).

The processing of camel hides is common in Northern Africa and the Middle East (MacNamara et al. 2003). The data relating to the production of camel hide and leather is not available; however, the slaughter figures suggest that the countries with the greatest volume of camel hides available are: Sudan, Saudi Arabia, Egypt, Mauritania, the United Arab Emirates, and China, which collectively account for almost 53% of camels processed for meat in 2005 (Goulding et al. 2007). Italy and the United States are the major markets. Italy is currently the most promising market for leather because the

Italian industry believes the hides are well suited to the production of accessories, belts, jackets, shoes, and upholstery. The industry has also stated that natural scarring does not diminish a hide's quality because it makes each one unique (Goulding et al. 2007).

Camel wool is harvested and processed for making padded cloths, quilts, and mattresses. In China in the early 1980s, approximately 1500 tonnes of wool was collected annually and consumed domestically (Yagil 1982).

5. Commercial use of feral camels in Australia

5.1 Industry size

The presence of a significant feral camel population in Australia provides an opportunity to develop a commercial camel industry. Feral camels were first harvested for meat in 1988 in Alice Springs in the Northern Territory (NT). Since then, commercial harvesting has occurred irregularly in both the NT and Western Australia (WA). In the mid-1990s, initial investigations showed possible markets for Australian feral camel products did exist, particularly internationally. The launch of the Central Australian Camel Industry Association (CACIA) in 1995 was a landmark event in the establishment of the Australian camel industry.

Unlike the rest of the world, the development of the camel industry in Australia has focused on the wild harvest of feral animals, not on the development of a domesticated population. Wild harvest for live export and meat production has been the major components of the camel industry in Australia up until now. Marketing efforts have concentrated on live camel exports to Asia and the Middle East where camels are used for racing and for breeding stock. Domestically, Australian camel meat is mainly used for human consumption. There is only a small quantity of camel meat exported currently because of little international market development and lack of an export accredited abattoir. In the past few years the harvest of camels for pet meat has become an important component of the industry, in terms of the numbers of animals harvested. This component of the industry is growing because of its acceptability to stakeholders and due to the accessibility of a proven market, including the international pet food market.

Reliable data that measures the production, consumption, and live export of camels and meat is hard to obtain as it is not included in national statistics. According to a report produced by the Rural Industries Research and Development Corporation (RIRDC), the farm gate value of the camel industry in Australia is small and has declined since the late 1990s. In 1999–2000 the report estimated that the value of camel meat was \$200 000, dropping to \$100 000 in 2003, and less than \$100 000 in 2004, while live export declined from \$200 000 in 2003 to less than \$100 000 in 2004 (RIRDC 2005).

However, based on the best information we have been able to find, we estimate that the gross sales value of camel primary products is currently between \$1.87–2.50 million (Table 9.8), including \$0.27–0.36 million for live exports, \$0.92–1.10 million for meat production for human consumption, and \$0.68–1.04 million for meat production for pet food manufacturing. The total export value is around \$0.45–0.58 million, or 24% of the total sales value. The number of feral camels harvested for commercial use in 2006 was estimated to be 2200–3200: fewer than 400 for live export, 800 for human consumption, and 1000–2000 for pet meat. However, in 2007 this number increased to 5000–6000, as the commercial use of camel meat for pet food was dramatically increased to 3600–4600 camels and the use for human consumption was also increased to 1000 camels, including 200 camels slaughtered for international markets. The details will be discussed in following sections.

Table 9.8: Australian camel production (2007–08)

Camel meat production for human consumption		
Slaughtering	no.	1000
Meat production (natural fall)	tonnes	167–200
Gross sales value	$ million	0.92–1.10
Export value	$ million	0.18–0.22
Camel meat production for pet food manufacturing		
Harvesting	no.	3600–4600
Meat production (carcass)	tonnes	900–1,380
Gross sales value	$ million	0.68–1.04
Live camel exports		
Volume	no.	<400 (363)
Sales value	$ million	0.27–0.36
All camel products		
Harvested camels	no.	5000–6000
Total export value	$ million	0.45–0.58
Gross value of production	$ million	1.87–2.50

5.2 Major participants in the Australian camel industry

Currently involved in the Australian camel industry are:

- four main companies involved in slaughtering camels and processing them for human consumption. They are Territory Camel Pty Ltd in the NT, Strath Meats and Metro Velda in South Australia (SA) and Meramist Pty Ltd in Queensland (Qld) (refer to Section 5.5.1)
- a small number of meat wholesalers and retail businesses
- a small number of live export traders, and their number is determined by the current demand for camels. Camel Exports Pty Ltd, based in Alice Springs, has consistently maintained a profile in this area over a number of years (refer to Section 5.4.1).
- at least three pet food companies using camel meat for pet food manufacturing and more interested in using camel meat (refer to Section 5.5.2)
- only a small number of professional shooters directly involved in pet meating operations, with most of them operating in WA
- approximately 50 small businesses involved in camel tourism, most of them operating on a small scale using small numbers of camels (refer to Section 5.6.2).

5.2.1 Aboriginal people

Aboriginal people have an important role in the emerging camel industry because a significant number of the existing population of camels live on Aboriginal-owned and -managed land. Many Aboriginal people have had some involvement in pastoral enterprises and the camel industry (Vaarzon-Morel 2008a, 2008b), especially in the harvesting of animals for meat or live export (refer to Section 5.3). As the managers of significant tracts of the camel range, Aboriginal people will strongly affect the implementation of any management actions, whether it is the development of a commercial industry or the implementation of a culling regime. The involvement of Aboriginal land managers in the development of a sustainable camel industry is crucial to its success. An expansion of the current industry could provide much needed employment, business opportunities, and income to remote areas.

According to the survey of 27 Aboriginal communities in the camel range carried out as part of this research project, most Aboriginal people support the commercial use of feral camels and would like to be involved in a camel industry. They expect that the development of the industry would not only achieve economic returns but also create employment and empower local communities (refer to Vaarzon-Morel 2008a, 2008b).

5.2.2 Pastoralists

Pastoralists have been both active participants and strong disbelievers in the development of a camel industry. They have established facilities and used their pastoral infrastructure to muster and hold camels for on-selling. They have also been very vocal in their scepticism about the sustainability of a camel industry. Their dilemma can best be explained as follows: they want to actively participate in feral camel management activities because of the substantial impact that feral camels have on their pastoral operations, and from a financial perspective they would like see camels supplement their pastoral income. They also have concerns about the economic viability of a camel industry and its potential competition with the cattle industry, which is currently more profitable. This is confirmed by the results of a survey of pastoralists (described in Zeng & Edwards 2008a). According to the survey of 209 pastoral properties, 21% of pastoralists have been involved in camel use, and approximately 1599 camels were harvested over the period July 05 – June 07. This was around 20% of the total number of camels harvested in the same period by the whole camel industry in Australia.

5.2.3 Industry bodies

Industry pioneers formed a representative industry body, the Central Australian Camel Industry Association (CACIA), in Alice Springs in 1995. CACIA is comprised of members of the pastoral industry, the meat industry, representatives from Aboriginal settlements, tourism operators, transport operators, contractors, and government agencies, who all have a common interest in developing the commercial potential of the camel industry. The role of CACIA is to promote the sustainable development of the camel industry through promoting the use, understanding, and wellbeing of camels in Australia. Since its inception it has been has been one of the most important players in the development of the Australian camel industry.

CACIA is involved with camel product and market development through its trading company Camels International Pty Ltd. It has also developed and disseminated a significant amount of industry information, including information for livestock dealers, zoos, safari parks, veterinarians, meat brokers, exporters, butchers, executive chefs, food and beverage managers, and supermarket meat buyers. It has developed the specifications and ordering codes for domestic and international trade and guidelines for the capture and handling of camels destined for the abattoir (CACIA 2007). Also, a Camel Industry Steering Committee has been established in WA, to facilitate and coordinate the commercial utilisation of camels.

5.2.4 Governments

It is estimated that since 1998, the total government investment in the camel industry has been over $4.37 million (Edwards, Zeng & Saalfeld 2008). Governments have also played an important role by developing the policies and laws associated with the use of camels in Australia (Carey et al. 2008).

The roles that governments have played include the following:

- The Commonwealth Government, through initiatives such as the RIRDC, has supported research into, and implementation of, camel management, including evaluations of the viability of commercial activities.

- The NT Government through its then Department of Primary Industry, Fisheries and Mines (DPIFM) and Department of Business, Economic and Regional Development (DBERD) supported the development of the CACIA with funding of approximately $120 000 per year for ten years. This support ceased in 2006.
- The Qld Government has allocated a senior officer in the Department of Primary Industry and Fisheries (DPI&F) to coordinate and support the development of the camel industry. A series of studies have been conducted to explore the viability of a camel farming industry.
- The WA Government has set up a special camel group to coordinate camel management in Western Australia, where live export is considered one of the most important commercial uses for feral camels.
- The SA Government is supporting a market-based instrument project through SA Arid Lands Natural Resources Management (SAAL NRM) Board and Rural Solutions SA. This project aims to investigate the creation of a market mechanism that would drive sustainable feral camel control.

5.3 Camel harvest

Pastoralists, Aboriginal communities, professional shooters, and musterers are all involved in camel harvesting. Harvested animals are either sold to abattoirs, or to live exporters, or slaughtered on site and sold to pet food companies, or occasionally consumed. Harvesting is usually accomplished by trapping or mustering the camels using helicopters, motorbikes, horses, or other vehicles, or by shooting in the field from the ground. Harvesting has not been undertaken on a consistent basis as there has not been a steady market demand. There is evidence that feral camels have been held in sizeable enclosures in anticipation of markets becoming available, but this is unusual. Harvesting has mainly occurred in SA, the NT, and WA. In Qld the feral camel population is relatively small and there has not been substantial wild harvest activity.

5.3.1 Camel harvest in South Australia

Feral camels are harvested from the SAAL NRM region for economic return. They are sold for live export, human consumption, pet food and, to a lesser extent, for domestication, racing, and for on-selling to Qld for the control of woody weed species (Gee & Greenfield 2007). Mustering wild camels for sale mainly occurs on an ad hoc basis from stations including Macumba, Cowarie, Bollard’s Lagoon, and Clifton Hills.

The Anangu Pitjantjatjara and Yankunytjatjara (APY) Lands in SA have a high feral camel density (refer to Saalfeld & Edwards 2008). The APY Land Management unit at Umuwa has been attempting to develop a sustainable live harvest camel industry. Feral camels mustered on the APY Lands are transported for slaughter to Wamboden (NT), Peterborough, and Strathalbyn abattoirs (SA), and some are purchased by Camel Exports Ltd for live export when the opportunity arises. It is estimated that around 2 000 feral camels were harvested in the APY lands in 2007 for commercial utilisation, including human consumption, pet meat manufacturing, and other uses (Phil Gee 2008, Senior Consultant, Rural Solution, SA, pers. comm.).

5.3.2 Camel harvest in Northern Territory

In the NT there are a number of pastoral stations that maintain camel herds including Henbury, Narwietooma, Aileron, Kings Creek, Horseshoe Bend, and Ringwood. The feral camels are mustered or trapped and are then maintained and fed, awaiting buyers. Camels are also mustered on other stations and Aboriginal lands on an ad hoc basis.

Henbury Station started a camel business in 2000 and currently has 1500 camels. These animals were mustered and trucked to the station from the Kaltukatjara (Docker River) region. According to Ross Morton, the owner of the property, the camels impose little extra cost on the property. Since 2000, approximately 3000 camels (most of them harvested from the station) have been sold, including 1600 that were slaughtered at an abattoir; the remainder were sold for live export (Ross Morton 2008, owner of Henbury Station, NT, pers. comm.).

An interest in harvesting feral camels was sparked in many Aboriginal settlements by the formation of the CACIA about 10 years ago. A number of initiatives have been developed to provide funding and skills development. The Undurana Camel Farm is a pilot program for the camel industry. The initial proposal for the project was completed in 2000 by the Central Land Council (CLC) with funding from the Indigenous Land Corporation (ILC). The proposal involved fencing a 50 km x 50 km v-shaped area, enclosed by ranges, with trap gates at one end. Trapped camels were managed as a semi-domesticated herd, with regular mustering for live export. The ILC, CLC, and Tjuwanpa Resource Centre provided funding and practical assistance to build the fence. The energy company Santos also became involved, providing further funding and support staff when funding ran out (Peter Donohoe 2007, CLC, pers. comm.). The fence was completed in 2005 and it has been reported that there are now around 500 camels within the paddock. There has been little activity since this time, apart from the occasional sale of animals to camel traders. In 2006 a proposal was made to lease the paddock for cattle grazing; however, local people were not interested because this would have meant taking the camels elsewhere. Andrew Drenen, the Indigenous Protected Area Officer from the CLC Land Management Unit, also approached the local Aboriginal people in 2006 regarding the possibility of their selling camels for pet meat. However, the $25 offered per head fell far short of the figure they expected to receive for their camels and none were sold. In March 2008 approximately 100 animals were helicopter mustered into yards and 40 were sold to Wamboden Abattoir in Alice Springs (James Huston 2008, Independent community health worker, pers. comm.).

Kaltukatjara (Docker River) received a small grant from the Winemakers' Federation of Australia in 2000–2001 to help establish a local camel harvesting enterprise. Local Aboriginal people were to be employed to muster, maintain, and slaughter camels. The money was used to build a camel holding yard that was designed to catch some of the thousands of feral camels at Junti, near Lasseter's cave. Only half of the yard was completed during this project. The project was overseen by Ngaanyatjarra Aboriginal Corporation but was interrupted when senior community members protested about the young men involved being paid in food (i.e. pies from the community store). A further grant from the Winemakers' Federation was received in 2005. This money was used to buy a vehicle and complete the stockyard. A single water trough was put in place to lure feral camels into the yard. However, there has been no mustering and trucking out of camels since the stockyard was completed, mainly because there is no market for the meat. The bore to feed the trough is not currently working. The main way that camels are currently being used in the Docker River area is as meat for community consumption, with approximately one animal per week being killed and butchered.

In other settlements such as Kintore, on the western border of the NT, there has been some interest in harvesting feral camels for the past 10 years. There has not been a commercial harvest yet, although young men do hunt camels and distribute the meat to old people in the community (ABC Online 2008).

5.3.3 Camel harvest in Western Australia

There are no stations in WA running commercial camel herds. The closest thing to a commercial operation is conducted at Anna Plains Station where the camels are not culled but are rounded up by the rouseabouts and sold to augment their wages (Peter Kendrick 2007, Head of Nature Conservation in the Pilbara Region for WA Department of Environment and Conservation, pers. comm.). It has not been established whether these camels were used for live export or were intended for domestication. Two or three Aboriginal settlements have mustered small numbers of camels for live sale: Warburton, where a few small truckloads (possibly two loads of 10 camels) have been sold to the camel farm in Kalgoorlie; and Jameson where one load was sent for live export (Andrew Drenen 2007, Regional Land Management Officer, CLC, pers. comm.).

The West Australian Ngaanyatjarra settlements have started working with the SA APY camel program. Community members travelled to the APY lands for training in camel butchering techniques and to see first hand what APY Land Management have been doing in relation to herd management and mustering (Alex Knight 2007, Director of Land and Cultural Management Unit, Ngaanyatjarra Land Council, pers. comm.). Since March 2007, a small group of professional shooters has been harvesting feral camels for pet meat around Ngaanyatjarra settlements (Warakurna, Jameson, and Tjukurla). They were contracted by Ngaanyatjarra Council and the local settlements. Approximately 2000 camels have been shot from the ground for pet meat (see Appendix 9.2: Case study: Pet meat operation in Warakurna for details).

Kunawarritji settlement in the Great Sandy Desert has built a mustering yard and is interested in developing a live harvest enterprise (Peter Kendrick 2007, Head of Nature Conservation in the Pilbara Region for WA Department of Environment and Conservation, pers. comm.).

5.3.4 Harvest cost

Feral camel mustering consumes a lot of time and money. Mustering costs vary from case to case, depending on the geography, camel density, road access, transportation distance, harvest method, and the skills and knowledge of the harvesting team. Permanent trap yards can be used to capture animals, but once trapped the camels still need to be further aggregated, using motorbikes, vehicles, and even helicopters, before loading onto trucks. From the trucks they can go either for sale or to holding paddocks awaiting a buyer. In the case of Henbury Station in the NT the estimated cost of mustering was between $50 and $100 per head (Ross Morton 2008, owner of Henbury Station, NT, pers. comm.). In addition to this, the station faced a transport cost of between $100 and $150 per head making a total cost of between $150 and $250 per head. The current farm gate price for live export is $400 and for meat it is $200.

5.4 Live exports

The live export of feral camels is currently one of the most important components of the camel industry in Australia. Camels are traded both domestically and internationally. Domestically, they are sold to abattoirs, tourism operators, and camel farms where they are stocked for meat production and other commercial purposes including the control of woody weeds. The number of camels traded within Australia is approximately 1500 per year. This figure is determined by the demand for camel meat (discussed in more detail in Section 5.5).

5.4.1 Current situation

Camel Exports Pty Ltd has been operating a live export business for 19 years. The volumes and destinations of live camel exports vary substantially from year to year. According to CACIA, the total number of camels exported live from 1988 to 2007 was 4761 head (Table 9.9), an average of approximately 250 head annually. In 2007 this figure was 363 head. The majority (77%) were exported to South-East Asia, with most going to Malaysia; the rest were exported to the Middle East and America.

Table 9.9: Numbers of Australian camels exported 1988–2007

Export destination	Number	Export destination	Number
USA	612	Taiwan	20
Brunei	991	Korea	25
UAE	45	Saudi Arabia	126
Cuba	24	Kuwait	122
Indonesia	53	Jordan	160
Thailand	96		
Pen. Malaysia	2487	**Total**	**4761**

Source: CACIA 2006; Camel Exports Pty Ltd

Since 2003, the income received from exports of live camels has declined. The value of live camel export trade reached a peak of $579 000 in 2003, but since then has declined to $100 000 or less, with a rise again in 2007 (Table 9.10).

Table 9.10: Income received from Australian live camel exports

	Unit	2000–01	2001–02	2002–03	2003	2003–04	2004	2005	2006	2007
Number	no.	197	415	130	-	115	-	-	-	363
Value	$'000	141	297	93	579	82	104	30	27	272–363

Source: Data for 2000–01, 2001–02, 2002–03 and 2003–04 from (Foster et al. 2005); Data for 2003, 2004, 2005, 2006 and 2007 from CACIA Office (Peter Seidel 2008, Central Australian Camel Industry Association, pers. comm.).

There seems to have been some recent signs of recovery in the number of live camels exported. In 2003–04 there were 115 live camels exported to Malaysia (57% of total), Brunei Darussalam (35% of total), and Saudi Arabia (7% of total), which is less than half of the average number over the last 19 years (250 camels per annum). However, in 2006–07 there was a significant increase in the number of camels exported, with 363 camels shipped, most of them to Malaysia (94%) (DAFF 2008). The value of live camels sold is currently around $272 000–363 000 per annum, i.e. $750–1000 Free on Board (FOB) per camel. It should be noted, however, that the numbers exported have remained small, there are no long-term supply agreements in place, and sales occur on an ad hoc basis. There is therefore no incentive for companies and individual landholders to invest in infrastructure.

The majority of camels are shipped through Darwin, but other ports, including Townsville, Broome, Wyndham, and Adelaide have been used, or have the capacity to export live camels.

5.4.2 Markets

South-East Asian, Middle Eastern, and African countries are currently the major markets for Australian feral camels. Australian animals are sought after because they are free range and have none of the diseases that have impacted herds in the destination countries. The current world trade in live camels is around 100 000 camels per year (refer to Section 4.2). They are mainly supplied by African countries such as Mauritania and Sudan.

The landed price is the major factor that determines Australia's capacity to penetrate this market. As noted above, the current Free On Board (FOB) value of camels in Darwin is between $750–1000 per camel. As a comparison, in 2003 the average price for a camel in Pakistan was Rs.21 500 (AU$579) (Isani 2003). Recent research in Pakistan has found that, at the Mangrota Camel Mela (Fair) in 2006–2007, 8000–10 000 camels were traded, with an average price of Rs.50 000 (AU$1039). The camels were bought for a variety of purposes including physical work, domestic slaughter, live export to Iran, and meat export to Gulf countries (Raziq 2007). While there is an opportunity for Australia to export camels, the margins are likely to be small unless they are supplied into high value niche markets.

5.5 Meat production

5.5.1 Human consumption

In the early 2000s, the number of camels slaughtered for human consumption was around 400 head per year. With the advent of new businesses such as Territory Camel in the NT, the number slaughtered has been increasing since 2005. It has been estimated that currently the Australian camel industry slaughters a total of about 1000 head per year for human consumption, including 800 for domestic and 200 for international markets (Table 9.11). The value of this production is estimated to be $1.01 million. This figure is based on an average live weight of 500–600 kg, generating an average saleable meat volume of 184 kg (167–200 kg) at a price of $5.50 per kg.

Table 9.11: Number of camels slaughtered in Australia

Period	Number of camels slaughtered (per year)	Source
2001–2005	400	(Goulding et al. 2007)
2003	397	(Invest Australia 2005)
2005/06	600	Garry Dann 2008, Managing Director of Territory Camel Pty Ltd, pers.comm., Peter Seidel 2008, Central Australian Camel Industry Association, pers. comm.
2006/07	800	Garry Dann 2008, Managing Director of Territory Camel Pty Ltd, pers. comm., Peter Seidel 2008, Central Australian Camel Industry Association, pers. comm.
2007/08	1000	Garry Dann 2008, Managing Director of Territory Camel Pty Ltd, pers. comm., Peter Seidel 2008, Central Australian Camel Industry Association, pers. comm.

The value of camel meat sold can be estimated by another method. If only 26.6% of a camel carcass is retail cuts (including topside, silverside, eye of round, sirloin, silverside heel, hind shank, loin without bones, tenderloin, shoulder clod, chuck tenderloin, blade, small shoulder cut, shank for roasting, and fore shank) (Farach & Fischer 2004), a camel would have around 66.5–79.8 kg of meat that could be for sold for human consumption in retail outlets. There are, therefore, around 66.5–79.8 (an average of 73.2) tonnes of camel meat currently produced each year that could be sold.

According to CACIA, from 2003–2006, 14 tonnes of camel meat (retail cuts) valued at around $175 000 were sold annually by Camels International Pty Ltd. The average price for camel retail cuts was, therefore, around $12.50 per kg. Using this price, the current value of camel retail cuts sold for human consumption (73.2 tonnes) is about $0.91 million. If the value of other saleable meat is included (e.g. processing materials such as camel meat with some visible fat and connective tissue) in the estimate, the total value of camel meat sold would be over $1.00 million.

The main processors of camel meat for human consumption domestically are Territory Camel in the NT (refer to Appendix 9.1: Case study: Territory Camel Pty Ltd), Strath Meats, and Metro Velda, these last two both in SA. They mainly process camels from the NT and SA, mustered from wild and commercial herds. Small numbers of camels from both Qld and SA have been processed by Meramist in Caboolture, Qld for export. In 2007/08 Territory Camel Pty Ltd slaughtered 450 camels, and the meat was supplied only to domestic markets. Meramist Pty Ltd is currently the only company with export accreditation that is processing camel meat for export. In 2007/08 Meramist started to export camel meat to the United Kingdom (UK). Currently around 4.7 tonnes of camel meat are exported every fortnight (Lauren Brisbane 2008, Brisbane Hornery Partnership, pers. comm.).

The main wholesaler of camel meat for the domestic market is Wyuna Meats in Adelaide, SA (Peter Seidel 2007, Central Australian Camel Industry Association, pers. comm.). They sell directly to restaurants, butchers, and manufacturers across Australia. Other businesses, including Territory Camel, also sell their own camel products direct to the public.

A small number of restaurants serve camel meat; these are usually confined to tourist areas where tourists are interested in trying camel meat for variety, for its novelty appeal and because it is 'bush tucker' (Warfield & Tume 2000). Some supermarkets in SA and the NT have sold camel meat in the past (Woolworths and Coles in Alice Springs were the main outlets) (Warfield & Tume 2000), but discontinued it a few years ago, along with other exotic meats such as buffalo and crocodile because of lack of demand (Peter Seidel 2007, Central Australian Camel Industry Association, pers. comm.).

5.5.2 Pet food

5.5.2.1 Scale of camel harvest for pet meat

Pet meat is an important commercial use for feral camels in Australia. The industry initially relied on off-cuts from the slaughter of feral camels for human consumption, and the specialty pet meat operations commenced in a substantial way in 2006 on some pastoral properties in WA and the NT. Since 2007, a small scale third-party pet meat operation (see Appendix 9.2 for a case study) has been undertaken on Aboriginal land in WA, and more pastoral properties have been conducting opportunistic harvesting. It is estimated that between 3600 and 4600 feral camels were harvested for pet meat in 2007 (Table 9.12), which was an increase of approximately 3000 from the previous year. Compared with live export and the slaughter for human consumption, more camels are currently harvested for pet meat in Australia. To date, camels used for pet meat have been mainly harvested from Aboriginal land and pastoral properties in WA by professional hunters and contractors.

On average a camel sold for pet meat is worth between \$187–225 (i.e. 250–300 kg carcass sold for \$0.75 per kg) (refer to Appendix 9.2). Based on current numbers this gives a total value of the pet meat industry of between \$0.68–1.04 million annually (an average of \$0.86 million).

Table 9.12: Estimated number of camels harvested for pet meat in 2007

State/ Territory	Location	Estimated camel numbers	Harvester	Source
NT	Mulga Park Station	400	A pet meat company	Shane Nicolle 2007, Manager of Mulga Park Station NT, pers. comm.
WA	Warakurna settlement	1000	Professional hunters	Appendix 9.2
WA	Jameson settlement	700	Professional hunters	Gordon Sanders 2008, Project officer, Ngaanyatjarra Council, pers. comm.
WA	Pastoral lands	1000–1500	Contractors and shooters	Estimate based on the pastoral survey, Chapter 3.
SA and NT	Pastoral lands and Aboriginal lands	500–1000	Pet meat companies, contractors and shooters	Estimated based on the pastoral survey, community survey and personal communication, Chapter 3, 5 and Phil Gee 2008, Senior Consultant, Rural Solution, SA, pers. comm. Shane Nicolle 2008, Manager of Mulga Park Station, pers. comm.

5.5.2.2 Pet meat operations

A number of pet food companies and local Aboriginal settlements have been keen to work together to develop commercial pet meat operations. Although these operations have only occurred in a small way, there is potential and a willingness to undertake the commercial harvest of camels for pet meat.

There have been a number of enquiries from pet meat companies and other enterprises wanting to access camels on Aboriginal land in the NT over the past few years. In general, these proposals are more acceptable to Aboriginal people than 'shoot to waste' culling programs, particularly where they include possible financial returns and the employment of locals (Vaarzon-Morel 2008a, 2008b). The returns to Aboriginal communities from this type of operation are, in reality, likely to be very low, and it is not certain how viable these operations are for the companies themselves. Nonetheless, there are some companies very interested in these operations (such as V.I.P. Petfoods (Aust) Pty Ltd, Howard Springs Petmeating, and burgeoning Aboriginal crocodile farm enterprises).

We are aware that Centre Farm (NT) has recently been studying the viability of Aboriginal communities establishing small-scale pet meat enterprises. They have assessed the environmental, social, and market factors that would affect the long-term sustainability of small-scale live harvest enterprises that provide camels for commercial use, including for pet meat (Andrew Drenen 2007, Regional Land Management Officer, CLC, pers. comm.).

In SA and the NT, some small scale, ad hoc harvesting of camels for pet food has also been undertaken. Around 400 camels were taken from Mulga Park Station in the NT (Shane Nicolle 2008, Manager of Mulga Park Station, pers. comm.) and an estimated 500–1000 camels were harvested for pet food from other areas in SA and NT (see Table 9.12).

In Western Australia, Ngaanyatjarra Land Management has recently negotiated a contract with a national pet meat company to undertake field-based slaughter and butchering on a settlement-by-settlement basis on the Ngaanyatjarra Lands. This operation – the first to have been negotiated for Aboriginal land – has been in progress since late March 2007. Local people have been employed to guide the operation and are also involved in the killing and butchering processes. This operation has been completed in two settlements (Warakurna and Jameson), with 1000 and 800 camels harvested respectively, and is continuing in Tjukurla. By May 2008, the operation in Tjukurla had harvested 500 camels. A case study of the pet meat operation in Warakurna has been undertaken and is reported in Appendix 9.2. Pet meat operators and kangaroo shooters have also carried out the field-based slaughter of relatively large numbers of camels on pastoral stations during dry periods. It is estimated that 1 000–1 500 camels were harvested for pet food on pastoral properties in WA in 2007.

5.5.3 Markets

5.5.3.1 Human consumption

People closely involved in the camel meat industry believe that once consumers try camel meat, this healthy and superior meat will become commonplace in Australian households (Garry Dann 2008, Managing Director of Territory Camel Pty Ltd, pers. comm.). RIRDC research suggests that there are two potential markets for camel meat domestically. The primary target market includes tourists and Australian Muslims, with a secondary target market of consumers of other game meats (Warfield & Tume 2000; NTCA 2003). According to wholesalers and retailers, Muslims from the Middle East, Indonesia, Malaysia, Pakistan, India, and Turkey are most likely to buy camel meat. Tourists are perceived to be the target market by restaurants, while butchers perceived local residents as well as tourists as the most likely buyers of camel meat (Warfield & Tume 2000). However, the current domestic market for camels is quite small: equivalent to about 12 carcasses (two tonnes of meat) per week, of which 78% goes to the food service, primarily restaurants in the Adelaide and Sydney areas; 20% to manufacturing, and the remaining 2% to retail; mainly in supermarkets in the NT and some butcher shops (NTCA 2003). The size of the Muslim market within Australia is difficult to assess. There are strong indications from mosques in Sydney and Perth that Muslims in big cities are interested in camel meat; however, this demand would only account for the equivalent of 30 animals per week in a slash pack form (NTCA 2003). These animals would have to be killed in accordance with Halal requirements.

There is potentially a large market for camel meat in Muslim countries in the Middle East, Africa and Asia. However, it is difficult to get an estimation of the true market size and the profitable product types, because the live trade in camels is so small internationally and no accredited camel meat has been exported. According to Sarah Debney, Senior Manager of Territory Camel, the traditional markets for camel mostly want a ‘wet’ product, which is very costly for Australian producers to provide because it relies on live export, and the current Australia live animal export infrastructure is geared towards smaller animals. Recent reviews of camel meat markets in some Middle Eastern countries suggested that currently there is no market for imported boxed camel meat (Ash et al. 2008; Students 2008b).

It must be noted that there are limits to market research about the effect of cultural factors on demand for camel products. These markets are extremely price sensitive. Most camel meat goes to wet markets, or is sold through mosques where it is provided as cheap food, primarily for low income families. This means that there is a high degree of price sensitivity and the product must be sold within an affordable range (NTCA 2003). It is understood that the Muslim market differentiates between male and female camels, with a preference for males, and there is a stipulation that only male camel meat be used during the Haj religious period. In some cases female camel meat will be accepted, provided the camels are not in calf (NTCA 2003).

Australia may be in a position to supply quality meat animals, because camel meat is of poor quality in many countries where there are large numbers of camels (Warfield and Tume 2000). It is understood that camels are normally slaughtered at the end of their working life in Sudan (Warfield and Tume 2000) and Pakistan (Isani 2003). Reports say that in Pakistan, camel meat is not liked by a majority of the population because of its inferior taste and quality due to the meat coming from old (>20 years old), worn out camels. However, it is estimated that nearly 9000 metric tonnes of camel meat, valued at Rs. 270 million (AU$7.3 million), is produced and consumed annually in Pakistan (Isani 2003). Although the price is very low, Australian camel meat producers could find opportunities to meet the demands of undersupplied markets like this. However, a better prospect is to supply a quality product to the higher end of these markets. This would require the development of a consistent quality product of two-year old male animals to medium- to high-income earners in Saudi Arabia and the United Arab Emirates (Rouda 2004).

A more realistic international market is in Europe, especially in the UK. According to recent research conducted by Charles Darwin University (Bell et al. 2008), it is clear that the existing market price of camel meat (e.g. a 340 g pack of pre-portioned camel steaks is sold at $16.50 AUD each in the UK market, almost $50 AUD per kilo, compared with the market price of camel retail cuts of $12.50 AUD per kg in Australia) is attractive for Australian exporters, although the market capacity is still not clear. The current camel meat exports from Meramist in Qld are targeting the UK market.

The issues in marketing camel meat include a low public acceptance and high market prices. To gain a broad public acceptance, camel meat needs a coordinated public education and marketing campaign. The high market price, which acts as a barrier to many people tasting camel meat, is due to the high costs associated with the small size of the industry. If the scale of production were increased, the unit cost would come down, and consequently the market price for camel products would also come down. Since it takes time to achieve such an economy of scale, the industry has pushed for government to accelerate this process by introducing a series of policies that support the camel industry in its early stages. Such policies include investment in infrastructure and regulatory institutions, publicity, and marketing (NTCA 2003).

5.5.3.2 Pet meat

The pet care industry is one of the largest industries in Australia, contributing approximately $4.62 billion to the economy annually and employing 44 700 people (Petnet 2007). In 2005, the total consumer expenditure on pet food exceeded $2 billion and the total volume of pet food sold was 438 000 tonnes (Hill 2006). The huge scale of the pet food market in Australia has the potential to provide a market for feral camel meat.

International research conducted with pet owners reveals another exciting niche market for camel meat used as pet food. Pet owners are increasingly looking for healthier food to feed to their pets. Natural and organic pet food products have a compound annual growth rate of 15–25% of sales. This is such a significant trend that sales of natural and organic pet foods are expected to outpace those in the overall pet food market in the near future (Pet Industry News 2007). This does not directly relate to the use of camel meat, but it does show a niche market that could be exploited.

There are at least four pet food companies in Australia that use camel meat for pet food production: V.I.P. in Qld, Howard Springs Petmeating in the NT, and TuckerTime for Pets and Prota Pet Food Co. both in WA. There are more companies interested in introducing camel meat into their pet food manufacturing (refer to Section 5.5.2.2). The survey conducted by this project of manufacturers who are members of The Pet Food Industry Association of Australia (PFIAA) indicates that there is a niche market for camel pet meat and some of them would like to use camel meat for pet food manufacturing in the future. It is also suggested that '… the meat/bones/offal could be dried/smoked for use as a treat i.e. as per current pig trotters/ears/liver pieces/kangaroo tails in supermarkets'.

The prices (at gate) proposed by different pet food processors were \$0.50–0.75 per kg for bone-in meat and \$0.90–1.20 per kg for bone-out meat (Table 9.13). The market price for kangaroo meat (as pet meat) was suggested by some pet food companies as a benchmark price for camel meat, given that it is a similar ingredient with similar logistical challenges.

Table 9.13: Offered price of camel meat for pet food by Australian pet food manufacturers

	Bone-in	Bone-out	Information source
Processor A (actually offered)	---	\$1.20/kg	Garry Dann 2007, Managing Director of Territory Camel Pty Ltd, pers. comm.
Processor B (willingness to pay)	\$0.50/kg	\$0.90/kg	Survey with PFIAA members
Processor C (willingness to pay)	---	\$1.00/kg	Survey with PFIAA members
Processor D (actually paid)	\$0.75/kg	---	Appendix 9.2

It is believed that camel meat will gradually be accepted by the pet meat market (both pet owners and pet food companies), thereby creating a significant market for feral camel meat as pet food.

5.6 Other commercial utilisation of camels

Camel by-products may include camel milk, wool and hair, hump fat, and offal. The commercial utilisation of camel by-products is currently very small in Australia.

5.6.1 Camel by-products

Currently, there is only a small amount of camel skin and leather used in Australia. There is only one tannery in Australia that processes camel hides: Austanners Pty Ltd in Victoria (Peter Seidel 2007, Central Australian Camel Industry Association, pers. comm.). Their leather is made into a variety of different products. Camel hide is a popular material for fashion accessories, belts, jackets, shoes, and upholstery as it has high tensile strength and an attractive grain pattern. According to Peter Seidel, camel skin will be increasingly used by the leather industry, particularly for making boots. The world-renowned footwear company RM Williams has started to use camel leather to make their footwear. This is a sign that there could be a promising future for camel leather footwear; however, product development is in its very early stages. Camel leather has become more popular in the United States and Italy in recent years.

The development of camel milk and wool as marketable commodities has been limited by the lack of domesticated animals and suitable infrastructure. There are currently no commercial producers of camel milk or wool, in Australia.

Hump fat is sold for cosmetics and for food for some animals (such as emus) at variable prices (from \$1.00 up to \$3.00 per kg) (refer to Appendix 9.1). It is unclear how much camel hump fat is being used currently but it is likely to be a very small amount.

The CACIA is continuing to work with manufacturers to promote the value of camel by-products such as camel oil, wool, and leather (Peter Seidel 2008, Central Australian Camel Industry Association, pers. comm.).

5.6.2 Camel tourism

The tourism industry uses a small number of camels, and the camel is an icon used by Tourism Australia to attract domestic and international tourists (Figure 9.3); the most well-known camel tourism operation is that which offers camel rides on Cable Beach in Broome, WA.

In the late 1960s there was renewed interest in camels in tourism, and by 1970 Australia had two tourist attractions using camels, both operating in Alice Springs. In 1971, the inaugural Lions Club Camel Cup race was held in Alice Springs and there are now several camel races held around Australia (CACIA 2007). An international camel race event has recently been promoted. This big event, The Sheikh Zayed International Camel Endurance Race, was held in Hughenden, Qld, in late August 2008. The race covered 160 km and is said to be one of the longest camel races in the world. Teams and camels come from all over Australia, the Middle East, America, Asia, and Europe to participate (Admin 2008).

There are about 50 camel farms around Australia targeting international and local tourists (see Edwards, Zeng & Saalfeld 2008). They offer camel races, camel rides, and desert trekking. Although camel tourism businesses may benefit the economy, it is clear that tourism businesses do not use enough camels (only 150–200) to significantly influence the feral camel population. Increased running costs have also meant that the operation of camel treks and expeditions is declining (John Wilkinson 2008, experienced Australian cameleer, pers. comm.). However, camel tourism may strongly influence people’s perspectives on feral camels and their management.

Figure 9.3: Home page of Tourism Australia’s website

Source: Tourism Australia 2007

5.6.3 Woody weed control

Feral camels have been purchased by land holders in Qld to control woody weeds. Currently there are around 5000 camels in Qld that are used for this purpose (Nicholas Swadling 2008, Industry Development Officer, Qld Department of Primary Industries and Fisheries, pers. comm.). The likelihood that the numbers will increase significantly enough to have an impact on feral camel numbers is slight. Animals currently used for woody weed control could, however, form the basis of a sustainable domesticated herd.

6. Potential contributions of commercial utilisation to feral camel control in Australia

6.1 Estimated maximum camel numbers for commercial utilisation

The Multiple Criteria Decision Support Tool described in Saalfeld et al. (2008) has allowed the camel range to be categorised according to its suitability for commercial utilisation activities including live export, human consumption, and pet meat. Commercial utilisation of feral camels is not practical over much of the feral camels' range due to constraints that significantly limit commercial activities such as distance to markets, inaccessibility, low density of feral camels, etc.

The Decision Support Tool indicated that the commercial utilisation of camels is most likely to be economically viable in two regions: in the corner of NT, SA, and WA border region, and the Alice Springs district. These regions are largely suitable to live export, human consumption, and pet meat operation (Figure 9.4, 9.5, and 9.6).

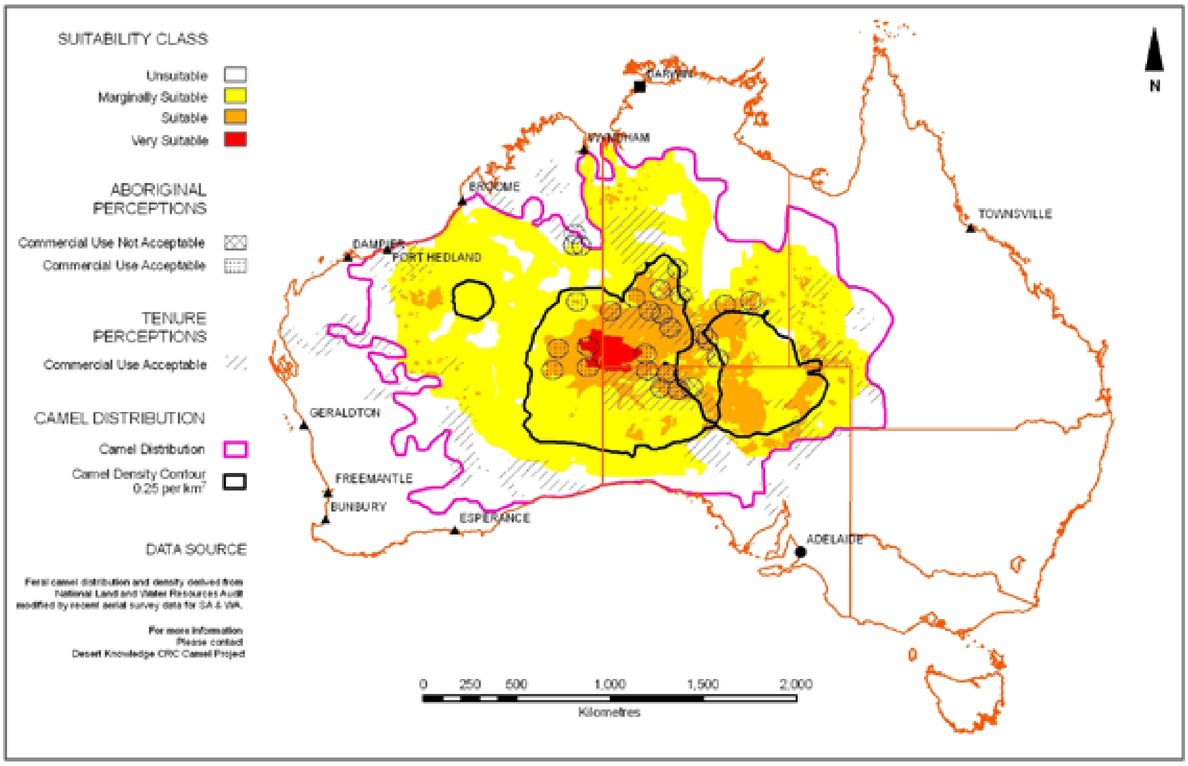


Figure 9.4: Map of live export suitability

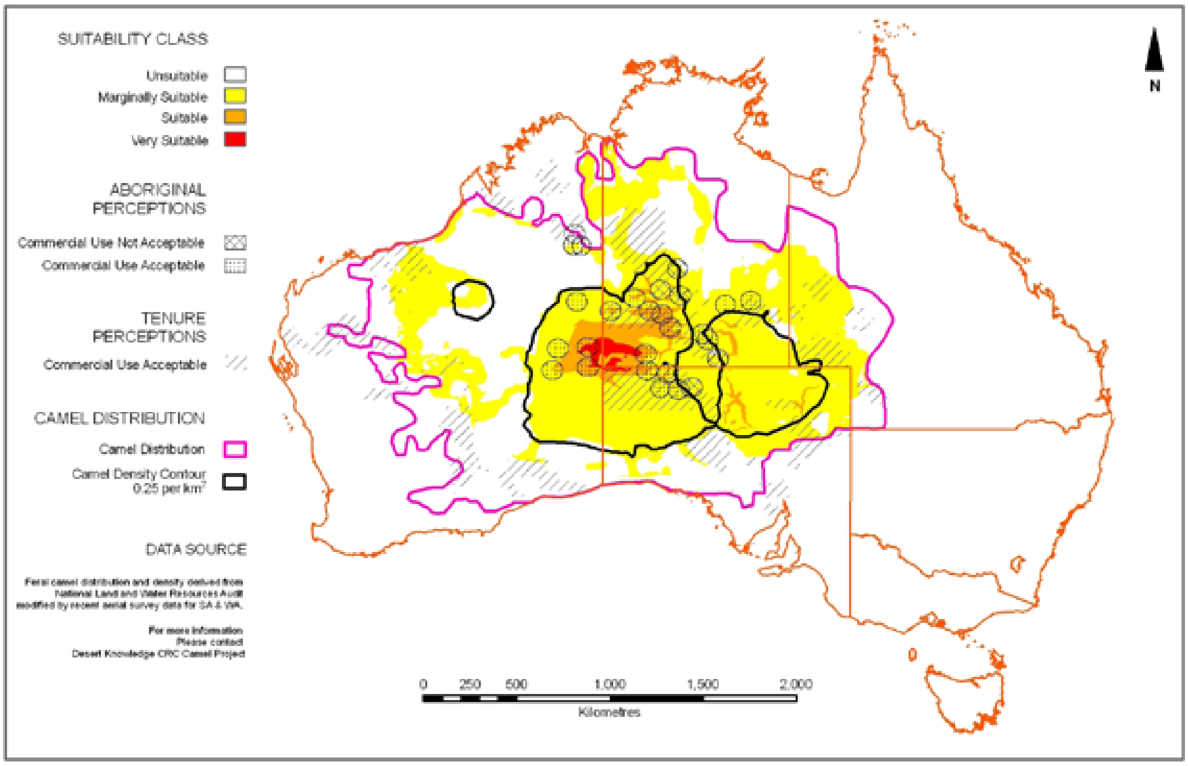


Figure 9.5: Map of human consumption suitability (not considering existing abattoirs)

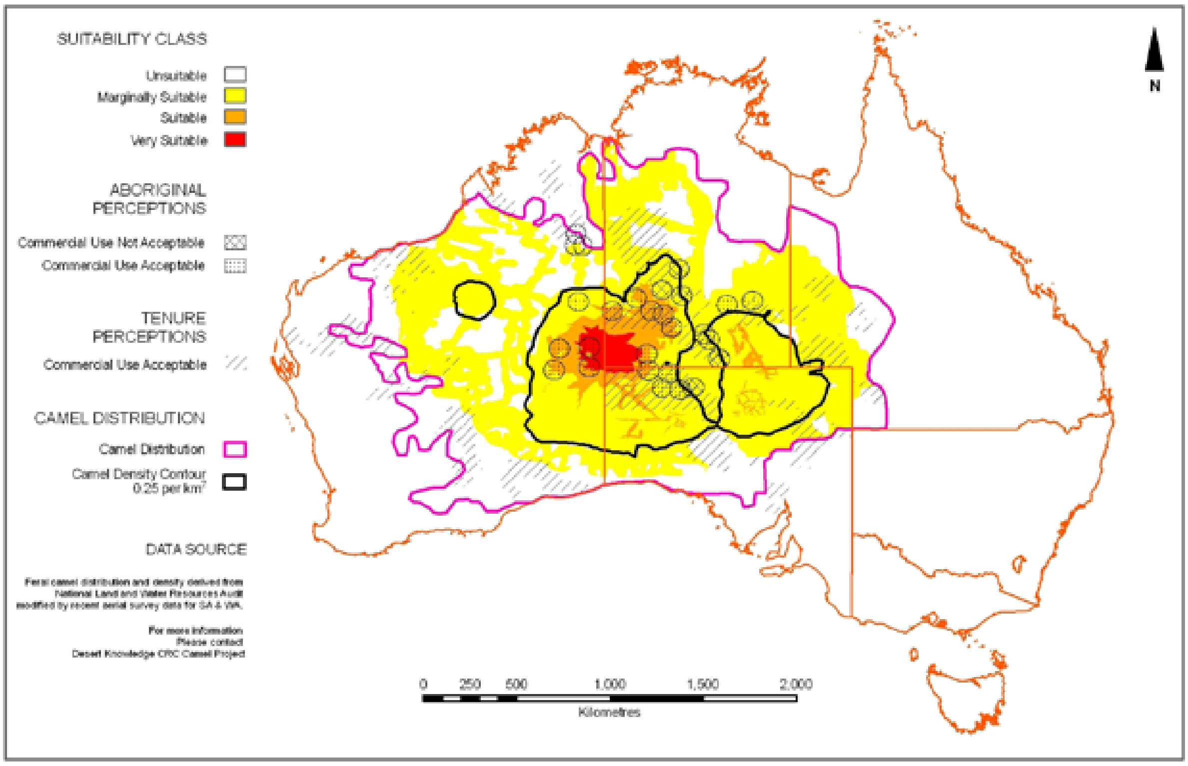


Figure 9.6: Map of pet meating operation suitability

The area that is estimated to be suitable for commercial operations is 3–8% of the total camel range, that is, 110 000–260 000 km^2, and it is estimated to contain 9–19% of the total feral camel population, that is, 90 000 to 190 000 camels. This population should be interpreted as the maximum feral camel population that could potentially be used for commercial harvest and processing in the identified areas. However, this does not mean that 90 000 to 190 000 camels can be harvested for commercial utilisation annually, as it still relies on market, industry capacity, and the increasing marginal costs of harvesting when the camel density is reduced by continuous commercial use or other integrated management instruments. The mean broadscale camel density in these areas is high at around 0.8 camels/km^2. When camel density is lower than 0.25 camels/km^2, the areas are unlikely to still be suitable for commercial use. Therefore, the number of camels currently available for commercial utilisation would be approximately 62 500–125 000.

It is recognised that there is currently some ad hoc and opportunistic harvest of camels occurring outside the identified suitable regions. However, these activities have been small scale where there may be higher localised camel densities (but a lower broadscale density) and are operating on a short time horizon rather than a longer-term sustainable operation.

The following sections attempt to describe the possible scenarios for different forms of commercial utilisation.

6.2 Potential contribution of major commercial opportunities

6.2.1 Live export

If 1% of the world live camel trade came from Australian camels (one-fifth of Australia's 5% share of the camel population in the world), that would be 800 camels per year, which is three times the average number of camels exported in the past 19 years. If this rose to 5%, which is equivalent to Australia's share of the world camel population, the live camel export would be 4000 camels per year, with a value of around $2–3 million. Live camel exports on this scale would significantly expand the industry and benefit other participants, such as pastoralists and local Aboriginal communities. However, an increase in feral camel harvesting on this scale would still have little impact on the total feral camel population (currently one million and increasing at 8% per year) (refer to Saalfeld & Edwards 2008) and hence on their impacts.

It would also be very difficult to achieve this level of live exports in the next ten years as it represents a more than ten-fold increase on current export levels and would equate to a continuous increase of 26% per year over that period. A number of other factors would need to occur including a detailed understanding of potential markets and their requirements, alignment of supply with market demand, and a significant increase in handling infrastructure at point of harvest, through the logistics chain, to the export port and shipping. While such changes are possible, the levels of growth will be slow and live export is unlikely to make a significant contribution to reducing the numbers or impacts of feral camels.

6.2.2 Meat for human consumption

The amount of camel meat sold for human consumption in Australia is currently approximately 800 camels per year, which is equivalent to 134–160 tonnes of saleable camel meat (refer to Section 5.5.1). If camel meat production increased in line with its trajectory of the past ten years (15% growth over 10 years), the number of camels harvested for human consumption would be around 3200 in 2018. At these growth rates, the human consumption of camel meat will not contribute significantly to reducing the numbers or impacts of feral camels. There have been a number of enquiries from domestic and international investors in developing a camel meat industry based on an export-accredited abattoir. It has been suggested that the scale of these operations would require 20 000–25 000 animals per year to make them, viable and the proponents have indicated that they have a ready market for the product. At these levels of off-take, the industry would make a contribution to reducing the numbers and negative impacts of feral camels.

Key enablers to achieve this are to identify committed investors; the development of an export accredited plant; and development of a supply system that would ensure continuity and quality of animals to ensure that the capital invested operated efficiently.

6.2.3 Pet meating

The increasing use of kangaroo meat in the pet food market provides the camel industry with a useful precedent. Currently the pet meat market absorbs over 75% of the kangaroo meat harvested each year. In 2002, sales of fresh pet meat were calculated to be 20 000–30 000 tonnes of kangaroo meat (PacALLIANCE (Australia) Pty Ltd 2002).

If camel meat gained a market share equivalent to 20% of the kangaroo meat share in the pet meat market in the next 10 years, that would be 4000–6000 tonnes of fresh camel meat sold. That is equivalent to 16 000–24 000 (an average of 20 000) camels slaughtered per year, which is around a four-fold increase on current numbers (3600–4600 camels, an average of 4100) or an annual increase rate of 17% per annum over ten years. If such numbers were achieved it is likely to contribute significantly to the reduction in the feral population.

6.3 Potential contribution of other commercial utilisation opportunities

6.3.1 By-products

There is little experience in Australia of using camel hides and hump fat, and the markets are yet to be proved. However, according to Wondu Business and Technology Services (2004), the revenue obtained through the use of camel by-products can reduce first stage processing costs by more than 30%.

Camel hide is considered the most competitive by-product for international markets (Italy and USA particularly) where it is valued for its high tensile strength. Australian camel hide has less scarring than camel hide supplied by other countries; this makes it well suited to the Western-style boot market (Goulding et al. 2007). Promotion to these markets must be improved to take advantage of the increase in number of camel hides available as the number of camels slaughtered for human consumption increases. The harvest of camels for pet meat would mostly occur in the field, and in many cases camels would be slaughtered on the ground where it is hard to harvest their hides.

Hump fat is another by-product that could make the commercial use of camels more profitable. All camels slaughtered could easily have their humps harvested.

It is unlikely that it will be feasible to use camel milk in the near future, simply due to the high costs involved. Not only is it expensive to feed milk-camels, but there are also substantial costs associated with establishing the milking and associated processing infrastructure. There is no doubt that there is a substantial international market (Fletcher 2006), but there is little chance that Australia would be competitive in the international market (Ellard & Seidel 2000).

The use of camel by-products will be increased in association with increased camel meat production. It does not seem realistic for feral camels to be harvested to produce by-products, so by-products will not directly contribute to feral camel population reduction. However, the sale of by-products will definitely increase profits and thereby make the industry more viable.

6.3.2 Game meat

In Australia there is a significant game meat industry. The main animals hunted are hare, deer, wild boar, kangaroo, rabbit, buffalo, and goat. The industry is worth approximately $20 million a year. Feral pigs are a major source of game meat, and the export of wild pig meat generates between $3 and $5 million in annual revenue (House of Representatives of AFF 2005).

The consumption of game meat is growing strongly in Europe, North America, and some countries in Africa. In the UK alone, the market for game meat has grown 58% since 2002 (albeit from a small base), with annual sales in 2006 of £57 million. This market growth is more than that of red meat, poultry, or fish and is on par with the growth in the market for organic products. A recent study in South Africa revealed that most tourists from Germany and Belgium know and like eating game meat. Tourists indicated that game meat was the meat type they preferred to order in restaurants, although only a few of them had hunted before (Hoffman et al. 2003).

The sale of camels for game meat could provide another opportunity to use feral camels commercially. Game meat comes from an animal that is exotic or unusual to eat, although not necessarily wild, which is killed in its natural environment. According to the *Australian standard for hygienic production of game meat for human consumption* (Agriculture and Resource Management Council of Australia and New Zealand 2003) 'game animal' is defined as:

> *Any vertebrate animal: (a) including a mammal, bird or reptile but, excluding fish; (b) of a species that can be legally harvested; and (c) has not been husbanded in the manner of a farmed animal and is killed in the field.*

and 'game meat' is defined as:

> *The edible part of any game animal that has been dressed or prepared in a game-processing establishment, and passed by an inspector as fit for human consumption.*

The standard states that only animals of healthy appearance can be killed, and that this should occur in a humane way and the meat handled in such a way as to minimise the risk of contamination. A key element here is that the carcase must be refrigerated within two hours of being harvested and the deep muscle temperature must be reduced to 7^{o}C as soon as possible (within a maximum of 24 hours). There is also a requirement that the person killing the animal must be trained and approved in the approved killing procedures, field inspection, and hygiene practices. Courses have been established for kangaroo harvesting, but there is currently no such course for camel harvesting.

There is an opportunity to promote camel meat as a game meat and to initiate game meat production. This would broaden camel consumption and contribute to feral camel removal. There are some remote areas with a high density of camels and reasonable road access where the use of a mobile abattoir to produce game meat would be feasible (refer to Saalfeld et al. 2008). However, it is critical that marketing, investment, and policing issues are addressed before embarking down this path.

6.3.3 Camel tourism

Currently, camel tourism enterprises do not make a significant contribution to feral camel control as they use very few camels in a non-consumptive way, and therefore do not have a continuous demand for camels. However, the hunting of camels for entertainment could be classed as camel tourism. As feral camels are considered a pest in Australia and need to be controlled, feral camels could be a target species for game hunters. Although camel is not a favoured species for international or domestic hunters, it is a 'big game' animal (Dryden & Craig-Smith 2004). Although camels are not used for game hunting currently, hunting could contribute to camel population reduction in future. However, the potential contribution would not be very significant.

6.3.4 Camel farming

Camel farming could be developed in some areas to provide a supplementary source of camels. This would reduce the risk of an inconsistent supply in terms of numbers and quality from wild harvest. Currently, camels have been used to control woody weeds and, apart from some camels being held in sizeable holding areas, there has been no development of an intensively managed camel herd. The farming of camels is likely to occur as a consequence of a more mature meat-oriented industry, but in the short to medium term it is unlikely to have any contribution to the reduction of feral camel numbers or their negative impacts.

7. Value chain approach to camel industry development

Supply and value chains are vertically integrated strategic alliances between a series of independent businesses that have come together as a group to more efficiently capitalise on specific market opportunities (Cox 1999). The goal of a supply/value chain is to optimise performance in that industry using the combined expertise and abilities of the members of the chain. Successful chains depend on integration, coordination, communication, and cooperation between partners with the traditional measure of success being the return on investment (O'Keefe 1998, Boehlje 1999).

The conventional view of a successful value chain is that it incorporates competitive advantage (Porter 1985) with some acknowledgement and consideration of social factors such as trust, satisfaction, appropriate power structures, commitment, communication, relationship-specific investment, and strong personal relationships (Batt 2003). These social factors relate to both vertical and horizontal connections within the chain (Lazzarini et al. 2007). At present there are multiple entities wanting to participate in the utilisation of feral camels, but little evidence exists to suggest either integration of these entities for competitive advantage or, as has been noted in the bush foods industry (Cleary et al. 2008), an understanding of the need to recognise and develop the social components of a potential value chain.

It has been noted that the Australian bush foods industry sits in an inter-cultural space; as such, the focus of the value chain needs to accommodate non-market social and cultural considerations in addition to profit (Cleary et al. 2008). This is also the case in the developing camel industry where there will be a need to recognise financial, social, and environmental factors in the decisions relating to the operation of the chain.

The development of a consumer orientation, cooperative relationships, and effective information and communication systems proved to be critical to the new bamboo shoot industry (Collins & Keilar 2005). As an emerging industry, the camel industry in Australia has three major risks to its development: lack of accurate information, lack of a strategic orientation that incorporates the needs of the marketplace and its stakeholders in desert Australia, and failure to implement a collective vision. This does not mean that one industry should be created, but means that the value chains that do develop need to incorporate these factors in their structure if they are to operate efficiently.

7.1 Supply chain in the camel industry

A value chain for the commercial use of camels was structured and discussed in the Feral Camel Action Plan Workshop held in Alice Springs in April 2005 (Figure 9.7).

All current and potential management options for feral camels, including commercial and non-commercial options, should contribute to natural resource management (NRM) and should benefit stakeholders, including Aboriginal communities and pastoralists. Direct economic value can be realised by the commercial utilisation of feral camels. These elements have been discussed in Section 5.

The value chain for the camel industry (commercial use of camels) includes all the kinds of camel resources through to the final camel product market. The issues along the supply chain are addressed, including the availability of the resource, supply capacity (harvesting and processing), market capacity and accessibility, and economic viability.

The camel industry value chain is an important tool for ensuring the viability of the camel industry in Australia, as it can identify the issues connected to each node of the supply chain.

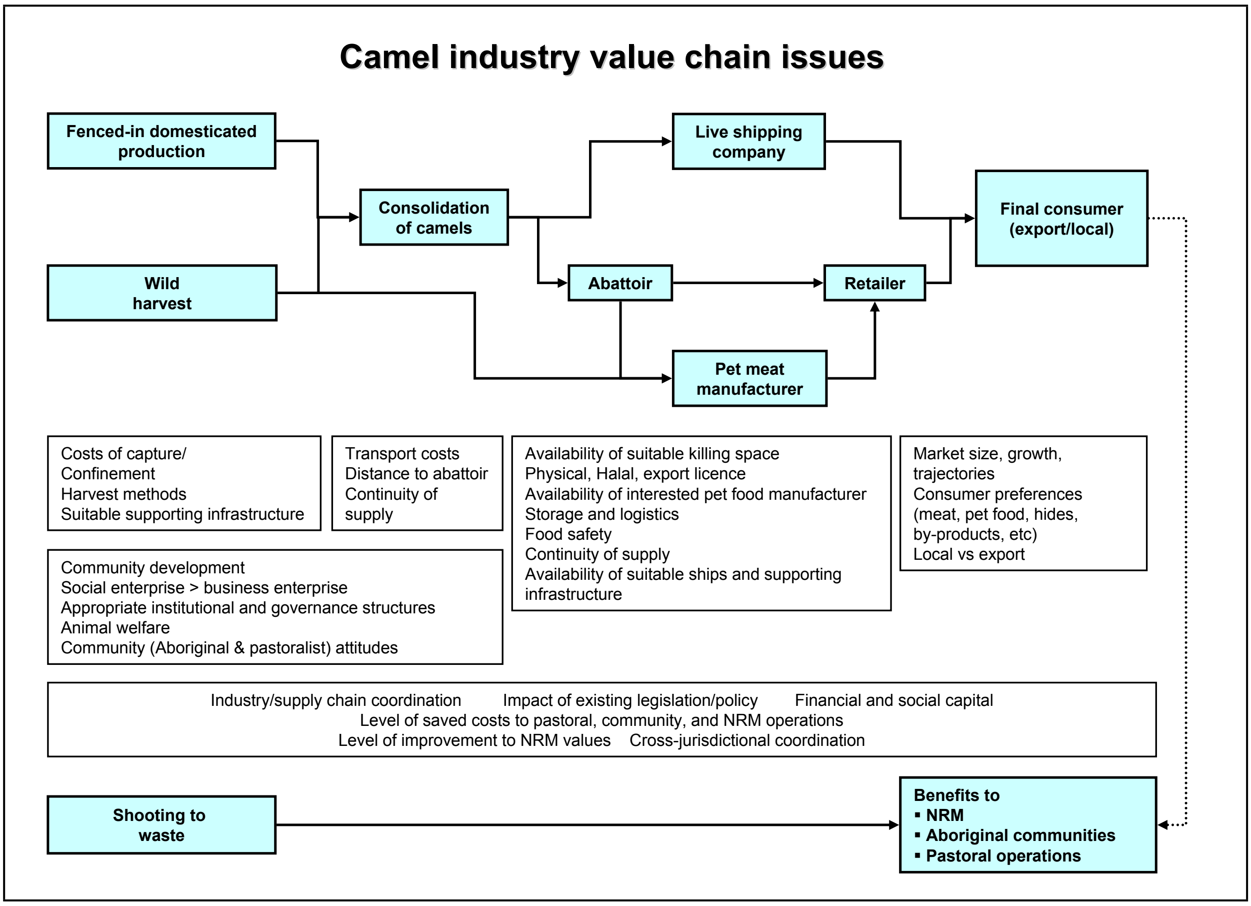


Figure 9.7: Camel industry value chain

Source: McGregor 2008

7.2 Camel industry structure

The camel industry comprises a range of enterprises that use camels commercially, as shown in Figure 9.7, including harvesters, camel farmers and consolidators, transporters, live exporters, abattoir operators, pet meat manufacturers, product wholesalers, and retailers. These enterprises vary in size from one-person businesses to major abattoirs employing tens of staff. The industry can be divided into five sectors: harvest, live export, meat for human consumption, pet meat, and by-products.

7.3 Continuity of supply

7.3.1 Extent of the resource and its availability

Recognition of the commercial value of feral camels does not necessarily lead to a good understanding of the feral camel resources available for commercial use. It is important to address the difference between the presence of feral camels and a commercial supply of camels. This is because camels are highly mobile and also potentially very expensive to harvest. Many factors influence harvest efficiency: population distribution, density, the local social and physical environment which affects this availability, economic feasibility, and the numbers of camels available. Moreover, the influencing factors vary between different types of usage.

A focus group discussion listed the major factors that would influence the effectiveness of the commercial uses of feral camels (Table 9.14).

Table 9.14: Factors influencing the commercial use of camels

Factors	Rank for each commercial utilisation option			
	Human consumption	Pet meat	Live export	Overall
Roads	1	1	1	1
Bore and yards	1	3	4	3
Camel density	1	1	2	1
Abattoir	3	-	-	3
Aboriginal settlements	4	3	-	3
Tenure, perception	4	3	3	3
Port	-	-	3	3

Table 9.14 indicates that accessibility (roads) and camel density are the most important factors that affect the commercial utilisation of feral camels (see also Saalfeld et al. 2008).

Although camel density is important, it is less important than accessibility. Economic viability will be dramatically reduced even in locations where there is a high camel density but low road accessibility.

Other infrastructure, including water sources, yards, abattoirs, and settlements (providing a base with established facilities) are also major factors. Port location is important for live export. The perception of the camel industry by land owners is another major factor significantly affecting the commercial utilisation of feral camels. The major land tenure types in the camel ranges are pastoral, Aboriginal, and Crown land. The perspectives of the different stakeholders, especially Aboriginal communities, pastoralists, and governments (responsible for the policies and laws related to the management of feral animals) should be understood and addressed in the development of new value chains (see Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a; Carey et al. 2008).

Generally, there are enough feral camels to support a large scale camel industry in Australia. A 10% removal of the established one million camels (refer to Saalfeld & Edwards 2008) in Australia each year equates to 100 000 camels, which would only contain population growth. However, many camels are not accessible because they are in the Simpson Desert and other regions (refer to Saalfeld & Edwards 2008, Saalfeld et al. 2008) where it is uneconomical to muster, and many camels are in regions with low population density. Based on recent GIS work associated with this project, there would be a maximum of 62 500–125 000 camels available in Australia per year, moderately to highly suited to commercial use (refer to Section 6.1).

7.3.2 Harvest efficiency

The availability of a resource does not necessarily convert to an efficient, continuous commercial supply. Appropriate harvest techniques must provide a sustainable and timely camel supply and also possibly provide them at a lower price. These factors are important in the value chain sense as substantial capital assets may be employed further down the chain – assets which rely on a continuity of supply to ensure that the capital is employed at optimal levels.

Trapping and mustering are the main methods used to harvest camels for commercial purposes. Helicopters, motorbikes, horses, or other vehicles are used. As harvest efficiency mainly relies on the number of camels harvested in a time period, the time taken to locate a reasonable number of camels becomes very important. Therefore, any system that improves the chances of locating herds of camels, and facilitates their subsequent capture, is financially beneficial. Because of their gregarious nature, the 'Judas' animal technique (Parkes et al. 1996), which uses a radio-collar on one camel, should prove a useful tool to locate herds of feral camels for population control or for commercial utilisation (Edwards et al. 2004). Satellite telemetry could provide cost-effective technology to implement the Judas animal technique, particularly in the more arid regions where camels move over very large areas. A recently developed technology called 'wireless sensor network' could also be used to locate camel groups for harvest. This technology could be used to achieve continuous monitoring of a group of animals without human involvement (Zhou et al. 2007). The research of camel's physiology, anatomy, and behaviour suggested that it is possible to use water sources (especially in dry times) and satellite greenness images to locate camels, as well as using sacrifice water points and salt lakes to attract camels (Coventry et al. In press).

Harvest efficiency is also affected by the fact that around 50% of camels are currently on Aboriginal land. The involvement of the relevant Aboriginal community, either as direct participants or through participation in a royalty scheme, is necessary to gain access to the camels. Engagement with communities is occurring, but the development of a capacity to harvest feral camels is still at an early stage. It is important to remember that Aboriginal people have valuable traditional knowledge of their country and the wildlife there. If local Aboriginal people are engaged properly, and they use their knowledge (e.g. to locate camels), operations would be much more efficient. This engagement would broaden supply and build a mutually beneficial partnership, which is critical for a sustainable operation and would provide livelihood opportunities where few exist at present.

Meanwhile, to increase the harvest efficiency and continuity of supply in some more marginal country, pastoral stations could be encouraged to co-graze cattle and camels, since research suggests that this kind of approach can generate extra income for stations without having a significant negative impact on cattle production (Phillips et al. 2001).

7.4 Efficient development of the camel industry: Comprehensive utilisation of camels

Currently the camel industry uses only some of the camels mustered and only some parts of camel carcasses. This kind of usage does not provide good economic returns for camel harvesters and processors. The comprehensive utilisation of camels is one of the key issues for the camel industry.

Live camel importers have strict quality requirements, so only a very small proportion of mustered camels qualify for live export. Furthermore, because of height restrictions in the boats, they can only take younger camels. Generally, only one in seven camels mustered can be used for live export (Peter Seidel 2007, Central Australian Camel Industry Association, pers. comm.). This ratio seems unlikely to significantly increase as the overseas quality requirements are tending to become stricter and more specific.

This raises the issue of how the rest of the camels mustered for live export could be utilised instead of releasing them back into the wild, which is illegal in most jurisdictions. This amounts to a large number of camels that would be suitable for slaughter for human consumption or pet meat. Both live trade and slaughter should be developed simultaneously to make the camel harvest more effective and economical by providing an outlet for stock that is not suitable for the live trade.

There is a big difference in the price offered to harvesters for live-export camels and that offered for meat production. The price for live-export camels is much higher than that for meat production (e.g. \$400 vs. \$150 farm gate price). This is because there are different value chains and different requirements for these two products. This means that camel harvesters have to accept two different prices for the camels mustered and maintained in their yards. There is a need for individual supply chains to develop clear quality parameters so that harvesters understand that different camels will be utilised for different purposes with different values. This then needs to be supported by feedback to the suppliers on how individual animals were valued in the final market or how they were processed in the abattoir. Information asymmetry leads to the development of power relationships in a value chain, which is not conducive to chain participants identifying opportunities at each stage in the chain and which prevents an otherwise possible increase in value through the chain.

In abattoirs, camel meat is generally the only part taken for commercial use. Moreover, only some of the meat is sold to butchers or other retail outlets. It is important to develop a variety of camel products so that the camel is comprehensively utilised, such as skin for leather, meat for human consumption, and some cuts for pet meat, camel hair and wool, offal, etc. Modern abattoir management has moved to zero-wastage and cleaner production approaches, both of which will lead to maximum returns and increased efficiency of capital usage. This comprehensive utilisation of camels would increase the commercial benefits for musterers and producers, and as a result would guarantee the sustainable development of the camel industry and a continuity of supply for live export and meat production.

7.5 Market and its accessibility

7.5.1 Target market

A number of researchers (Ellard & Seidel 2000, McCloy & Rowe 2000, Warfield & Tume 2000, NTCA 2003, Rouda 2004) have looked at the potential markets for Australian camels: meat for human consumption (local and export), pet meat, hides, live export, dairy production, and specialist by-products.

As discussed in Section 5, the traditional market for live export is the Middle East and South-East Asia. For camel meat, the market is mainly in South-East Asia, Europe, and North America. For leather, milk, and other by-products the market is in Europe and North America, especially Italy and USA. Meanwhile, some growing markets – such as China and India – should be considered because of their potentially huge niche markets backed by their large population, strong economic growth, and abundant food culture.

The domestic market is also very important, both for camel meat for human consumption and pet meat.

7.5.2 Marketing strategy: Customer orientation

The main issue with marketing is not that there is no market, but that producers have difficulty accessing that market. Marketing is, therefore, a very important issue. A customer-oriented marketing strategy is necessary for an emerging industry (Collins & Keilar 2005). An in-depth market investigation to understand the customer demand for camel products is desperately needed. The marketing strategy and implementation should be based on this customer analysis. For example, since wet meat is preferred by Middle Eastern countries (refer to Section 5.5.3), it is likely to be a good marketing option for Australia to export live camels rather than boxed camel meat to those countries. Since Muslims prefer camels to be Halal-butchered, it is essential that any abattoirs built (or modified) in Australia are compliant. The APY Land Management Unit has been investigating the potential to development a market for Halal camel meat domestically and for export.

One of the barriers to accessing the international market is the shortage of abattoirs with an export license that are suitable for processing camels. This issue will be discussed further in Section 7.6.1.

On one hand, it is necessary to keep Australian camel products visible in the international market to gain a reasonable share of that market. On the other hand, it is crucial to promote camel consumption in the domestic market, since there is real potential for camel meat to become popular in Australia. The absence of both general consumer awareness and established retail outlets across Australia needs to be addressed. A promotional campaign would need to include information on how to identify and cook the various cuts (NTCA 2003). A source of funds for this advertising would need to be identified, and the industry itself should bear the cost.

7.6 Efficient flow from suppliers to producers to consumers

An efficient flow along the supply chain is critical for business and for the industry. In the camel industry, the renovation or building of abattoirs, the establishment of mutually beneficial relationships, and the active functioning of trading companies, agents, and brokers are the urgent issues to be addressed.

7.6.1 Abattoirs

There is a lack of appropriately located abattoirs for processing camels. The hot spots for commercial utilisation of camels are the tri-state corner region of NT, SA, and WA borders and the Alice Springs district. In the Alice Springs district, there is only one small abattoir (Wamboden) processing a small number of camels for human consumption, and there is no abattoir in the vicinity of the tri-state border region. Currently, the access to camels is difficult for most abattoirs and camels are slaughtered and processed in permanent abattoirs, far away from where the feral camels are found in numbers. The transportation costs are significant as animals are often transported large distances for processing. Industry margins are very sensitive to transportation costs (refer to Appendix 9.1 and Appendix 9.2), so it is important to find a way to decrease these costs. One way would be to design a new vehicle for transporting camels or using the existing rail network where appropriate (see Section 7.6.2). Another way would be to move abattoirs closer to the camel supply, by building new abattoirs in Aboriginal settlements with a high camel density nearby, or by building mobile or demountable abattoirs that could move to access greater camel supplies.

There is also a lack of accredited abattoirs for camel meat export. Expansion of the camel meat industry into export markets can only be achieved if abattoirs have licences for export processing. Currently, there are only three abattoirs with international export license for processing camel meat for export (Peter Seidel 2007, Central Australian Camel Industry Association, pers. comm.). Once an international market for Australian camel meat is established, the current capacity will not meet the increased demand.

New abattoirs built in the right places with international export licenses are critical to the expansion of camel meat production. A proposed abattoir in the Alice Springs district with an export licence would cost \$6–7 million to start up (Garry Dann 2008, Managing Director of Territory Camel Pty Ltd, pers. comm.). Funding is an issue. International investment is possibly an option for this abattoir. A small abattoir is being built in the APY lands in SA (refer to Appendix 9.1 for more detail).

If the creation of an international camel meat market were to be achieved in a short time, constructing new abattoirs to meet market demand seems reasonable. However, given that marketing consumes time and money, especially for a new industry, and that the current capacity for camel meat export (three accredited abattoirs) has yet to be realised, new abattoirs would need to develop both a domestic and international market simultaneously to warrant the capital expenditure. There has been interest from overseas investors who, we believe, have access to markets, but they have been concerned about the continuity of supply arrangements into their abattoir. There is a possible point of intervention here relating to the use of a Market Based Instrument (MBI) approach – similar to that being trialled in SA (Pastoral Board SA 2008) – as a mechanism to help secure continuity of supply while simultaneously reducing the negative impacts that feral camels are having on the nation’s natural resource values.

Mobile abattoirs are another option to facilitate a more efficient flow from camel suppliers to producers. Mobile abattoirs allow the processor to work closer to the feral camel resources. There have been arguments about their feasibility, however, and there are no mobile abattoirs continuously operating. While some consider that mobile abattoirs are too impractical and uneconomical (Ellard & Seidel 2000), field processing using mobile abattoirs is an immediate industry option that has the potential to impact significantly on feral camel populations (Gee & Greenfield 2007). They would be most suited to areas where camels are densely populated and reasonable infrastructure is established (Garry Dann 2008, Managing Director of Territory Camel Pty Ltd, pers. comm.). Cairns-based inventor Harvey Douglas has created a prototype mobile abattoir for use in remote areas to harvest camels, pigs, and horses. Field trials are underway and the results look promising (Stephen 2007). Although there is no hard evidence to prove the viability of mobile abattoirs, it must be an option for some regions where there is reasonable road access and high camel density.

7.6.2 Transportation

Currently, camels are transported using truck and trailer units designed for cattle. Because of regulation[1] only a single deck (carrying approximately 20 camels) can be used, which in turn means that transport costs are twice those for cattle. This is proving a significant impediment to the development of a meat industry and for live export. An option would be to investigate the viability of utilising the rail network that traverses some of the feral camel range to transport animals to abattoirs or ports.

7.6.3 Mutual benefit

The price paid for camels has an effect on the number of camels supplied for slaughter. Prices need to be sufficiently high to make the capture of feral camels attractive to contract musterers, pastoralists, and Aboriginal communities. In some seasons the numbers of camels mustered are not sufficient to cover mustering costs. Meat processors and live exporters need to work closely with their suppliers to ensure that pricing reflects the true costs of harvesting.

Different stakeholders have different expectations of harvested feral camels. Most pastoralists suffering from the negative impacts of feral camels want to eradicate them to avoid more losses, and they are doing so mainly by culling (refer to Zeng & Edwards 2008a). They are likely to accept a lower price for allowing harvesters to access feral camels on their properties, and many regard the income from harvesting feral camels as a bonus. However, if they are interested in harvesting camels for themselves, they are likely to deal with it as an additional business alongside their current livestock production. Aboriginal people are keen to use camels as a livelihood and income opportunity (refer to Vaarzon-Morel 2008a). It is, therefore, important to understand that they would like to be directly involved in feral camel harvesting. There is a clear need for value chains to work synergistically with Aboriginal people in developing a sustainable supply of camels such that their expectations for income and livelihoods can be met.

Processors and exporters would like to pay a lower price to get camels of an acceptable quality. On top of this, trading costs make the gap between sellers' and buyers' price expectations even bigger. Lower prices are only possible when there are sufficient camels to allow for cheaper harvesting, the different stakeholders have reasonable expectations, and an effective trading system exists. This result is only achievable when all the participants recognise the value added by the different chain members, and that this added value is necessary for a profitable camel industry. A perception of mutual benefit and a more efficient supply chain built on value creation and benefit sharing are essential to bridge the price gap. As noted earlier there is a possible point of intervention here relating to the use of an MBI approach – similar to that being trialled in SA – as a mechanism to help secure continuity of supply at a price that makes both supply and processing economic in the early phases of the industry's development.

Oscillation and uncertainty in the market have made it difficult to develop a successful trade in live camels. Currently, live camel export is irregular. There is no certainty of a sufficient supply of high quality camels or a reliable shipping service that will guarantee punctual delivery once a contract is offered. As payment is usually made after successful delivery, musterers must take costly risks when there is no payment in advance for their work mustering camels. This situation discourages them from being involved in the provision of a reliable camel supply. It is, therefore, important to set up

1 According to the *Model Code of Practice for the Welfare of Animals – The Camel*, 'camels must only be transported in single deck trailers with sufficient clearance for them to stand comfortably' (Agriculture and Resource Management Council of Australia and New Zealand 1997).

a mechanism to coordinate supply and demand, but the greatest gain will come from having a strong meat-based industry that will allow animals deemed unsuitable for live export to have an economic value as meat animals.

It would seem likely that over time the industry as a whole will mature to the extent that it will rely on domesticated rather than feral animals in a similar way that deer farming evolved in New Zealand. This will allow the industry to concentrate on producing animals of a size, sex, and conformity that maximises returns in both domestic and international markets. It will be important that appropriate regulatory structures are put in place ahead of this occurring. Such regulatory structures will need to ensure that domesticated animals are contained in such a way that they cannot return to the feral herd and are traceable through electronic tagging in the same way as cattle are now.

7.6.4 Trading companies, agents, and brokers

Along the supply chain trading companies, agents, and brokers are important links between supply, processing, distribution and the market. The emerging camel industry needs an effective trading sector that is focused on developing the industry in a sustainable rather than an ad hoc way. Current barriers that need addressing include weak and asymmetric market information; lack of quality standards for camels harvested; lack of a genuine partnering with Aboriginal managers and traditional owners in developing a sustainable industry; the informal nature of contracts (in particular with Aboriginal communities) which, when linked with asymmetric market information reduces harvesters' ability to negotiate on an equal footing; and lack of a skilled workforce. As there are currently very few companies addressing these issues, there is a significant weakness in the trading sector of the camel industry.

7.7 Integration of industry

7.7.1 Collective vision

It is important that an industry builds a collective vision among all its participants. The collective vision should include an expectation of mutual benefit, information sharing, cooperation, and effective competition. National peak bodies have been effective in other new industry areas. Such bodies have been found to be effective in lobbying for the industry, consolidating industry information including market information, establishing industry wide standards, and developing long-term visions for the industry. The Australian wine industry is a good example.

7.7.2 Information sharing

A lack of accurate information puts the camel industry at risk. There are two aspects to this problem: insufficient accurate information and insufficient exchange of information. According to a survey conducted (refer to Zeng & Edwards 2008a), pastoralists – some of the most important participants in the camel industry – generally do not feel that they have sufficient information to guide their involvement in the industry.

Important industry information regarding supply, production, and markets is not being collected and organised. Additionally, information regarding techniques and knowledge has not been sufficiently shared by industry stakeholders. There has been substantial duplication in some studies of camel industry development, in areas such as camel meat nutrient analysis, and in discussions about camel markets. Increased information sharing could avoid a waste of resources, circumvent some confusion, reduce conflict, and generally assist industry development. For example, delivery and slaughtering procedures are well established in the NT and SA. Experienced people from the trapping, penning, transport, slaughter, and retail sectors could pass on advice that would be valuable to start up the industry in WA. This information sharing could benefit all stakeholders and facilitate the cooperation between them.

8. Conclusions

Internationally, there is a significant camel industry based on meat, live animals, and by-products. In Australia by contrast, the industry has struggled to gain momentum because it has been based on the ad hoc harvest of a feral animal herd that is located in very remote parts of the country and is a long distance from domestic markets, let alone international markets. The lack of appropriately located and accredited processing abattoirs has been also a significant obstruction for the industry. The harvesting of feral camels started in the late 1980s, and by 2007 it was estimated that the Australian camel industry harvested around 5000–6000 camels per year: 3600–4600 for pet meat, fewer than 400 for live export, and 1000 for mainly domestic human consumption. The camel industry in Australia is still very small when compared internationally. However, the size of the feral camel resource of approximately one million animals makes the Australian herd the fifth largest in the world behind Somalia, Sudan, Ethiopia, and Mauritania.

There is potentially a large market for camel products, and a well-developed camel industry could provide an important management tool for the control of feral camels and their impacts and provide much-needed employment and economic activity in desert Australia. Although the current number of camels removed is small, commercial utilisation could potentially remove enough animals to have a significant localised impact on the levels of damage being caused at present and form part of a wider management program to arrest the continued growth in the feral population. However, a flourishing camel industry alone cannot bring down the camel population in the short term, as the industry will take some time to develop. Therefore, commercial utilisation is potentially an effective tool for managing feral camels and their impacts in targeted areas rather than across their whole range and as part of a more substantial integrated management approach.

Of the commercial uses investigated in this research, the slaughtering of feral camels for pet meat seems likely to make the greatest contribution to managing camel impacts in the short term, followed by a meat industry for human consumption and live export. Pet meating is attractive as it involves minimal capital infrastructure to develop and could quickly provide livelihoods for Aboriginal people. However, the contribution from commercial activities will depend on the development of secure markets that are prepared to pay the real costs of harvesting and transport.

The industry at present is not organised and lacks some key components to allow it to develop. The key missing elements are the lack of suitable capital infrastructure for harvesting, transporting, and processing animals; incomplete information on potential markets, including meat for human consumption and pet meat; no collective vision on how the industry should develop; and a lack of dialogue and consultation with land owners.

In many Aboriginal communities there has been considerable discussion about the development of the camel industry and the use of feral camels (e.g. for pet meat). This has contributed to a perception that feral camels are a resource rather than a pest in remote desert settlements (Gee & Greenfield 2007). Aboriginal people and pastoralists are keen to take up opportunities presented by the commercial utilisation of camels, and they see it as an opportunity for local economic development, employment, capacity building, and empowerment (Zeng & Edwards 2008a, Vaarzon-Morel 2008a). They generally would like to be directly involved in the industry rather than see economic benefits go to external businesses.

The camel industry in Australia needs to have a unique structure because commercial utilisation would also form part of a national strategy to control feral camels. Commercial utilisation must be integrated into the comprehensive feral camel management strategy. There is clearly a market failure in play at present that has allowed camel numbers to increase in an uncontrolled manner as society has not factored in the non-market impacts of feral camels on Australia's natural and cultural resources. A MBI approach is currently being trialled in SA and may prove to be an effective way of dealing with this market failure. However, the use of MBIs should be limited to situations where the commercial extraction of feral camels is a strategic component of a wider cross-jurisdictional feral camel management plan and not as a subsidy for the establishment of a new industry.

The farming of camels could support a sustainable alternative pastoral industry but would not contribute to the management of feral camels because camel farming will establish and maintain a permanent domesticated population of camels. It will be important that appropriate regulatory structures are put in place to ensure that domesticated animals are contained so they cannot return to the feral herd and are traceable through electronic tagging in the same way as cattle.

Live camel export, meat for human consumption, and pet meat are the major commercial enterprises that would contribute directly to feral camel management. While there should be a focus on continuing to enlarge the international market, the domestic market must also be considered. Other commercial uses for feral camels – such as the production of milk, skin, and game meat; the development of camel tourism and camel farms; and their use for undertaking weed control – would contribute very little to reducing the impacts of feral camels. However, the multiple use of camels would increase the economic viability of a camel industry.

8.1 Recommendations

- The commercial utilisation of feral camels can, and should, be integrated into a national feral camel management strategy. Commercial utilisation will have localised impact on feral camel numbers (and their negative impacts), but such utilisation needs to be seen as part of a comprehensive feral camel management strategy aimed at significantly reducing the negative impacts of the species.
- Harvesting for commercial utilisation should focus on two regions. These are the tri-state border region (SA, NT, and WA) and the Alice Springs region.
- There is a need to develop critical capital infrastructure, particularly export-accredited abattoirs to support the development of commercial activities in the two target regions. While this should be funded by the private sector, governments have a role in correcting an existing market failure (where the market does not account for the environmental, cultural, and social costs associated with a feral camel herd).
- A Market Based Instrument (MBI) approach should be trialled across tenures and jurisdictional boundaries, but MBIs should only be used to encourage the reduction in feral camel impact and should not be seen as a subsidy for the establishment of a new industry.
- The commercial utilisation of feral camels provides an opportunity for local economic development, employment, capacity building, and empowerment. Aboriginal people and pastoralists suffering from the impact of camels must be consulted fully on the management approaches adopted on the land that they manage. Such consultation should involve the sharing of information on the costs and benefits of all options, including commercial options, so people can make a informed decisions.
- Any future operations on Aboriginal land (and other areas) should attempt to increase the involvement of local people. An effective business model that supports broader and deeper local participation should be encouraged and supported by governments. Such a model should include direct commercial utilisation of camels but also, in the longer term, environmental management initiatives such as Aboriginal Ranger Groups and should be supported by training, including mentoring in business management.
- A national peak body should be established to coordinate the camel industry’s development. The role of the peak body would be to speak for the commercial industry; advise government on the needs of the industry in terms of legislation and regulation, capital infrastructure, training, market development, and research based on an industry strategic plan; research potential markets for camel products; facilitate communication, information sharing, and cooperation among the industry participants; and develop a dialogue between the industry, land managers, and government.

9. References

ABC Online. 2008. 'Camel hunting helps youth overcome boredom hump'. Available at: http://www.abc.net.au/news/stories/2008/02/04/2153725.htm, Retrieved 20 May 2008.

Admin. 2008. 'The Great Hughenden Camel Endurance Challenge'. Available at: http://www.aridlandsaustralia.org/camel-race.html, Retrieved 15 July 2008.

Agrawal RP, Beniwal R, Sharma S, Kochar DK, Tuteja FC, Ghorui SK and Sahani MS. 2005. Effect of Raw Camel Milk in Type 1 Diabetic Patients: 1 Year Randomised Study. *Journal of Camel Practice and Research,* vol. 12**,** no. (1), pp. 27–31.

Agriculture and Resource Management Council of Australia and New Zealand. 1997. *Model Code of Practice for the Welfare of Animals – The Camel*. CSIRO Publishing, Collingwood, Victoria, Australia.

Agriculture and Resource Management Council of Australia and New Zealand. 2003, *Australian standard for hygienic production of game meat for human consumption (on-line version)*. CSIRO Publishing, Collingwood, Victoria, Australia.

Ash E, Awan F, Forrest I, Gerhardt LV, Errington L and McWhirter M. 2008. *Exporting camel meat to the United Arab Emirates: An opportunity analysis prepared for Territory Camel (Course report: MKT303-International Marketing)*. Charles Darwin University, Darwin, Australia.

Batt PJ. 2003. Building trust between growers and market agents. *Supply Chain Management: an International Journal*, 8(1), 65–78.

Bell E, Hale E, Roberts K, Miao J, Zhang C, Chow C and Galvan K. 2008. *UK Group-Opportunity analysis presentation for Territory Camel (Student Course Report: MKT303)*. Charles Darwin University, Darwin, Australia.

Boehlje M. 1999. Structural changes in the agricultural industries: How do we measure, analyze and understand them? *American Journal of Agricultural Economics,* Vol. 81(5), pp.10–28.

CACIA. 2005. *The Northern Territory Camel Industry at the Crossroads*. Central Australian Camel Industry Association, Alice Springs, Australia.

CACIA. 2006. *The Central Australian Camel Industry*. Central Australian Camel Industry Association Inc., Alice Springs, Australia.

CACIA. 2007. 'History', Available at: http://www.camelsaust.com.au/, Retrieved 15 December 2006.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H, Williams G, Edwards GP, McGregor M and Zeng B. 2008. Review of legislation and regulations relating to feral camel management (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 125–132. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Chen G, Kwan E, Morriss D, Oketa S, Smith C and Woods K. 2008. *Opportunity analysis for Territory Camel: Country: North China (Course report: MKT303-International Marketing)*. Charles Darwin University, Darwin, Australia.

Cleary J, McGregor MJ, Bryecson K and James C. 2008. Development of a value-driven bush foods industry chain that rewards Aboriginal people. *Proceedings of the Australian Rangelands Conference* (forthcoming).

Collins R and Keilar S. 2005. *The Australian Bamboo Shoot Industry - A supply chain approach*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Coventry J, Edwards G and Zeng B 2008. In press. 'The odyssey of managing feral camels and their impacts – is there an Achilles' heel?'. *Australian Zoology*.

Cox A. 1999. Power, Value and Supply Chain Management. *Supply Chain Management,* Vol. 4(4), pp 167–175.

DAFF. 2008. 'Camel Industry Background'. Available at: http://www.daff.gov.au/agriculture-food/meat-wool-dairy/ilg/industries/camels. Retrieved 17 July 2008.

Dryden GM and Craig-Smith SJ. 2004. *Safari Hunting of Australian Exotic Wild Game*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Edwards GP, Saalfeld K and Clifford B. 2004. 'Population trend of camels in the Northern Territory, Australia', *Wildlife Research,* vol. 31**,** pp. 509–511.

Edwards GP, Zeng B and Saalfeld WK. 2008. Evaluation of the impacts of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 133–182. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

El-Amin FM. 1979. 'The dromedary camel of the Sudan'. IFS Symposium Camels, Sudan, pp. 35–54.

Ellard K and Seidel P. 2000. *Development of a Sustainable Camel Industry*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Encyclopedia. 1990. 'Camel meat', Available at: http://www.100md.com, Retrieved 15 January 2007.

Ethiopian News Agency. 2008. 'Ethiopia: Firm plans to export 20,000 camels', Available at: http://www.africanews.com/site/list_messages/15997, Retrieved 30 May 2008.

FAOSTAT. 2008. Food and Agriculture Organization of the United Nations (FAO) Databases. Available at: http://faostat.fao.org/, Retrieved 10 August 2008.

Farach Z and Fischer A. (eds) 2004. *Milk and meat from camel: Handbook on products and processing,* vdf Hochschulverlag AG, Swiss Federal Institute of Technology, Zurich.

Finnane K. 2008. 'Camels out of control: efforts are inadequate & sporadic, says report', *Alice Springs News*, 22 May 2008.

Fletcher A. 2006. 'Camel milk: the dairy product of the future', Available at: http://www.dairyreporter.com/news/ng.asp?id=67146-milk-cheese-chocolate, Retrieved 1 March 2008.

Foster M, Jahan N and Smith P. 2005. *Emerging Animal and Plant Industries – their value to Australia*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Gee P and Greenfield B. 2007. *SA Arid Lands Feral Camel Management Plan,* DRAFT, South Australian Arid Lands Natural Resource Management Board, Port Augusta.

Goulding B, Riedel E, Bevan A and Warfield B. 2007. *Export markets for skins and leather for Australia's camel, crocodile, emu and goat industries*. Project No. DAQ-312A Rural Industries Research and Development Corporation (RIRDC), Canberra.

Haddad G. 2006. 'Camel Milk And Urine Hadiths', Available at: http://mac.abc.se/~onesr/f/Camel%20Milk.html, Retrieved 2 January 2007.

Hill M. 2006. *Contribution of the pet care industry to the Australian economy*. BIS Shrapnel Pty Limited North Sydney, NSW.

Hoffman LC, Crafford K, Muller N and Schutte DW. 2003. 'Perceptions and consumption of game meat by a group of tourists visiting South Africa ', *South African Journal of Wildlife Research,* vol. 33**,** no. (2), pp. 125–130.

House of Representatives of AFF. 2005. *Taking control: a national approach to pest animals---Inquiry into the impact on agriculture of pest animals*, ISBN 0 642 78732 8, The Parliament of the Commonwealth of Australia, Canberra.

Inayat S and Farooq AA. 2005. 'Therapeutic values of camel milk', *Journal of Animal and Plant Sciences,* vol. 15, no. (3/4), pp. 68–69.

Invest Australia. 2005. *Australian Meat Industry Capability Report*. Invest Australia, Canberra.

Isani GB. 2003. *Aspect of Camel Marketing in Pakistan*, CARDN/ACSAD/Camel/P 112/2003, The Camel Applied Research and Development Network (CARDN). The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD).

Keikin D. 1976. 'Camel breeding can be economical', *Konevodstroi Konnyi Sport*, No. 2: pp. 12–13.

Kelly J. 2005. *Kangaroo industry strategic plan: 2005–2010*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Khanna ND, Tandon SN and Rai AK. 1993. 'Reproductive status of Bikaneri camels managed under farm conditions', *Proceedings of the Workshop on: Is it possible to improve the reproductive performance of the camel?*, September 1990, Paris, France, CIRAD-EMVT, pp. 337–351.

Lazzarini SG, Chaddad F and Cook ML. 2001. Integrating supply chain and network analyses: The study of netchains, *Journal on Chain and Network Science,* vol. 1, no. 1, pp. 7–22.

Lethbridge MR. 2007. unpub. *Final Report of 2007 Camel Aerial Survey of South Australia and Western Australia*. Rural Solutions South Australia, Adelaide.

Li S. 1596. *Compendium of Materia Medica (in Chinese)*. Nanjin, China.

Liu Z. 2006. 'Restaurants are going to serve camel meat (in Chinese)', Available at: http://www.xinhuanet.com/food/gzys.htm, Retrieved 20 January 2007.

MacNamara K, Nicholas P, Murphy D, Riedal E, Goulding B, Horsburgh C, Whiting T and Warfield B. 2003. *Markets for Skins and Leather from Goat, Emu, Ostrich, Crocodile and Camel Industries*. Publication 02/142, Rural Industry Research and Development Corporation (RIRDC), Canberra, Australia.

McCloy L and Rowe P. 2000. *Assessing the potential for a Commercial Camel Industry in Western Australia*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

McGregor M. 2008. 'What management options do we have?' In Edwards G 2008, *Outcomes and recommendations of the Feral Camel Action Plan Workshop 13–14 April 2005*, DKCRC Working Paper 25. Desert Knowledge CRC, Alice Springs, Australia.

O'Keefe M. 1998. Establishing Supply Chain Partnerships: Lessons from Australian Agribusiness, *Supply Chain Management*, vol. 3(1), pp. 5–9.

NTCA. 2003. *Evaluation of the feasibility of establishing a Northern Territory multi-species abattoir*. Northern Territory Cattlemen's Association/NTDBIRD, Alice Springs, Australia.

PacALLIANCE (Australia) Pty Ltd. 2002. *Kangaroo Pet Meat Survey*. RIRDC Publication No 02/145, Rural Industries Research and Development Corporation (RIRDC), Canberra.

Parkes J, Henzell R and Pickles G. 1996. *Managing vertebrate pests: Feral goats*. Australian Government Publishing Service, Canberra.

Pastoral Board SA. 2008. 'Feral Camel Management: Market-based approach "unprecedented"', *Across the Outback,* vol. May 2008, no. (37), pp. 1–3.

Pet Industry News. 2007. Sales of 'natural' and 'organic' pet food soar, Available at: http://www.petnews.com.au, Retrieved 25 March 2008.

Petnet. 2007. Pet Statistics, Available at: http://www.petnet.com.au/petstatistics.asp, Retrieved 24 August 2007.

Phillips A, Heucke J, Dörges B and O'Reilly G. 2001. *Co-grazing cattle and camels*, Publication 01/092. Rural Industry Research and Development Corporation (RIRDC), Canberra, Australia.

Porter ME. 1985. *Competitive Advantage, Creating and Sustaining Superior Performance*. The Free Press, New York.

Raziq A. 2007. 'Mangrota camel fair', Available at: www.lifeinitiative.net/docs/mangrota_camel_fair.doc.

RIRDC. 2005. *New Animal Products R&D Plan 2006–2009*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Rose B. 1995. *Aboriginal Land Management Issues in Central Australia*. Central Land Council, Alice Springs.

Rouda RR. 2004. *Development of Camel Industries in Western Australia – Final Report*. Gascoyne Murchison Strategy, Department of Agriculture Western Australia, Perth, Australia.

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK, Edwards GP, Zeng B and Lamb D. 2008. A Multiple Criteria Decision Support Tool for feral camel management. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 287–330. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Seidel P. 2000. *Development of a sustainable Camel Industry*. Rural Industries Research and Development Corporation (RIRDC), ACT, Australia.

Shabo Y, Barzel R, Margoulis M and Yagil R. 2005. 'Camel Milk for Food Allergies in Children', *Immunology and Allergies,* vol. 7**,** no. 12 (December), pp. 796–798.

Sharp T and Saunders G. 2005a. *Model Code of Practice for the Humane Control of Feral Horses*. NSW Department of Primary Industries, Sydney, Australia.

Sharp T and Saunders G. 2005b. *HOR001 ground shooting of feral horses*. NSW Department of Primary Industries, Sydney, Australia.

Sharp T and Saunders G. 2005c. *HOR003 mustering of feral horses*. NSW Department of Primary Industries, Sydney, Australia.

Sharp T and Saunders G. 2005d. *HOR004 trapping of feral horses*. NSW Department of Primary Industries, Sydney, Australia.

Stayner R. 2007. *Economic Analysis and Business Development of Sustainable Wildlife Enterprises trial sites*. RIRDC Publication No 07/042, Rural Industries Research and Development Corporation (RIRDC), Canberra.

Stephen A. 2007. 'Mobile abattoirs', Available at: http://www.abc.net.au/rural/wa/content/2006/s2067988.htm, Retrieved 10 April 2008.

Students. 2008a. *Final report for Territory Camel: Opportunity analysis for Indonesia (Course report: MKT303-International Marketing)*. Charles Darwin University, Darwin, Australia.

Students. 2008b. *Exporting camel meat to Saudi Arabia: Opportunity analysis prepared for Territory Camel Pty Ltd (Course report: MKT303-International Marketing)*. Charles Darwin University, Darwin, Australia.

Tourism Australia. 2007. 'Tourism Info', Available at: http://www.australia.com/, Retrieved 9 February 2007.

Vaarzon-Morel P. 2008a. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008b. *Key stakeholder perceptions of feral camels: Aboriginal community survey,* DKCRC Research Report 49. Desert Knowledge CRC, Alice Springs.

Warfield B and Tume L. 2000. *Market Analysis and Plan for the Camel Industry*. Rural Industry Research and Development Corporation (RIRDC), Canberra.

Wilson RT. 1984. *The Camel*. Longman Group Ltd, London and New York.

Wondu Business and Technology Services. 2004. *Adding value to new animal product supply chains*. Rural Industries Research and Development Corporation (RIRDC), Canberra.

Yagil R. 1982. *Camels and camel milk*. FAO, Rome, Italy.

Zeng B and Edwards GP. 2008a. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008b. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zhou H, Jin L, Zhang Z, Hesham A and Wang C. 2007. 'Applications and Performances of Extended TTDDs in Large-Scale Wireless Sensor Networks', In: The 3rd International Conference of Mobile Ad-hoc and Sensor Networks, 12–14 Dec 2007, Beijing, China.

10. Appendices

Appendix 9.1: Case study: Territory Camel Pty Ltd

(Benxiang Zeng, Department of Natural Resources Environment, The Arts and Sport, Northern Territory Government)

Acknowledgements

Thanks to Garry Dann, the Managing Director of Territory Camel, for his kind support and close cooperation in this case study. Thanks to Murray McGregor and Glenn Edwards for their valuable comments and discussion.

1. Introduction

Territory Camel Pty Ltd is an Alice Springs–based company that slaughters, processes, and supplies camel products to the domestic market. The Managing Director of Territory Camel, Garry Dann, has a lifetime commitment to the rural industry. Garry and his family have operated several significant beef cattle properties in the Northern Territory. In 1988, Garry started to produce and sell camel meat for human consumption in cooperation with Centapakit Meats (a meat wholesaler that operated in Alice Springs until 1991).

In 2005, Garry leased a local abattoir (Wamboden) to process his own natural grass-fed, free range beef cattle under the brand name 'Centralian Gold'. He used this opportunity to become commercially involved in the camel industry under the brand name 'Territory Camel'.

Garry has a belief in natural goodness, both in relation to the health of his camels, and the health and wellbeing of consumers. Camels living in central Australia are recognised to be among the healthiest in the world. They forage on natural bush land that is untainted by chemicals, pesticides, or disease; they are like cattle and sheep, except they use more bush and shrubs for food.

Territory Camel is one of the key members of the Central Australian Camel Industry Association (CACIA), and Garry himself has had an involvement in camel and industry associations for the past 10 years and has been the Deputy President of CACIA since 2007.

Territory Camel is a major player in the camel industry. An analysis of its development reveals the key issues faced by the camel industry generally, especially in relation to camel meat production, and provides valuable experiences and lessons.

Over the last 12 months Garry has been interviewed four times by the DKCRC camel project. This case study is mainly based on those interviews; otherwise information sources are cited.

2. Camel meat production

2.1 Source of supply

Territory Camel runs a commercial camel herd on Garry's station, Aileron. There are currently 500 camels on the station, which partly supplies the camels needed to meet existing demands. Territory Camel also buys camels from other stations in the Northern Territory and from the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands in South Australia (SA). Garry has said: 'Where in Alice a mob of 60 to 70 is a big mob, in the APY lands you get mobs of 700 to 1500 or better.' (Garry Dann 2008, Managing Director of Camel Territory Pty Ltd, pers. comm.).

2.2 Processing

Wamboden Abattoir, just to the north of Alice Springs on the Tanami Road, has a slaughtering capacity of 300 animals per week. The abattoir is currently slaughtering and processing cattle and camels for the domestic market.

The abattoir employs three staff, one full-time and two part-time. Every week 20–40 camels can be slaughtered for human consumption; however, the actual number of slaughtered camels varies with the market demand. Garry emphasised that if the abattoir were accredited as Tier 1 (T1) with the Australian Quarantine Inspection Service (AQIS), he would be able to export the meat to up to 26 countries, and he could employ approximately 15 staff to process around 200 camels per week.

2.3 Camel products

Territory Camel is focusing on value-added camel meat products for human consumption. These products are manufactured for it by Charbray Meats, an Alice Springs–based company. The products include: plain and gourmet sausages (date, chilli, curry, cheese, Italian); Territory camel burgers; marinated and BBQ steak; scotch (yearling, large); porterhouse; T-bone; fillet; rump; corned brisket; premium diced or minced cuts; and smallgoods (cabana, mettwurst [chilli, garlic], pepperoni [hot, mild]).

All products are processed in Alice Springs using free range camels. The products are quality controlled and provided at competitive prices. The sausage, burger, and mince products are preservative and gluten free, and for this reason they are all supplied fresh, snap frozen, or in cryovac.

3. Camel meat sales

Camel meat has been provided to the domestic market by Territory Camel since 2005. There were 450 camels slaughtered and sold in 2007/08, which is approximately 40% of the camels slaughtered for human consumption in Australia. Over the last three years, production and sales of camel meat have slowly been increasing. Market development is still a challenge.

Territory Camel has sold hump as feed for emus in Qld. The quantity sold was very small, and at $1.25 per kg does not significantly influence the value of the animal.

3.1 Market strategy

A lot of time has passed since Centapakit sold camel meat, either locally or to various states in Australia. The camel industry is still very small. The current small size of the market is one of most important issues hindering industry development.

Garry believes that camels are a great resource and produce good meat. He also understands that the benefits are only real if there is a market for his products. Garry believes that camel should be promoted in the domestic market, particularly to some specific groups such as the Muslim communities in big cities. He says that there is an international market but that it is difficult to access at the moment.

Territory Camel mainly distributes its camel steaks, mince, and sausages through consumer outlets in Adelaide, Darwin, and Alice Springs, but some also go to Qld, NSW, and other parts of SA.

A Territory Camel direct-to-public outlet and two retail outlets have been successfully selling camel products – from sausages and mettwurst to prime cuts – for over 12 months, and another outlet has recently approached the company wanting to sell their camel products. Sales are increasing (Finnane 2008). The Camel Hump Restaurant in Alice Springs is supplied with $1500 worth of camel meat every week by Territory Camel.

Creating more consumer demand is, however, the biggest challenge for the company. Territory Camel is making a great effort to explore the international market. Researchers from Charles Darwin University (CDU) were commissioned by Territory Camel to do an ‘opportunity analysis’ of the market in five overseas countries. Territory Camel wanted to find a market for ‘boxed’ meat (not just the wet meat that is provided through live exports) and was hoping the CDU research would point to opportunities in new markets, such as the European Union countries. The research reports were completed in late July 2008. These five reports analysed the opportunities and challenges for Territory Camel’s camel meat products in:

- the United Kingdom (UK) (Bell et al. 2008)
- China (only focusing on north China) (Chen et al. 2008)
- Indonesia (Students 2008a)
- Saudi Arabia (Students 2008b)
- United Arab Emirates (UAE) (Ash et al. 2008).

They found that there is a realistic market opportunity in the UK, but not in the other four countries because of a low demand for boxed camel meat (e.g. in Saudi Arabia and UAE) or because of the low prices that would be paid and the high transportation costs (e.g. in China and Indonesia).

Public acceptance of camel meat is Territory Camel's most important concern. Territory Camel aims to address this through public education and marketing events. In order to explore the market in Australia (particularly Muslim and Asian ethnic groups), camel meals – such as Camel Green Curry and Camel Pasta – have been developed with a Queensland-based company. These products are now being promoted. Brochures have also been distributed that provide information about the nutritional value of camel meat and how to cook it. A senior manager of the company has moved from Alice Springs to Darwin to spearhead the development of the market there, attending trade shows and conducting retail trials (Finnane 2008).

3.2 Industry margins

An approximation of the industry margin can be made using data provided by Territory Camel and other service providers.

3.2.1 Mustering and handling cost

The mustering cost varies substantially. According to Ross Morton, a pastoralist who has been involved with camel mustering for eight years in central Australia, mustering using trucks and motor bikes costs around $50–100 per camel (an average of $75) in a high camel density area (>0.5 camel per square kilometre, in areas such as Docker River and the APY lands) (Ross Morton 2008, owner of Henbury Station Northern Territory, pers. comm.).

Feral camels need to be yarded for up to a week after mustering to ensure the meat quality is of a sufficiently good standard. This holding period helps to reduce bruising and stress which would otherwise diminish meat quality. The animals need to be held at a staging facility or at the abattoir (McCloy & Rowe 2000). For this analysis an amount of $35 per camel is assumed to include feed, watering, and management costs and an annual contribution to the cost of establishing a yard facility.

3.2.2 Transportation cost

Transport from where the camels are trapped to the abattoir site is a major cost for the feral camel industry. Camels need to be transported on a single level trailer because they are so much taller than cattle. Additionally, camels are more safely transported over long distances while seated. This means they can take up to 40% more space than cattle. Only about 18–20 adult camels can be carried on each trailer (Agriculture and Resource Management Council of Australia and New Zealand 1997; McCloy & Rowe 2000). It costs $3.50–4.00 per km to freight live camels using cattle trucks; that is, $130–140 per camel (an average of $135) from the APY lands in SA to the Wamboden Abattoir, a distance of approximately 700 km.

3.2.3 Processing cost

Slaughtering and processing costs total approximately $300 per animal, which covers all stages of the process: slaughtering, processing, freezing, packing, freighting, the cost to adapt killing facilities, the cost to put yarding facilities in place, and the cost to train personnel.

3.2.4 Industry margin

Table 9.15 summarises the estimated costs to process a camel for human consumption.

Table 9.15: Costs of processing a camel for human consumption based on Territory Camel operation

Item	Cost ($/animal)	percentage of total cost (%)
Mustering	75	14
Handling	35	6
Transportation	135	25
Processing	300	55
Total cost	**545**	**100**

This table demonstrates that the total cost to process a camel is $545. The industry margin must be set to cover that cost.

The live weight of adult camels is about 600 kg and the dressing rate is 50%. This yields a 300 kg camel carcass. Another third of the carcass will be cut off (bones, offal and tendons, hump, and other cutting loss) leaving 200 kg of saleable meat (natural fall) from each camel. Without considering the camel skin and hide usage (currently not utilised), the marginal cost for a kilogram of natural fall meat would be $2.73.

According to Garry, the price accepted by the camel slaughtering sector needs to be a minimum of $5.50 per kg (for natural fall), which is nearly double the marginal cost. Given Territory Camel's small scale, this amount of profit for the production of camel meat is still very small given that the fixed costs of running the abattoir need to be covered. The price offered by some wholesalers and other meat processors has been much lower than this price. For example, a recent enquiry (29 November 2007) for 20 boxes of camel meat for human consumption was at a price of only $3.50 per kg.

3.2.5 Sensitivity analysis

The cost per kilogram is sensitive to processing costs, which make up 55% of the total cost (Table 9.15), but also to handling and transport costs. Sourcing animals from areas closer to the abattoir and from a confined space would have a significant impact on costs. A farmed supply close to the abattoir would help reduce costs but would also ensure continuity of supply and animals of the optimal weight, age, and sex. Camel live-weight is also an important driver. If live-weight decreases by 10%, the marginal price is increased by 10%. This implies that large animals should be harvested for human consumption to keep the marginal price lower. However, this must be balanced by the fact that the age of a camel determines the camel meat quality.

4. Accredited abattoirs

Besides marketing, the renovation of the existing Wamboden abattoir and the set up of new abattoirs are major tasks being undertaken by Territory Camel. As mentioned in Section 2.2, the company is upgrading its Wamboden Abattoir to T1 accreditation to permit export sales. The inspection from AQIS has been completed, and the renovation is being done according to the requirements of AQIS. It is hoped that it will be accredited in the near future.

To shorten the distance between abattoirs and camel sources, Territory Camel is seeking cooperation from APY Council to set up a joint venture to run an abattoir in the APY lands, where the local Aboriginal communities will provide most of the workforce to muster camels. This proposed abattoir would be a permanent, small, multiple-species abattoir to produce camel meat and other feral animal meats (e.g. horses) for human consumption and pet food. It would be built and start operation in the near future. Feral camels will be mustered and drafted for different uses: human consumption, pet food, and domestication. Once the abattoir is built, the cost of camel production will be dramatically reduced because of lower transportation costs. The abattoir is also intended for use in processing game meat.

The construction of another big, multiple-species abattoir is also proposed for an Alice Springs suburb. A businessman from Saudi Arabia is interested in setting up a joint venture with Garry to supply 1000 tonnes of frozen camel cuts (with bone in) per year to countries overseas (through the Alice Springs Airport). This is equivalent to 3000–3500 slaughtered camels each year. Garry is very confident that it would be viable. The proposed multiple-purpose abattoir would have the capacity to handle at least 1000 animals per week, but in the early stages it would handle fewer than that. More time would be needed to get it fully operational. The potential abattoir site has been identified and negotiations with the NT Government are in progress. A total of $6 million investment would be required, including land and underground infrastructure worth around $1.5 million. Strong support from the NT Government is crucial to the success of this international venture.

5. Discussion and conclusions

Territory Camel is a major provider of camel meat within Australia. It currently has approximately a 40% share of the domestic camel meat market. Territory Camel is confident that the demand for Australian camel meat will increase both in Australia and overseas, despite the fact that production in Australia has not significantly increased in the 20 years since camel meat was first provided in Alice Springs in 1988. Territory Camel will put more resources into marketing in both the domestic and international markets. A public campaign and special promotional events will be conducted in domestic markets to create more demand for camel meat.

Territory Camel believes that boxed meat is much more viable for Australian camel meat producers to export to international markets, rather than ‘wet’ meat. Abattoirs with international accreditation and Halal accreditation are necessary to provide uninterrupted camel meat production.

Territory Camel has the capacity to produce greater quantities of camel meat in Wamboden abattoir. However, the limited market is a constraint on the plant reaching full production capacity. Major constraints at present are that the abattoir does not have export accreditation for camel meat, and its distance from the main camel harvesting region. This has meant that the business is looking to establish facilities closer to the source of animals. It is important that the existing processing capacity of Wamboden abattoir is integrated with the establishment of any new abattoirs. If markets are created in a short time period, this arrangement seems a reasonable way to meet the market demand by increasing production capacity. However, because the marketing process consumes time and money, the decision to build new abattoirs must be based on expected demand in both the international and domestic markets.

International investment is possible, but investors would have an expectation of substantial economic returns over the defined time period. It is important to demonstrate to investors the existence of abundant camel resources, ambitious business operators, strong government support for the camel industry, and to convince them that there is an accessible market for camel products.

Considerable hard work – including new product development, marketing research, and public education – is critical to create and maintain increased demand for camel products and to keep the Australian camel industry visible in Australia and internationally. This tiny industry needs help to diminish the risks involved in channelling resources into an undeveloped market (Finnane 2008).

If the scale of production increases, Territory Camel could supply the market with camel meat at a more competitive price and offer camel harvesters a higher purchase price. This in turn would improve the efficiency of the plants’ operation and significantly improve both market competitiveness and continuity of camel supply.

Appendix 9.2: Case study: Pet meat operation in Warakurna

(**Benxiang Zeng,** Department of Natural Resources Environment, The Arts and Sport, Northern Territory Government; **Gordon Sander,** Land and Culture Unit, Ngaanyatjarra Council)

Acknowledgements

We are grateful for the support provided to us by Ngaanyatjarra Council in the case study. In particular we would like to acknowledge Jim Craig and his team for supplying the information about the pet meat operation. We would also like to thank Peter Armstrong for his contribution to field survey and information collection. The comments from Alex Knight, Murray McGregor, and Glenn Edwards are much appreciated.

1. Background

Warakurna is one of 12 settlements on the Ngaanyatjarra lands (250 000 km²) in Western Australia (WA) (Figure 9.8).

The Warakurna settlement has 150 Aboriginal residents and around 35 staff working for the community, Ngaanyatjarra Council, and other entities. There are approximately 50 houses. There are a large number of camels living around the settlement. According to an aerial survey in 2007 that covered this area, the overall camel density was 0.84 camel/km^2 (refer to Saalfeld & Edwards 2008, Saalfeld et al. 2008). Population growth and serious drought in recent years has led to feral camels causing considerable damage to property, waterholes, and vegetation in and surrounding the settlement. In the summer of 2006–07 a large number of camels got into the settlement and wandered around looking for water. They pushed over a fence, broke off taps and air-conditioners, and pulled down a water tank and a windmill. Local people thought there were 'too many camels'. In addition to the considerable mess they caused in the settlement, the community members noticed a significant reduction in the number of kangaroos, a favourite food for local people, in the immediate vicinity. According to Chris Moon, the former Community Development Advisor (CDA) in Warakurna, in the summer of 2006–07 feral camels directly caused $100 000 worth of economic damage (refer to Edwards, Zeng & Saalfeld 2008).

With this background, a small-scale, local action to shoot camels for pet meat was initiated in March 2007. This third-party pet meat operation has moved away from Warakurna but is still continuing operations from other settlements in the Ngaanyatjarra lands. On 22–23 June 2007, scientists from the DKCRC camel project visited Warakurna to document this operation. The partners involved in the operation were interviewed, and the Aboriginal people in Warakurna and other neighbouring settlements were asked about their attitudes towards the operation and about their general perspectives on feral camel management.

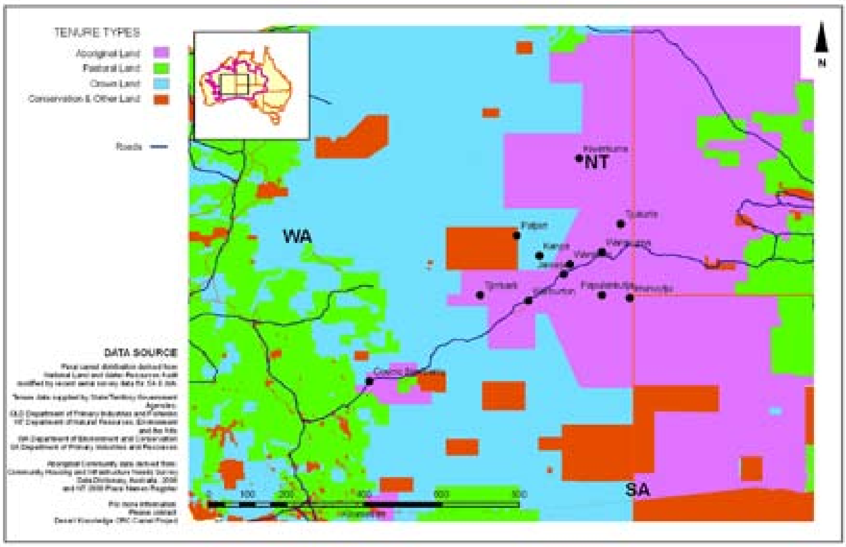


Figure 9.8: Location of Warakurna

2. Operation

The camel shooting operation was done under permit and a contract was arranged by Ngaanyatjarra Council's Land and Culture staff and lawyers. Ngaanyatjarra Council and Warakurna are both signatories to the contract, which states that professional hunters will conduct the operation. Ngaanyatjarra Council has been instrumental in getting this highly successful program together. The arrangement was supported and negotiated by Ngaanyatjarra Council Land and Culture staff members.

The operation started in late March 2007. The first term of the contract between the settlement and the shooter lasted three months to the end of June 2007. The operation was settlement-based and happened on a small scale with two professional hunters (with skills in both shooting and slaughtering), together with support staff, working at Warakurna. They worked on a four-week shift (one professional hunter and a support person worked together for four weeks as one shift). The operators lived in a house that was provided free by Warakurna. Camel meat was stored in a 40-foot refrigerated shipping container – with a capacity for the meat from 75 camels – parked at the power station on the outskirts of the settlement. The operators used a 4WD Toyota utility, equipped with a powered lift, as the main work vehicle and a 0.243 calibre rifle for shooting (from right behind the skull).

The operation was conducted every day, including weekends. Hunters always began with a search for camels, driving out along the main road tens of kilometres away from the settlement, then driving off the road to target a herd, shoot one or two, and then chase and shoot the rest. Only the bone-in cuts (four legs and the neck, approximately 250 kgs) were taken, while the remainder of the animal was left without any further treatment. The meat from five–eight animals was loaded onto the utility with the lift, transported to the settlement, and packed into the chiller for temporary storage. This operation took about one hour. Every week another chiller truck was hired to transport the cuts to a company in Perth.

The areas that the hunters were allowed to shoot in were established through consultation with senior Warakurna community members who accompanied them in the early stages. Camels are usually shot away from sensitive areas.

3. Key figures

The field survey has collected some useful numeric information on the operation. This information provides a base case for small-scale, settlement-based pet meat operations.

Operators: Only two professional hunters were involved in this operation. Each shift of four weeks was carried out by only two people: one professional hunter and one support person.

Camels taken per day: Ten–fifteen camels were harvested each day. In the Warakurna operation the operators went out twice a day and took five–eight camels each time.

Number of camels removed: During the term of the operation at Warakurna just over 1000 camels were removed. The hunters have since been based in Jameson, Wanarn, Docker River, and Tukurla Communities with over 5000 camels shot, butchered, and the pet meat sold.

Commercial benefits: The pet meat operation was a commercial venture that benefited all the partners involved. The operators sold the bone-in camel cuts to Prota Pet Foods for $0.75/kg. The local community received a royalty from the operators of $0.05/kg of cuts. The pet meat company got fresh meat at a low price to produce high quality pet food for the domestic and international pet care market.

4. Local involvement

4.1 People's attitudes to this operation

The operation began after approval for the project was given at a meeting of Warakurna Community Council. Members of the Shire Council were consulted directly prior to permission being granted to the camel shooters. The Ngaanyatjarra Council (Aboriginal Corporation) was informed about the operation at a full meeting of the Council held in Warakurna in 2007. Ngaanyatjarra Council worked closely with the community to implement the program.

As the operation progressed, local people became more and more supportive. Warakurna people supported the operation because the camels were damaging community buildings and local waterholes. They also supported the approach because the animals were not being wasted, as they would have been in a culling operation. The community received a small royalty per kilogram, and young men were employed as field hands by the shooter and learned useful work skills. Interviews with local people indicated most people thought something must be done to control feral camels. They felt that getting paid for the camels was one of the best options. Although the local people's perspective on feral camels is linked to commercial use without caring much about economic viability, their attitude towards camel control was positive and at odds with the attitudes reported by Rose (1995), which suggested that Aboriginal people did not want any killing of feral animals, including camels. It is interesting to note that most of the other Ngaanyatjarra settlements support Warakurna's initiative and are now keen on similar operations in their own areas. Similar pet meating operations have now been undertaken in areas such as Docker River, Northern Territory (NT) since then.

4.2 Local participation

A small number of local Aboriginal people were employed for a short time as guides during the operation. In the first two weeks, two men guided the shooters and showed them where feral camels were. The two local guides were paid $400 by shooters for the two weeks they were employed. The pet meat operation also passed on skills to members of the Ngaanyatjarra Council Land and Culture Team to help local Aboriginal people butcher camels for their own consumption.

One of the guides said in an interview that he was very happy and proud of his involvement in the operation. He got income from the involvement and he did something useful. Other local people said they would like to be involved in camel management in some way. Some people suggested that they have skills that could contribute to camel control: they know their lands well, they know where camels are, and they know how to muster camels using motorbikes. Some people also suggested that they could build yards to hold camels. Any future operations on Aboriginal land should attempt to involve local people more. Therefore, an effective business model that supports broader and deeper local participation should be encouraged and supported by governments.

4.3 Local benefit from the operation

The benefits obtained by local people must be analysed from several perspectives. From an economic perspective, not much benefit flowed into the local Aboriginal community. According to the contract between the settlement and the operators, the local community received a royalty of $0.05/kg of camel cuts. Ultimately, Warakurna settlement received over $10 000 in royalties from the three-month operation that removed 1000 camels. This amount of money was significant for a small settlement with only 150 residents. However, it was a relatively small proportion of total income generated, especially when accounting for the fact that the community had to pay the electricity costs for the operators and provided them with free accommodation. Any settlement conducting a similar operation should aim for an increased proportion of the economic benefits. Local communities should be considered one of the major collaborators and should share not just the non-financial but also the financial benefits. Such small-scale operations could be established by communities themselves.

From the environmental and social perspectives, however, the community did get a great deal of benefit. Obviously this operation has reduced the number of camels around the settlement, which will reduce the damage and mess to the settlement and the negative impact on native animals, vegetation, landscapes, and waterholes. As stated above, the damage done in the community in 2006–07 has been estimated at approximately $100 000, not including damage caused in road accidents. Additionally, the operation showed local Aboriginal people that effective action could be taken to control feral camels, reduce their impact on the settlement, and provide some economic benefit. Aboriginal communities are likely to become engaged in camel management in different ways. The presence of this operation, and the benefits it brought in terms of employment, reduction of camel numbers, and production of pet meat may have influenced people to accept a more diverse range of camel management strategies than may otherwise have been the case (refer to Vaarzon-Morel 2008a).

4.4 Community support

Community support was critical to the success of this operation. Free electricity and free accommodation were provided for the initial trial of this program – a voluntary offer made by Warakurna – in a bid to attract the shooters by reducing their financial risks. This demonstrates the willingness of Warakurna (and Ngaanyatjarra Council) to get a program running. Although the shooters paid for their electricity and rent in later programs, the free offer was important to initially establish the pet meat operation.

5. Financial viability and sustainability

A simple model has been developed to test the financial viability of small-scale pet meating operations. The model is based on a model developed to assess sustainable wildlife enterprise trial sites (Stayner 2007) and has assumptions based on the Warakurna case study discussed above.

5.1 Base case

Following the model adopted by the Rural Industry Research and Development Corporation (RIRDC) (Stayner 2007), the base case is built on the following assumptions:

1) Total area over which harvesting takes place

In this case the professional hunters were based at the settlement. They worked for eight hours per day with two returns to the settlement. The distance they drove out from the settlement was on average 40 km. We can assume an area of 5000 km² – within a circle of around 3.14 x (40km)² – was harvested around the settlement. According to the shooters in this case, one team could work two areas based on two settlements over a 12-month period. Therefore, in the base case, we assume the total harvested area could be two 5000 km² areas, that is, a total of 10 000 km² harvested in one year.

2) Camel density

There is a wide variation in the density of camels over desert areas (refer to Saalfeld & Edwards 2008, Saalfeld et al. 2008). Based on the research reported here, the average density over the whole camel range in Australia is around 0.3 camel/km^2. A recent aerial survey has estimated 0.84 camel/km^2 in WA (Ngaanyatjarra Lands) and 0.65 camel/km^2 in South Australia (SA) (APY Lands). This survey was undertaken between May and June 2007, in an area of 128 000 km^2 that straddles the northern part of the WA–SA border (Lethbridge 2007). This area is believed to have one of the highest densities of feral camels in Australia (refer to Saalfeld & Edwards 2008).

For the base case scenario, we assume a density of 0.8 camel/km^2.

3) Harvest rate per year

In this case, professional shooters actually harvested 1000 camels in the area around the Warukurna settlement, which equated to approximately 25% of estimated camel numbers in the harvest area. For the base case we have assumed a harvest rate of 25%. This will reduce the feral camel population quickly and lessen the impact of camels on the land. It is not a rate that will maintain sustainable harvesting. However, it is a realistic estimate of the harvest size likely to be accepted by local Aboriginal communities, pastoralists, and natural resource management (NRM) managers trying to reduce feral camel impacts, as well as by operators seeking economic returns while minimising their harvest costs.

4) Camels taken per day

The base case assumes 10 camels are harvested per day, although discussions with experienced hunters indicate that this number is often exceeded thereby improving the profitability of the enterprise substantially (see sensitivity testing).

5) Average camel cuts weight

A full-grown male camel weighs over 600 kg. Female and young camels weigh less, so the average weight of a camel is around 400–600 kg. Based on the real case in Warakurna, the average weight of camel carcass taken was assumed to be 250 kg in our base case. Economic returns are highly sensitive to reductions in this figure.

6) Labour cost

A figure of $440 a day equals $55 per hour for an eight-hour working day for two people: a professional shooter and one support person.

7) Cost and useful life of capital items

A dedicated vehicle fitted with a purpose-built lift is required for camel harvesting. A new 4WD vehicle at 2007 prices (on average $50 000) is used in these calculations. Capital costs are estimated to be $60 000 including the lift (hydraulic hoist), a rifle, and knives. For simplicity, all capital items are assumed to have the same useful life of eight years. The returns for harvesting (net of variable costs) must be adequate to repay the capital costs within eight years. The length of time to recoup capital costs, taking discounting into account, is relatively insensitive to the interest rate. Based on these assumptions, the base case is summarised in Table 9.16.

Table 9.16: Camel harvesting for pet meat – base case assumptions

	Rate		Total per year
Target Harvesting Area (HA)	This case study assumes that the team work two x 5000 km² over a 12-month period from two bases		10 000 km²
Income			
Camels present in target area (CN)	Camel density (CD): 0.8/km²		8000 head
Camels harvested	Harvest rate (HR): 25 %	8000×25% = 2000	2000 head
Camels harvested per day (ND)	10		
Harvesting days (HD)		2000/10 = 200	200 days
Camel meat harvested	Carcass weight (CW): 250 kg		500 000 kg
Price at pet food company (PG)	$0.75/kg		--
Total income			$375 000
Variable costs			
Distance travelled	200 km/day		--
Vehicle running cost (RC)	Including fuel, tyres, services, interest on loan, registration, insurance, and license $0.60/km	200×0.6×200 = 24 000	$24 000
Ammunition (AC)	$0.80 per camel	0.80×2000 = 1600	$1600
Chiller storage (SC)	$40 per head	40×2000 = 80 000	$80 000
Transport to pet food company (TC)	Transport distance (DI): 2000 km Cost per km: $3/km TC = 2000×3 =$ 6000 TC for per camel carcass (chiller holds 75 carcasses) $6000/75=$80 per carcass	80×2000=160 000	$160 000
Total variable costs (VC)			$265 600
Gross margin (before labour)			$109 400
Labour cost (LC)	$440/day	440×200=88 000	$88 000
Annual contribution to fixed costs (ACFC)			$21 400
Fixed costs (capital items)			
Vehicle	50 000		$6250
Lift (hydraulic hoist)	8000		$1000
Rifle	1500		$187.50
Knives	500		$62.50
Useful life of capital items	8 years		
Total fixed costs per year (FC)			$7500
Net annual profit (NP)			$13 900
Payback period (no discounting) PY = 8×FC/ACFC			3 years (2.8 years)

5.2 Sensitivity analyses

The sensitivity of the base case model was re-calculated by varying independently six of the key variables. The results of this analysis are presented below.

1) Camel population density

Because of the substantial capital investment required to establish a camel harvesting enterprise, the number of animals harvested in a year is a major determinant of its economic feasibility. The number of camels harvested in a year can be increased either by increasing the population density or by increasing the harvest rate.

Camel density on harvest sites largely depends on the selection of harvest sites in feral camel hot spots (regions), with some possible management interventions such as the introduction of attractant water sources at extra cost. However, it seems unlikely that landowners would be in favour of an increase in camel density (particularly using money to achieve it) as this would cause more damage to the landscape. Therefore camel density will not vary much in a selected site but will be affected by harvest site selection.

This model demonstrates that the density of camels (keeping all other variables at their base case level) is a key variable in determining the economic efficiency of harvesting (Table 9.17).

Table 9.17: The effect of camel density on ability to recoup fixed costs

Camel density (camel/km^2)	Contribution to fixed costs ($)	Payback period @ zero interest (Years)	Discounted payback period 5% (Years)
0.40	10 700	6 (5.61)	7 (6.74)
0.60	16 050	4 (3.74)	5 (4.24)
0.80 (Base case)	21 400	3 (2.80)	4 (3.10)
1.00	26 750	3 (2.24)	3 (2.44)
1.20	32 100	2 (1.87)	3 (2.01)

Compared to the base case with 0.8 camel/km^2, a harvest area with a lower density (e.g. 0.40 camel/km^2) would find that it could take a longer time (e.g. 7 years vs. 4 years) to recoup the capital costs, given that all other assumptions remain unchanged. On the other hand, a higher density (e.g. 1.20 camel/km^2) would result in a payback period of three years (just over two years). The break-even camel density for the operation to be able to pay off the fixed costs is 0.35 camels/km^2.

2*) Harvest rate*

The scenario in this case is to control and constructively reduce feral camels, so the harvest rate is assumed to be increased without the necessity of considering the long-term sustainability of the camel population from a biological perspective. Increasing the harvest rate significantly increases the annual contribution to fixed costs and reduces the payback period (Table 9.18). It should be noted that the analysis presented here assumes all other factors remain constant, but in reality there is likely to be higher marginal costs associated with increasing the percentage harvested. The break-even harvest rate for the operation to be able to pay off the fixed costs has been calculated as 11%.

Table 9.18: The effect of camel harvest rates on the ability to recoup fixed costs

percentage harvested p.a. (%)	Contribution to fixed costs ($)	Payback period @ zero interest (Years)	Discounted payback period @5% (Years)
15	12 840	5 (4.67)	6 (5.45)
20	17 120	4 (3.50)	4 (3.95)
25 (Base case)	21 400	3 (2.80)	4 (3.10)
30	25 680	3 (2.34)	3 (2.55)
35	29 960	2 (2.00)	3 (2.16)

3) Camels harvested per harvesting day

Table 9.19 shows that a variation in the number of camels taken per day has a significant impact on the economics of the operation. A reduction to eight camels per day reduces the contribution to fixed costs to a level that does not allow for replacement of capital equipment within the useful life of the assets. This analysis also shows the importance of harvester efficiency to the economics of the operation, in the sense that a 20% increase in the number of animals taken per day (from 10 to 12) doubles the contribution to fixed costs and halves the payback period. The break-even number of camels that must be harvested per day for the operation to be able to pay off the fixed costs is 9 animals.

Table 9.19: The effect of the number of camels harvested per harvesting day on ability to recoup fixed costs

Camels taken per day (No.)	Contribution to fixed costs ($)	Payback period @ zero interest (Years)	Discounted payback period 5% (Years)
6	-53 267	Not repaid	Not repaid
8	-6600	Not repaid	Not repaid
10 (Base case)	21 400	3 (2.80)	4 (3.10)
12	40 067	2 (1.50)	2 (1.60)
14	53 400	2 (1.12)	2 (1.19)

4) Average carcass weight

A variation in the average carcass weight (while keeping all other factors constant) makes a significant difference to the economic performance of this enterprise (see Table 9.20). For example, a 50 kg reduction in average carcass weight precludes the replacement of capital items over their useful life. This highlights the importance of a harvester being able to maximise the meat harvested from each animal in the field. It also emphasises the importance of building a model with a better capacity to take into account the sustainability of different harvesting regimes (harvest rate, age, and sex ratios). The break-even average weight of meat taken per animal – that is, the weight of meat at which the returns from the operation are able to pay off the fixed costs – is 242 kg.

Table 9.20: The effect of carcass weight on the ability to recoup fixed costs

Average carcass weight (kg)	Contribution to fixed costs ($)	Payback period @ zero interest (Years)	Discounted payback period @5% (Years)
150	-128 600	Not repaid	Not repaid
200	-53 600	Not repaid	Not repaid
250 (Base case)	21 400	3 (2.80)	4 (3.10)
300	96 400	1 (0.62)	1 (0.65)
350	171 400	1 (0.35)	1 (0.36)

5) Price per kg of camel meat

Table 9.21 shows that maximising the return per kilogram of meat harvested has a similar effect to increasing the meat harvested per animal. If the value of meat drops below $0.75 per kg (while keeping all other factors constant) then there are significant impacts on the viability of the enterprise. At meat prices greater than $0.90 per kg the repayment of fixed costs is dramatically shortened to less than one year. This highlights the importance of negotiating contracts with processors that include price premiums for characteristics that can be reasonably assured or managed over time. The break-even price received per kilogram – at which the returns from the operation are able to pay off the fixed costs – is $0.73 per kg.

Table 9.21: The effect of market value on the ability to recoup fixed costs

Price ($/kg)	Contribution to fixed costs ($)	Payback period @ zero interest (Years)	Discounted payback period 5% (Years)
0.45	-128 600	Not repaid	Not repaid
0.60	-53 600	Not repaid	Not repaid
0.75 (Base case)	21 400	3 (2.80)	4 (3.10)
0.90	96 400	1 (0.62)	1 (0.65)
1.05	171 400	1 (0.35)	1 (0.36)

6) Transport costs

Table 9.22 shows that transportation distance is critical to a viable pet meat operation. When the transportation distance increases to 2400 km, the expected returns do not allow for replacement of the capital equipment within the useful life of the assets. The break-even distance – at which the project returns would just be able to pay off the fixed costs – is 2151 km.

Table 9.22: The effect of transportation distance on the ability to recoup fixed costs

Distance to pet meat company (km)	Contribution to fixed costs ($)	Payback period @ zero interest (Years)	Discounted payback period @5% (Years)
1200	85 400	1 (0.70)	1 (0.73)
1600	53 400	2 (1.12)	2 (1.19)
2000 (Base case)	21 400	3 (2.80)	4 (3.10)
2400	-10 600	Not repaid	Not repaid
2800	-42 600	Not repaid	Not repaid

6. Discussion and conclusions

The third-party pet meat operation in Warakurna was generally successful economically, environmentally, and culturally. It created a new model for feral camel management – a small-scale, settlement-based pet meat operation. Such an operation could work very well with lower inputs to achieve a realistic, yet greater, output: continuously reducing camel numbers, making roads safer, protecting infrastructure and ephemeral waters, and consistently employing local young people. However, some issues need to be addressed so that future operations can be improved.

In this case the enterprise was extensively canvassed both at the local and regional level. It was supported by the Warakurna community and by a full council meeting of Ngaanyatjarra Council. This degree of support would not have been achieved without the preliminary consultations that took place in the preceding months. It is also very important to publicise clear and detailed information about sensitive issues, such as animal ethics, because this kind of settlement-based operation must be supported by the community.

An appropriate way to dispose of the unused parts of the slaughtered camels needs to be developed, rather than leaving them exposed in the bush. Burial is an option; however, there is a potential risk of serious environmental damage as a result of burial. For example, if weeds are spread into the country by disturbance of the ground, this could cause greater damage than that caused by the camels themselves. The increased costs arising from burying the remainders would probably make the operation unviable.

A standard for harvesting camels in the wild should be developed, including harvest quantities, timing, style, gender structure, and other relevant issues. The *Model Code of Practice for the Welfare of Animals – The Camel* (Agriculture and Resource Management Council of Australia of Australia and New Zealand 1997) should be applied in the standard. The existing standard operating procedure for ground shooting (HOR001), mustering (HOR003), and trapping (HOR004) of feral horses (Sharp and Saunders 2005a, 2005b, 2005c, 2005d) developed by New South Wales Department of Primary Industries (NSW DPI) might be adapted to guide the harvesting of feral camels.

The financial benefits accrued locally were relatively modest due to the minor amount of local participation, a minimal royalty rate paid to the community, and the free electricity and accommodation provided by the settlement. The latter was a necessary strategy to attract pioneer hunters to operate this program. However, this arrangement did hide the real cost of this operation and ultimately reduced the actual economic gains for the community from this operation further. It is critical that a more balanced partnership be set up in the long-term. The benefits should be shared by engaging all the stakeholders, including having local people actively involved in the operation. This would make this kind of enterprise sustainable.

This enterprise is not a social welfare project and so there is no budget, either financial or temporal, to cover the intensive training that would be required for the involvement of local Aboriginal community members. However, there is no doubt that the greatest environmental and social benefits would flow from a collaborative approach, with a program that is adequately funded to train local people to shoot, butcher, and prepare meat not only for the pet food industry, but also to game meat standards for human consumption.

Although this pet meat operation was effective, it only occurred at a small scale. It cannot simply be extended to other places at a bigger scale. The operators sold their products to pet food manufacturers, but it is unclear how big the market is for camel meat as pet food. The operators are exploring the possibility of exporting their camel meat directly to an international pet food market (Jim Craig 2008, pet meat operator, pers. comm.).

Small-scale pet meat operations are very economically sensitive to market price, camel weight, and transportation costs. Prospective pet meat operations must attend to the selection of their harvest area and the individual animals that will be harvested, and they must keep an eye on oscillation in the market price. A pre-harvesting arrangement with pet meat processors regarding carcass price and demand capacity is critical. Using mobile abattoirs to process the pet meat in the field is likely to be a more economically viable way of doing business, as the cost to transport the packed meat would be much cheaper than transportation of carcasses.

Chapter 10:
Economics of feral camel control in the central region of the Northern Territory (summary)

AG Drucker

Contributing author information

AG Drucker, School for Environmental Research, Charles Darwin University, Darwin, Northern Territory 0909, Australia

Contents

List of shortened forms

INRM	Integrated Natural Resources Management
NRM	Natural Resource Management

Acknowledgements

This report is Chapter 10 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of DKCRC or its participants.

Chapter 10: Economics of feral camel control in the central region of the Northern Territory (summary)

1. Summary

A cost-benefit analysis based on a bio-economic model was carried out to evaluate specific feral camel control strategies in the central region of the Northern Territory (NT). Based on expert opinion obtained through a series of workshops and meetings, and with a view to achieving the NT Integrated Natural Resources Management (INRM) Plan goal by 2020, specific control strategies for feral camels in the central region of the NT were identified (Drucker 2008).

Two different aerial control strategies were modelled. Strategy 1 involved annual removals, while strategy 2 involved periodic removals only when a specific feral camel density was reached. The direct economic benefits of feral camel control for the pastoral industry were also modelled in terms of reduced grazing competition together with reduced infrastructure damage. A single environmental service related to reduced methane emissions was further considered. Although cultural values and other environmental services are also likely to be important, their modelling was beyond the scope of this study. Consequently, the analysis carried out in this report does not account for these values.

The total present value of costs of the feral camel control strategies ranged from \$5.39 million (strategy 2) to \$6.00 million (strategy 1) over a 12-year time horizon (at a 5% discount rate), equivalent to an annualised present cost of \$608 000–\$676 000, respectively. Depending on how such a control program were implemented, these costs could be both public and private in their incidence (i.e. incurred by government and/or landholders).

Of the \$6.00 million strategy 1 costs, \$3.74 million (62.3% of total) would be spent in year 1; \$913,000 (15.2% of total) in year 2; and \$107 000–166 000 in each year thereafter. It is therefore apparent that the vast majority of the control costs are spent in the first two years of the control program, making the cost-effectiveness of a go-stop policy low (strategy 2).

Although control costs are large, they are far outweighed by the direct economic benefits to the livestock industry from reduced competition between livestock and feral camels (\$50.68 million under strategy 1 or 57.9% of total present benefits). The value of reduced methane emissions is also large (\$35.24 million or 40.3% of total present benefits), while reduced infrastructure damages make a relatively small contribution to total present benefits (\$1.62 million or 1.8%). Total present benefits under strategy 1 are thus \$87.54 million over 12 years or \$9.88 million per annum and were larger than those found under strategy 2 (\$83.98 million).

The difference between the economic benefits under the different strategies suggests that a control strategy based on annual removals is almost always likely to be preferred. We can therefore conclude that the magnitude of the benefits arising from a given control strategy should play a key role in control strategy choice. We also note that approximately 60% of the benefits (i.e. from reduced grazing competition and infrastructure damage) will accrue privately to pastoralists, while the remaining 40% (methane emissions avoided) will accrue publicly.

The net present value of control (i.e. total present benefits minus total present costs) is \$81.54 million under strategy 1. Delays in implementation of a control program could, however, reduce this value significantly. For example, a one-year delay could reduce this value by \$7.7m, largely because of benefits forgone during the delay.

Given the large positive net present value of control and the robustness of the overall findings, there would appear to be a very strong argument for considering the implementation of a full-scale, long-term feral camel control program in the near future.

1.1 Recommendations

- The difference between the present value of the economic benefits under the different strategies suggests that a control strategy based on annual removals should be preferred over a strategy of periodic removals.
- Given the large positive net present value of control and the robustness of the overall findings, there would appear to be a very strong argument for considering the immediate implementation of a full-scale long-term feral camel control program.

2. Reference

Drucker AG. 2008. *Economics of camel control in the central region of the Northern Territory*, DKCRC Research Report 52. Desert Knowledge CRC, Alice Springs.

Chapter 11:

A Multiple Criteria Decision Support Tool for feral camel management

WK Saalfeld

GP Edwards

B Zeng

D Lamb

Contributing author information

Keith Saalfeld: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia.

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

David Lamb: Institute of Advanced Studies, Charles Darwin University

Contents

Tables

Figures and graphs

List of shortened forms

APY	Anangu Pitjantjatjara Yankunytjatjara
MSA	Management Suitability Area
NRETAS	Natural Resources, Environment, The Arts and Sport (NT Government Department)
NRM	Natural Resource Management

Acknowledgements

This report is Chapter 11 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of DKCRC or its participants.

We thank Karen Nankeville and Theresa Nano for assistance in compiling the spatial data. We would like to thank Professor Murray McGregor for his contribution through the numerous discussions of what the Decision Support Tool could/should do/not do in terms of the management of feral camel impact, and just how far the data can be interpreted or extrapolated. Finally we would like to thank Professor Murray McGregor and Dr Christopher Auricht for their review of this work and their constructive criticisms which have improved it considerably.

Chapter 11: A Multiple Criteria Decision Support Tool for feral camel management

1. Summary

Managing the impact of feral camels requires that management decisions are based on a synthesis of the current best available information on camel distribution and density, actual impacts, and the logistical and stakeholder constraints on implementing management. This research has identified a need to develop a cross-jurisdictional strategic approach to feral camel management based on an analysis of the impacts of the animals across the full range of their distribution.

Scoping the problem identified a number of characteristics which suggest that a spatially based Multiple Criteria Decision Support Tool could help define strategic management plans. The key supporting factors (including feral camel distribution and density; impact data; logistical factors such as roads, bores, airstrips, etc; land manager attitudes to management options; locality of key infrastructure; and sites of significance) are spatial in nature and the management frame is characterised by the need to account for trade-offs between a range of required or desired outcomes.

The results produced by the Decision Support Tool are not intended to address fine or local-scale management but are applicable at a broadscale. The size of individual density cells (area cells to which a density value applies) used in the analysis was 0.5 degrees of latitude by 0.5 degrees of longitude. This is due to two major factors: the sheer scale of the feral camel distribution, which encompasses almost 50% of the total area of Australia; and the coarse minimum resolution from the spatial data used. However, with less grainy data the model can be easily adapted to support decision making at a more local level.

This research only considered six potential management methods for use in managing feral camel impact:

- aerial culling
- ground culling
- commercial extraction for live export
- commercial extraction for pet meat
- commercial extraction for human consumption
- fencing sensitive areas.

Each option was modelled, producing a suitability distribution for each management method within the Australian feral camel distribution (see Figures 11.1–11.7).

The management method suitability distribution maps were used to derive Management Zones for the application of one or more different management methods. Four broad management zones (see Figure 11.8) could be clearly derived from the suitability distribution maps, based on combinations of feral camel density and suitable management methods. The four management zones provide the basis of a framework for the cross-jurisdictional or national management of feral camel impacts as a consequence of the range of constraints, restrictions, or limitations associated with each management method.

The four zones were:

- Management Zone 1: This zone has the highest camel density and is approximately 116 000 km^2 in size, encompassing much of the Petermann Aboriginal Land Trust in the Northern Territory (NT), the Ngaanyatjarra Lands in Western Australia (WA) and the very northern part of the Aṉangu Pitjantjatjara Yankunytjatjara (APY) Lands in South Australia (SA). The area is suitable for all

of the available broadscale management methods, but aerial and ground culling options would be constrained by the views of Aboriginal landholders. These options would need to be negotiated with Aboriginal landholders before they could be adopted in this zone. Fencing could be used in Management Zone 1 to mitigate expected high levels of camel impact at important sites.

- Management Zone 2: This zone has high levels of camel impact and is appropriate for the immediate introduction of a broadscale aerial culling program. It encompasses an area of approximately 61 000 km^2 that covers much of the Simpson Desert. The area is suitable only for aerial culling and there should be few if any landholder constraints on undertaking aerial culling in this area. Fencing is considered only marginally suitable over most of Management Zone 2 but could be used to mitigate camel impact at important sites if warranted.
- Management Zone 3: This is a large area of approximately 785 000 km^2 and corresponds to about 23% of the total Australian camel distribution. It covers most of central Australia and encompasses the full suite of tenure classes addressed in the report: Aboriginal land, pastoral land, vacant Crown land, and conservation/other lands. Zone 3 supports lower densities of feral camels (ranging from 0.25 up to 1.0 animals/km^2 immediately surrounding Zone 1) than either of Management Zones 1 or 2. However, the minimum density of camels in the zone exceeds the recommended long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) required to mitigate broad-scale negative impacts (Edwards & Zeng et al. 2008), and there is a need for broadscale management across this zone. All of the management methods are either suitable or marginally suitable in this zone. There will be constraints on management methods due to landholder perceptions: non-commercial management methods are not acceptable across most Aboriginal land, and commercial management methods are less preferred on vacant Crown land and conservation/other lands. Fencing is considered only marginally suitable over most of Management Zone 3 but could be used to mitigate camel impact at important sites if warranted.
- Management Zone 4: This zone encompasses the remainder of the Australian camel distribution and covers 2.4 million km^2, slightly greater than 70% of the total distribution. The camel density across the zone was estimated to be relatively low in comparison to the other zones (fewer than 0.25 animals/km^2 over most of the zone but with a small area in north-west WA having a density slightly above 0.25 animals/km^2). However, there was a problem with the Krigging process used to estimate camel densities for this zone, particularly on the margins of the zone, and densities may be marginally higher than the estimates indicate. Despite this problem, camels are not considered to be causing serious broadscale damage to cultural and environmental values over most of the zone with the possible exception of the area in north-west WA having a density slightly above 0.25 animals/km^2. However, pastoral assets within this zone may need protection. Some cattle properties in the marginal region of the zone did report significant camel impacts during the survey of pastoral properties (Zeng & Edwards 2008a). This highlights the fact that there are camels on the margins of the distribution where Krigging indicated that there were none, and that localised densities may be high enough to be causing a level of impact that warrants management action. All of the broadscale management methods were deemed either marginally suitable or unsuitable for application over most of Zone 4. The exception to this is that small patches of Zone 4 in the east and west were identified as being suitable for both aerial culling and live export. Reported camel impacts on fringing pastoral properties may best be addressed through a coordinated program of ground shooting, providing that camels can be accessed by road. Fencing is considered unsuitable over most of Management Zone 4 but could be used to mitigate camel impact at important sites if warranted (e.g. individual waterholes or cultural sites).

1.1 Recommendations

- There should be an initial management focus on Management Zones 1, 2, and 3. Within these zones, the density of camels exceeds the recommended long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) required to mitigate broad-scale negative impacts (Edwards & Zeng et al. 2008).
- Subject to the constraints of Aboriginal landholders, Management Zone 1 is considered the most appropriate for any immediate introduction or expansion of commercial utilisation based management methods, that is, extraction for pet meat, human consumption, and live export.
- Management Zone 2 is considered the most appropriate area for the immediate introduction of any proposed broadscale aerial control operation. It is considered particularly suitable for conducting an index-manipulate-index type experiment to obtain accurate estimates of the biases associated with aerial survey of feral camel distribution and density.
- Management Zone 3 is considered the most appropriate zone for the introduction of integrated multiple management actions across multiple tenures. It is considered suitable for simultaneous application of commercial and non-commercial management approaches on the same or adjoining landholdings.
- In Management Zone 4, management should be applied locally in situations where camel impacts are considered unacceptably high. In general, the density of camels is too low throughout most of Zone 4 to warrant widespread application of broadscale management approaches.
- That the GIS based Multiple Criteria Decision Support Tool developed here be further enhanced and used for feral camel management planning at all scales from local through to national. The capacity of the model to function at a particular resolution is only limited by the resolution of the spatial data that it is based on.

2. Defining the problem

Australia's feral camel population has been permitted to grow relatively unchecked since establishment in the 1920s and 1930s (Saalfeld & Edwards 2008). A consequence of this unchecked growth has been an increase in the negative impacts of feral camels on production, natural resource and Aboriginal cultural values across the camel's range in Australia (Edwards & Zeng et al. 2008). The increasing impact of feral camels on these values, while recognised for some time, has only recently reached a level where broadscale management has been identified as an urgent necessity (Edwards & Zeng et al. 2008).

To date the management of feral camels has focused on three main strategies: culling, harvesting, and exclusion fencing (Norris & Low 2005, Saalfeld & Zeng 2008, Zeng & McGregor 2008), and has not generally been carried out in either a strategic or coordinated manner within or across jurisdictions (Edwards et al. 2004, Norris & Low 2005). Management has been directed at controlling or reducing camel numbers as a response to the perceived negative production, natural resource and Aboriginal cultural impacts of camels. However, prior to this study only limited quantitative assessment of the actual impact of feral camels had been undertaken (Dörges & Heucke 1995, 2003; Peeters et al. 2005; Norris & Low 2005). Consequently, management has failed to address actual impact in any meaningful way and there is little or no capacity to assess whether management is in fact addressing camel impacts rather than simply camel numbers.

Recognition that management needs to be focused on the impacts of feral camels rather than population numbers per se provides the underlying basis for the development of a strategic management program for feral camels across Australia. However, as there is a positive relationship between camel density and degree of damage, reducing camel density will often be fundamental to achieving damage mitigation (Edwards & Zeng et al. 2008).

A strategic management program for mitigating the negative impacts of feral camels requires:

- identification of the feral camel impact(s) to be managed at local, regional, State/Territory, and national scale (Edwards & Zeng et al. 2008)
- identification of the stakeholders affected by the impact(s) and of their perceptions, and identification of the parties responsible for the management of the impact(s) (Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a, 2008b; Carey et al. 2008)
- accurate estimation of the feral camel distribution and density generating the impact(s) and definition of the relationship between camel density, distribution, and impact (Saalfeld & Edwards 2008, Edwards & Zeng et al. 2008)
- determination of the desired change in feral camel impact to achieve an acceptable level of impact for the specific value(s) affected (Edwards & Zeng et al. 2008)
- assessment of the various management actions available to manage the impact(s) (Saalfeld & Zeng 2008, Zeng & McGregor 2008, Drucker 2008a, 2008b) and selection of the most appropriate management actions to achieve the desired outcomes agreed by all stakeholders and management authorities
- determination and implementation of a monitoring program sensitive to change in feral camel impact to determine whether management outcomes related to impact(s) are being achieved.

Additionally, a strategic management program should include both consultation and communication mechanisms to ensure that management objectives are set according to stakeholder requirements and expectations and to disseminate program results to stakeholders and management authorities.

As indicated, previous chapters of this report have addressed a number of the requirements outlined above for the strategic management of camel impacts. The remaining requirement related to monitoring is covered by recommendations in Edwards & McGregor et al. 2008. The major requirement the report has yet to address is the development of a tool which will help select the most appropriate management actions for particular situations to achieve the desired outcomes agreed by all stakeholders and management authorities. This is essential to the overall success of any strategic management program for the mitigation of feral camel impacts across the feral camel's distribution throughout Australia. The tool must provide the capacity for informed decisions to be made in relation to management methods, objectives, and outcomes based on the integration and synthesis of current data relating to all aspects of feral camel management. The most appropriate tool to achieve this integration is a Geographic Information System (GIS)–based spatial model that uses a range of spatial criteria relating to feral camels.

3. Multiple Criteria Decision Support Tool

Development of the GIS-based Multiple Criteria Decision Support Tool for feral camel management was undertaken by one of the authors (David Lamb) using a series of spatial data layers relevant to feral camel management. Details of the Decision Support Tool, including full model description, methodology, and outputs are given in Lamb and Saalfeld (2008).

3.1 Management Suitability Areas (MSAs)

For feral camels, broadscale management is defined as that which occurs at scales of greater than 10 000 km^2. Given the feral camel's considerable mobility and the large range occupied (Saalfeld & Edwards 2008), this is considered the minimum area over which management would need to occur to be effective in mitigating impacts on important values (Edwards & Zeng et al. 2008). The role of the Decision Support Tool was to identify areas within the camel's range where particular management methods, or combinations of management methods, can be applied to effect broadscale damage mitigation (i.e. broadscale management methods). These areas are termed Management Suitability Areas (MSAs).

The MSAs denote areas where specific management methods and associated actions may be logistically feasible subject to specific non-logistical constraints. Available broadscale management methods are economic exploitation for pet meat, human consumption, live export, and aerial and ground culling (Saalfeld & Zeng 2008, Zeng & McGregor 2008). Fencing is not considered to be a broadscale management tool (Saalfeld & McGregor 2008). We used the Decision Support Tool to attempt to identify the following potential MSAs, recognising that some key stakeholders were interested in the commercial use of feral camels and that some key stakeholders were opposed to the implementation of some of the available management options (e.g. shoot to waste) (Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a, 2008b):

MSA1: areas where all available management approaches can be implemented to effect broadscale damage mitigation (i.e. economic exploitation for pet meat, human consumption, live export, and aerial and ground culling).

MSA2: areas where economic exploitation for pet meat, human consumption, and live export are the only options; that is, aerial and ground culling is feasible but cannot be used due to stakeholder constraints.

MSA3a: areas where either aerial and/or ground culling is/are the only options and where landowners are comfortable with shoot to waste.

MSA3b: areas where aerial and/or ground culling is/are the only options and where landowners are not comfortable with shoot to waste.

MSA3c: areas where aerial and/or ground culling is/are the only options and where landowners will accept shoot to waste provided that it is done away from roads and communities.

MSA4: areas where management is not logistically feasible.

Each of the MSAs specified above is defined by the set of specific management actions/methods that can be undertaken within it. Each particular management method has a set of criteria that define whether or not it can be applied at a particular location. These criteria are a set of capacities defined by the logistical feasibility of the proposed management action(s) constrained by non-logistical socioeconomic factors. The main factors that determine the logistical feasibility of a control method include the quantity or level of impact of the resource proposed for management (i.e. the number or density of camels) and the ability to access the resource (i.e. the logistical capacity to access camels from the ground or air) (see Saalfeld & Zeng 2008, Zeng & McGregor 2008). Socioeconomic constraints include things such as whether a particular management method(s) is socially acceptable and cost/benefit considerations (see Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a, 2008b; Zeng & McGregor 2008; Drucker 2008a, 2008b). The parameters that determine these capacities for each management method are readily described in spatial terms and so are amenable to spatial modelling within a GIS. The GIS-based Decision Support Tool for feral camel management used a series of spatial data layers relevant to the management of feral camels that are discussed in detail below.

3.2 Input spatial data layers

The spatial data layers used in the development of the GIS-based Multiple Criteria Decision Support Tool for feral camel management were:

1. Camel density: spatial layer of camel density across the Australian camel distribution (Appendix 11.1). Density distribution was based on a Krigging interpolation of aerial survey density distribution data (see Saalfeld & Edwards 2008).
2. Land tenure: spatial layer of land tenure types across the Australian camel distribution (Appendix 11.2). The major tenure classifications used here and elsewhere in this report are Aboriginal lands (includes Aboriginal freehold and leasehold land, excludes Aboriginal pastoral

land), pastoral lands (includes private, Aboriginal, and government pastoral leasehold), vacant Crown land, and conservation/other land (includes all remaining lands). Within the Australian camel distribution the four most significant land tenures are Aboriginal land, Crown land, pastoral land, and Parks and Reserves. Other private and government-managed lands are relatively insignificant. Tenure data and cadastral boundaries used were the most recent available from each of the jurisdictions covered by the Australian camel distribution.

3. Roads: spatial layer of Australian road network derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium-scale vector representation of Australia topography – feature class 'roads' – polyline location of roads (Appendix 11.3). Road data outside of the Australian camel distribution reduced to show major roads only.
4. Bores: spatial layer of Australian bores derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium-scale vector representation of Australia topography – feature class 'bores' – point location of bores (Appendix 11.4). Additional NT bores data included were sourced from NT Department of Natural Resources, Environment, The Arts and Sport (NRETAS Maps: http://www.nt.gov.au/nreta/nretamaps/).
5. Yards: spatial layer of Australian yards derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – feature class 'yards' – point location of yards (Appendix 11.5).
6. Aircraft facilities: spatial layer of Australian airstrips derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – feature class 'AircraftFacilityPoints' – point location of aircraft facilities including airstrips (Appendix 11.6).
7. Ports: spatial layer of point locations of Australian ports able to handle live export of camels (Appendix 11.7).
8. Abattoirs: spatial layer of point locations of abattoirs in Australian able to process camels for human consumption (Appendix 11.8).
9. Aboriginal communities: spatial layer of point locations of Aboriginal communities in Australia other than major population centres (> 50% Aboriginal) derived from Community Housing and Infrastructure Needs Survey Data Dictionary, Australia, 2006 (Australian Bureau of Statistics and Geosciences Australia) and with additional locations of Aboriginal communities in the NT, derived from 2000 Place Names Register. Aboriginal communities are all places where 'Data_type' = 'Aboriginal Community' (Appendix 11.9).
10. Conservation significance: three separate spatial layers; one layer is Sites of Conservation Significance in the NT based on integration and synthesis of available NT conservation data to generate polygon layer of sites of conservation significance (only available for NT); one layer is point location of threatened species records from each jurisdiction; and third layer is a hydrography layer derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – hydrography features clipped by the Directory of Important Wetlands in Australia (Australian Nature Conservation Agency 1996) (Appendices 11.10, 11.11, & 11.12).

3.3 Defining the criteria and function of spatial data layers

The following descriptions of the functional use of the spatial data layers in the Decision Support Tool are derived from and encapsulated by the Expert Criteria Tables in Appendix D of Lamb and Saalfeld (2008).

Camel density distribution was taken as a direct correlate for feral camel impacts (see Edwards & Zeng et al. 2008 for justification). It is known that for the different management methods, cost increases with decreasing density and that there are density thresholds below which each method is not normally viable (Saalfeld & Zeng 2008, Zeng & McGregor 2008). Both the relationship between cost and density and the minimum density thresholds are poorly known or understood for any of the methods used to manage feral camels and their impacts (Saalfeld & Zeng 2008, Zeng & McGregor 2008). However, it was decided in the first instance that for the purposes of the analysis, a minimum density threshold of 0.25 camels/km^2 would be set and that locations with a density of less than 0.25 camels/km^2 would be classified as unsuitable for any of the management methods (Lamb & Saalfeld 2008). Higher densities were given a higher suitability score (Lamb & Saalfeld 2008).

The 0.25 animals/km^2 density threshold was selected on the premise that it is at or near this threshold that the costs of aerial control start to increase substantially (Saalfeld & Zeng 2008) and that it is the initial target threshold used in the cost/benefit modelling reported in Drucker (2008a, 2008b). This is generally in keeping with the recommendation made in Edwards et al. (2008a) that, on the basis of our current understanding of impacts, feral camels be managed to achieve a long-term target density of 0.1–0.2 camels/km^2 in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.

In considering the density distribution layer used for input into the Decision Support Tool, it was later recognised that, while this layer provides a broadscale density distribution across the range of the feral camel in Australia, it does not give local-scale density distributions. As a result, it does not have any capacity to identify areas of locally high density within a matrix of much lower broadscale density. In areas where the estimated broadscale density was less than 0.25 camels/km^2, it can reasonably be expected that there will be localised areas of much higher density, reflecting the non-uniform distribution of camels in the environment (Saalfeld & Edwards 2008). In order to address this, the Decision Support Tool was run without the 0.25 camels/km^2 density threshold for suitability. Density still influenced overall determination of the suitability of each management method, but areas with fewer than 0.25 camels/km^2 were no longer excluded from the model. This allowed for identification of areas potentially suitable for different management methods in the low density areas.

The roads, bores, yards, aircraft facilities, ports, and abattoirs layers functioned as access constraints to the resource for some management methods. The road network and type of road determines what areas can be reached on the ground and what areas are available for the positioning of required resources. The model assumed that the better the road quality (sealed versus unsealed and major road versus minor road versus track), the easier the access and hence the greater the suitability for management methods requiring ground access to the resource (see Lamb & Saalfeld 2008). Management methods requiring varying degrees of road access include ground culling, commercial exploitation for pet meat, human consumption, and live export. Of these methods, commercial exploitation for pet meat in its current form is the most restricted by road access, since field shooting of animals requires that they can be accessed by at least a four-wheel drive vehicle in the field (Zeng & McGregor 2008). Although commercial exploitation for human consumption and live export require road access for transport of live animals from either permanent or temporary yards, it was specified that mustering would be restricted to within 50 km of access roads.

Bores were considered an access constraint on commercial exploitation for pet meat, human consumption, and live export operations because water is needed:

- to process animals that have been field-slaughtered for pet meat
- as drinking water for animals mustered to yards so they can be transported to slaughter for human consumption or for live export.

Yards were flagged as a constraint on commercial exploitation for human consumption and live export because animals have to be mustered to yards before they can be transported to either abattoir or port. However, the capacity to build portable yards means that a lack of permanent yards does not restrict harvest. Rather, the presence of yards increases suitability for these methods. For both bores and yards, suitability was deemed to decrease with distance out to a maximum distance of 50 km, with areas beyond this being unsuitable.

As with yards, available aircraft facilities was presumed to increase suitability for aerial culling and operations involving mustering by allowing the use of spotter aircraft to support helicopter activities. For aircraft facilities, the maximum distance for suitability was set to 100 km.

For both ports and abattoirs it was presumed that proximity would increase suitability, with proximity to port increasing the suitability of an area for commercial exploitation for live export, and proximity to an abattoir increasing the suitability of an area for commercial exploitation for human consumption.

Aboriginal communities were considered an access constraint on commercial exploitation for pet meat, human consumption, and live export operations in that these communities provide a base with support infrastructure for these types of operations. Hence, presence of a community enhances the suitability of an area for these types of operations and this suitability decreases with distance from the community. A buffer of 50 km around each community was set as the maximum range for the positive influence of communities. In addition, Aboriginal communities (and land tenure) potentially functioned as a specific constraint on particular management methods based on stakeholder (community) perceptions and requirements with regards to management (see Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a, 2008b). In respect of the GIS analysis, it was decided not to impose this constraint on the Decision Support Tool. Rather, community perceptions were demarcated in the map outputs of the suitability analysis based on resource availability and logistical access constraints. This approach makes it possible to identify areas where it is logistically feasible to undertake a particular management method, but where action is constrained by stakeholder (community) perceptions and requirements (specifically MSAs 2, 3a, 3b, and 3c).

The final spatial data layers used in the Decision Support Tool were a number of layers providing spatial distribution data related to conservation values. It was expected that these layers would serve to identify areas that had a higher or greater need for camel impact management, increasing the suitability of the area relative to areas with lower conservation values. It was thought that this would be applicable to the range of management methods, but that it would most likely increase suitability for aerial culling to achieve either rapid or substantial impact reductions and, in the case of wetlands, increase the suitability for fencing as a management method. In the final form of the Decision Support Tool, only limited use was made of these layers on the basis of the rankings and comments in the Expert Criteria Tables used by Lamb and Saalfeld (2008). On this basis, the conservation values layers were only used in consideration of the special case of fencing as a localised management method (see below).

3.4 Decision Support Tool outputs

The Decision Support Tool was run separately for each of the broadscale management methods that have been identified as currently applicable for feral camel management in Australia (Saalfeld & Zeng 2008, Zeng & McGregor 2008). Broadscale methods considered in the tool were:

- aerial culling
- ground culling
- commercial extraction for pet meat
- commercial extraction for human consumption
- commercial extraction for live export.

We also ran the model with fencing, recognising that fencing is not a broadscale management tool. For all methods, the tool was run with the density distribution threshold set at zero animals/km^2.

Additionally, for commercial exploitation for human consumption, the tool was run with abattoir location influencing suitability and with it having no influence. This latter circumstance was considered to be a good approximation for commercial exploitation for human consumption using mobile abattoirs.

Output from the GIS-based Decision Support Tool consists of a series of maps, one to two for each of the management methods, showing areas of varying suitability for application of the particular management method. For most methods, the maps include demarcations indicating whether stakeholders find the method acceptable or not acceptable based on the perception surveys reported in Zeng & Edwards (2008a, 2008b); and in Vaarzon-Morel (2008a, 2008b). Also indicated is the 0.25 animals/km^2 density contour (see section 3.3) and any additional constraints that might impinge on use of the management methods.

The Decision Support Tool presents suitability on a seven-point scale ranging from no suitability to high suitability. In order to facilitate the interpretation of map outputs, the seven-point scale was converted to a four-point scale (Table 11.1). Output maps showing the spatial suitability for each method following the four-point scale are presented in Figures 11.1–11.7.

Table 11.1: Adjusted suitability scale and suitability interpretation from Decision Support Tool

Original suitability classification	Revised suitability classification	Revised suitability classification interpretation
No suitability and no to low suitability	Unsuitable	The management method should not be applied or used in the area for broadscale control, and if used is almost certain not to achieve management outcomes at that scale.
Low suitability and low to medium suitability	Marginally suitable	The management method could be applied or used in the area for broadscale control, but if used there is reasonable potential not to achieve management outcomes at that scale.
Medium suitability and medium to high suitability	Suitable	The management method is suitable for the area and would be expected to achieve management outcomes.
High suitability	Very suitable	The management method is very suitable for the area and would be expected to achieve management outcomes.

4. Interpretation

This section interprets each of the Decision Support Tool output maps (Figures 11.1–11.7) for each of the available management methods. The underlying basis of the interpretation is the MSAs in section 3.1 above.

4.1 Management methods

4.1.1 Aerial culling – helicopter shooting of feral camels to waste

Figure 11.1 identifies a number of distinct areas or regions where the estimated density of feral camels and the capacity to access animals would make it logistically feasible to use aerial culling to reduce feral camel population density and impacts.

The model identifies a ‘core’ area that has been classified as very suitable. This ‘core’ area is centred on the area of greatest feral camel density (Appendix 11.1), has good road access (Appendix 11.3), and a number of airstrips (Appendix 11.6), all of which contribute to the high degree of suitability. The area covers 55 000 km^2, slightly more than 1.5% of the total camel distribution in Australia, and takes in eastern parts of the Great Sandy Desert in the NT and WA (see Figure 7.7 in Edwards & Zeng et al. 2008 for place locations). It includes parts of the Petermann Aboriginal Land Trust in the NT, the Ngaanyatjarra Lands in WA and the top portion of the Anangu Pitjantjatjara Yankunytjatjara (APY) Lands in SA (see Figure 7.4 in Edwards & Zeng et al. 2008 for place locations). This area is very suited to aerial culling operations in terms of both feral camel density and the logistical capacity to undertake these operations. Overall there would be a very high expectation of a successful management outcome for an appropriately designed and implemented program.

The second area to note in Figure 11.1 is a large expanse of land classified as suitable for aerial culling. This large area encompasses 760 000 km^2, or 23% of the Australian feral camel distribution, and covers most of central Australia with a small outlier area (54 000 km^2) in Western Australia. This area falls almost completely within the 0.25 amimals/km^2 density contour, almost certainly reflecting the influence of density on the determination of suitability. Those areas within the 0.25 amimals/km^2 density contour that were not classified as suitable almost certainly lack the resources to support aerial culling (e.g. roads, airstrips), while the suitable areas lying outside the 0.25 amimals/km^2 density contour probably have these resources in areas where densities are only marginally below 0.25 amimals/km^2. Overall, the area deemed suitable for aerial culling covers extensive parts of the Great Sandy Desert in both the NT and WA, the Tanami Desert, the Gibson Desert, the Great Victoria Desert, and the Simpson Desert and takes in extensive areas of the southern NT, northern SA, and central-east WA. The area is suited to aerial culling operations in terms of both feral camel density and the logistical capacity to undertake these operations, and there would be an expectation of a successful management outcome for an appropriately designed and implemented program.

The final areas identified in Figure 11.1 constitute the remainder of the Australian feral camel distribution, classified mainly as marginally suitable for aerial culling but with the fringes classified as unsuitable. The unsuitable classification is in part a consequence of the interpolated density distribution used in the Decision Support Tool which gives zero density estimation at the extremities of the distribution (see Saalfeld & Edwards 2008). Camels are known to occur in these areas but at low density (Saalfeld & Edwards 2008). Given that most of the areas of unsuitable classification represent pastoral lands, it is expected that these areas would in fact be logistically capable of supporting aerial operations and should probably be considered as being marginally suitable. The total area of unsuitable/marginally suitable classification is 2 530 000 km^2 and represents slightly greater than 75% of the total camel distribution. The marginal suitability classification for most of this area is interpreted as indicating that for most of it, while it might be logistically feasible to undertake aerial culling operations, the broadscale density of feral camels is below the threshold that would support aerial culling as an optimal management method. Estimated density is below 0.25 animals/km2, which would put costs per head for control in the range of \$60–\$100 (Saalfeld & Zeng 2008, Figure 8.3). While this cost range has been acceptable for previous smaller-scale control operations (Saalfeld & Zeng 2008, Table 8.2) which have removed fewer than 5000 animals, it is unlikely to be considered viable for operations requiring the removal of more than 10 000 animals (equates to \$600 000–\$1 000 000).

The final information that can be interpreted from Figure 11.1 is that almost 34% of the area classified as either suitable or very suitable (100% of the very suitable) is Aboriginal land. On the basis of the perceptions reported in Vaarzon-Morel (2008a, 2008b), it is likely that aerial culling would not be acceptable on many of these lands, at least not without considerable consultation. Only two Aboriginal communities out of the 27 communities surveyed (Vaarzon-Morel 2008a, Figure 5.2) indicated that aerial culling was acceptable, and it has to be noted that one of these communities is associated with pastoral land on which regular aerial culling is undertaken. The remaining 66% of the area classified as suitable or very suitable is either pastoral land, vacant Crown land, or primarily conservation lands. It is expected that aerial culling would be acceptable to the managers of these land tenures (Zeng & Edwards 2008a, 2008b).

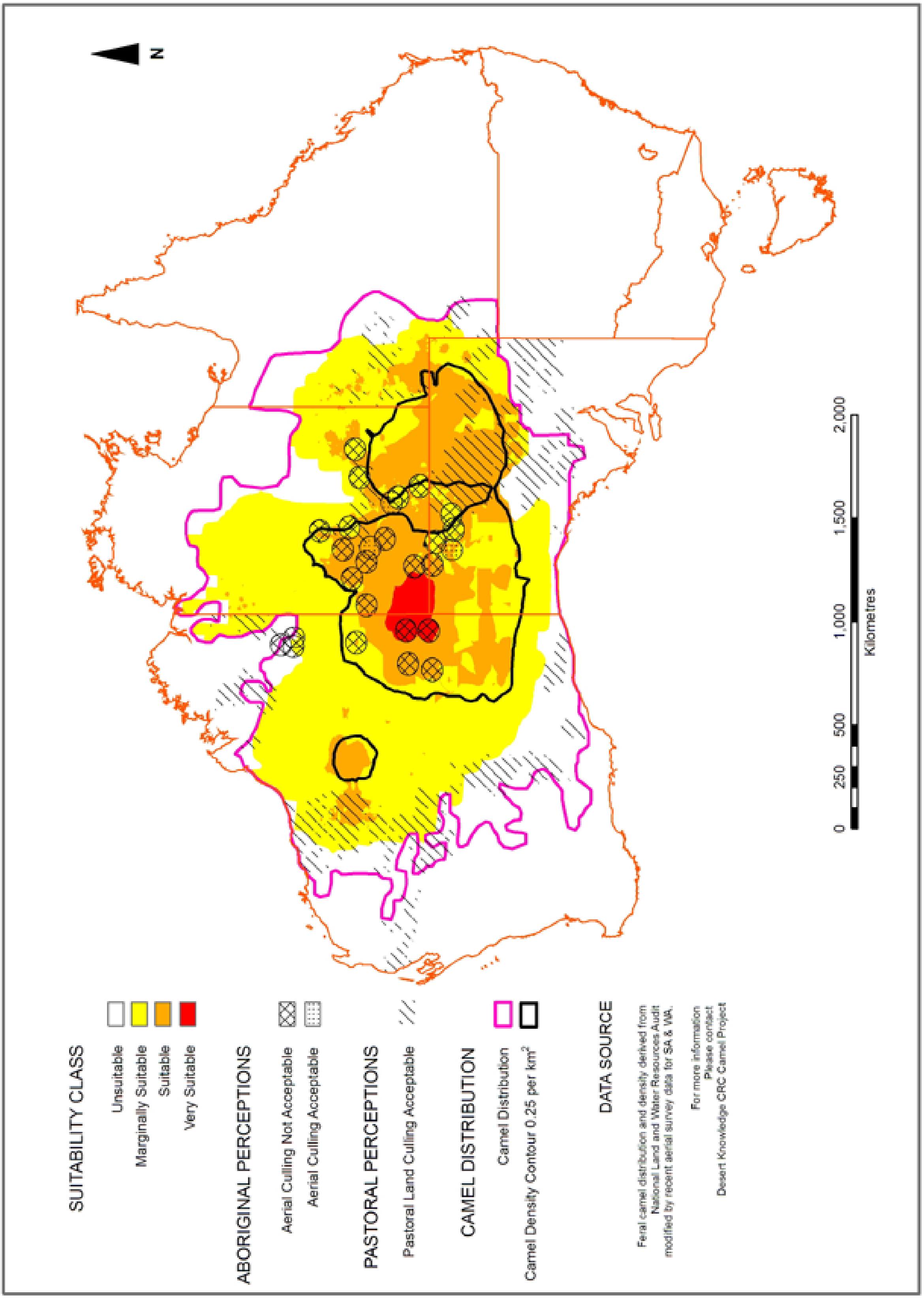


Figure 11.1: Feral camel management method suitability map – aerial culling

Note: With zero animal/km^2 density threshold applied and 0.25 animal/km^2 density contour indicated.

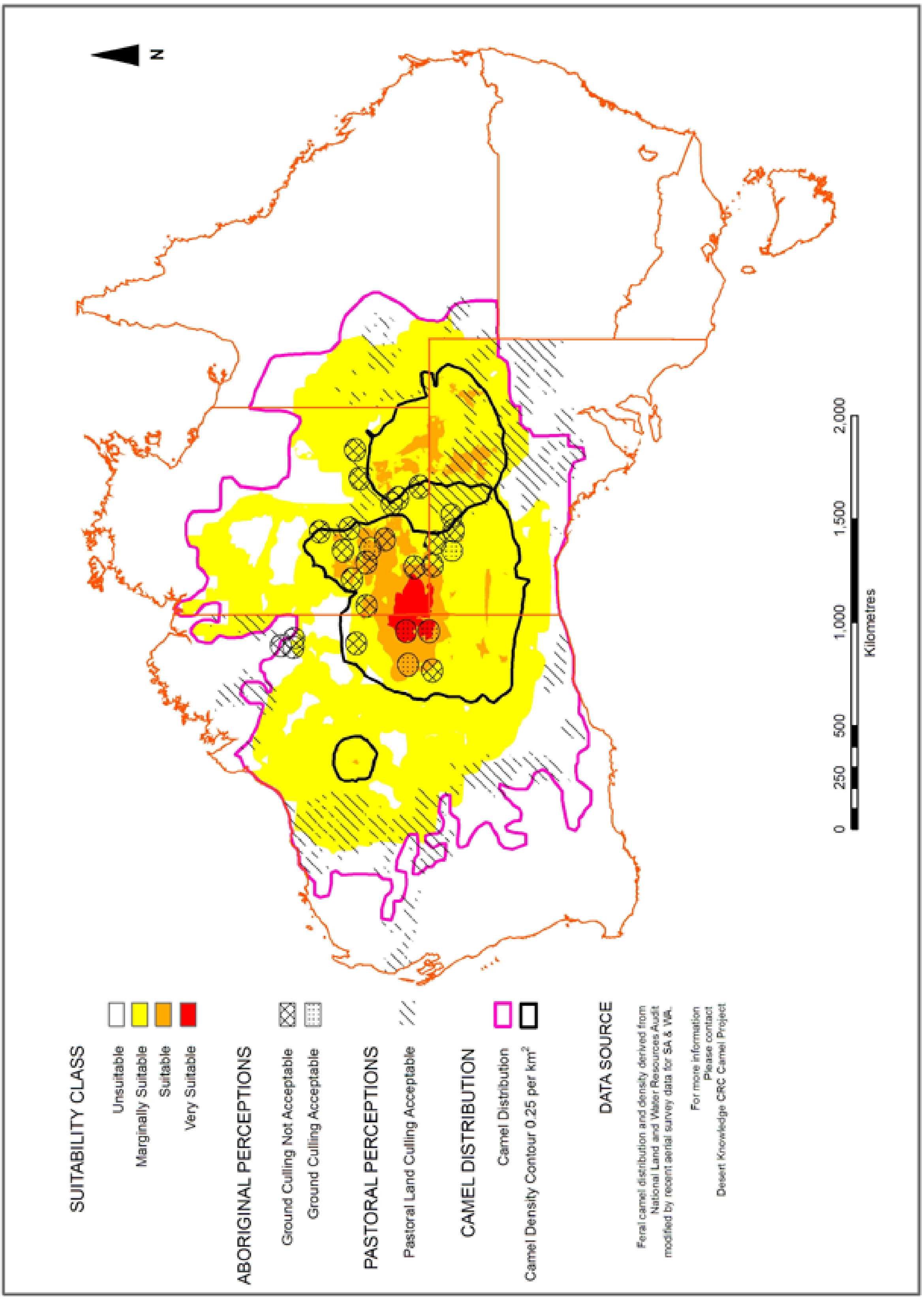


Figure 11.2: Feral camel management method suitability map – ground culling

Note: With zero animal/km^2 density threshold applied and 0.25 animal/km^2 density contour indicated.

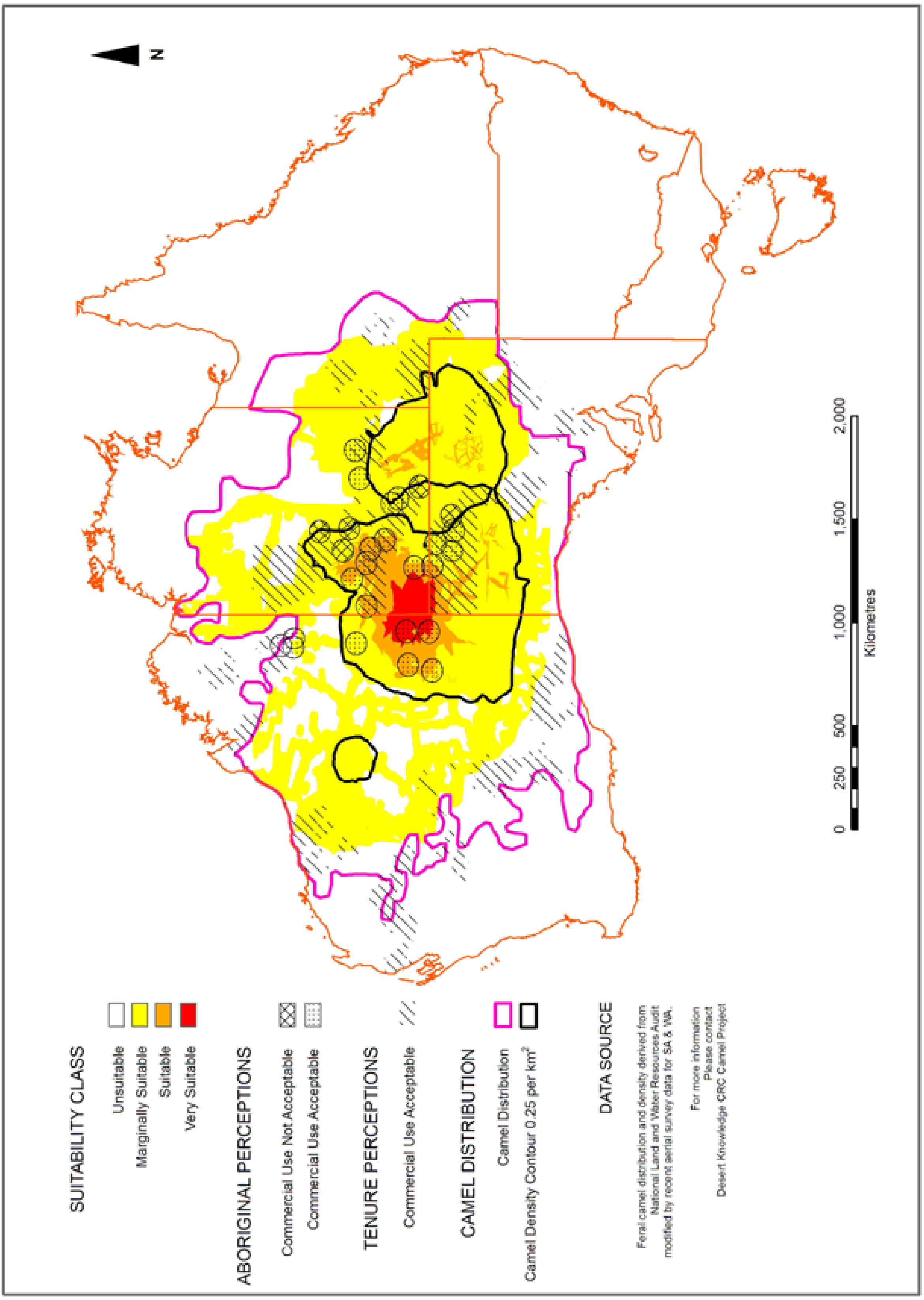


Figure 11.3: Feral camel management method suitability map – commercial extraction for pet meat

Note: With zero animal/km² density threshold applied and 0.25 animal/km² density contour indicated.

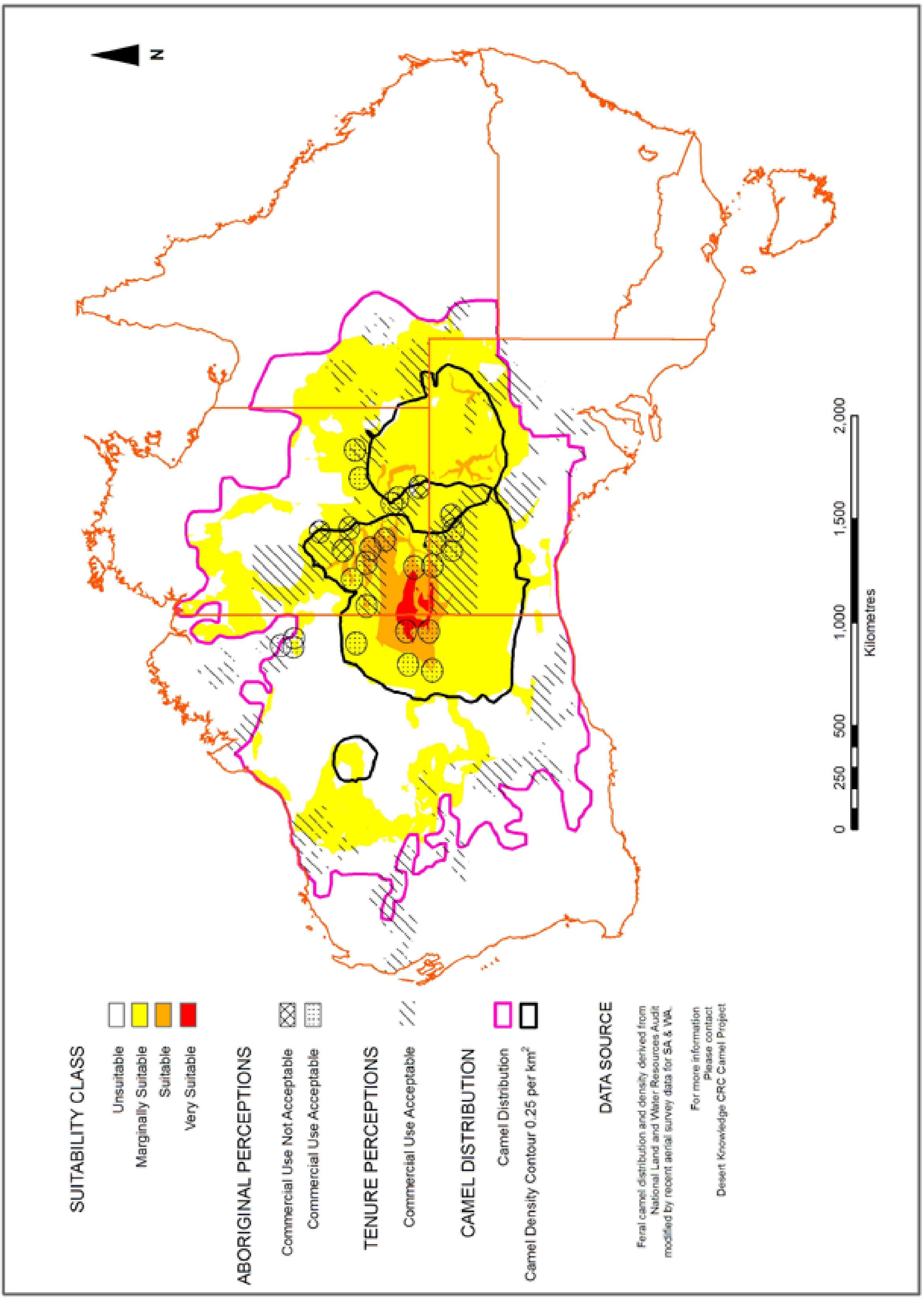


Figure 11.4: Feral camel management method suitability map – commercial extraction for human consumption

Note: With zero animal/km^2 density threshold applied and 0.25 animal/km^2 density contour indicated.

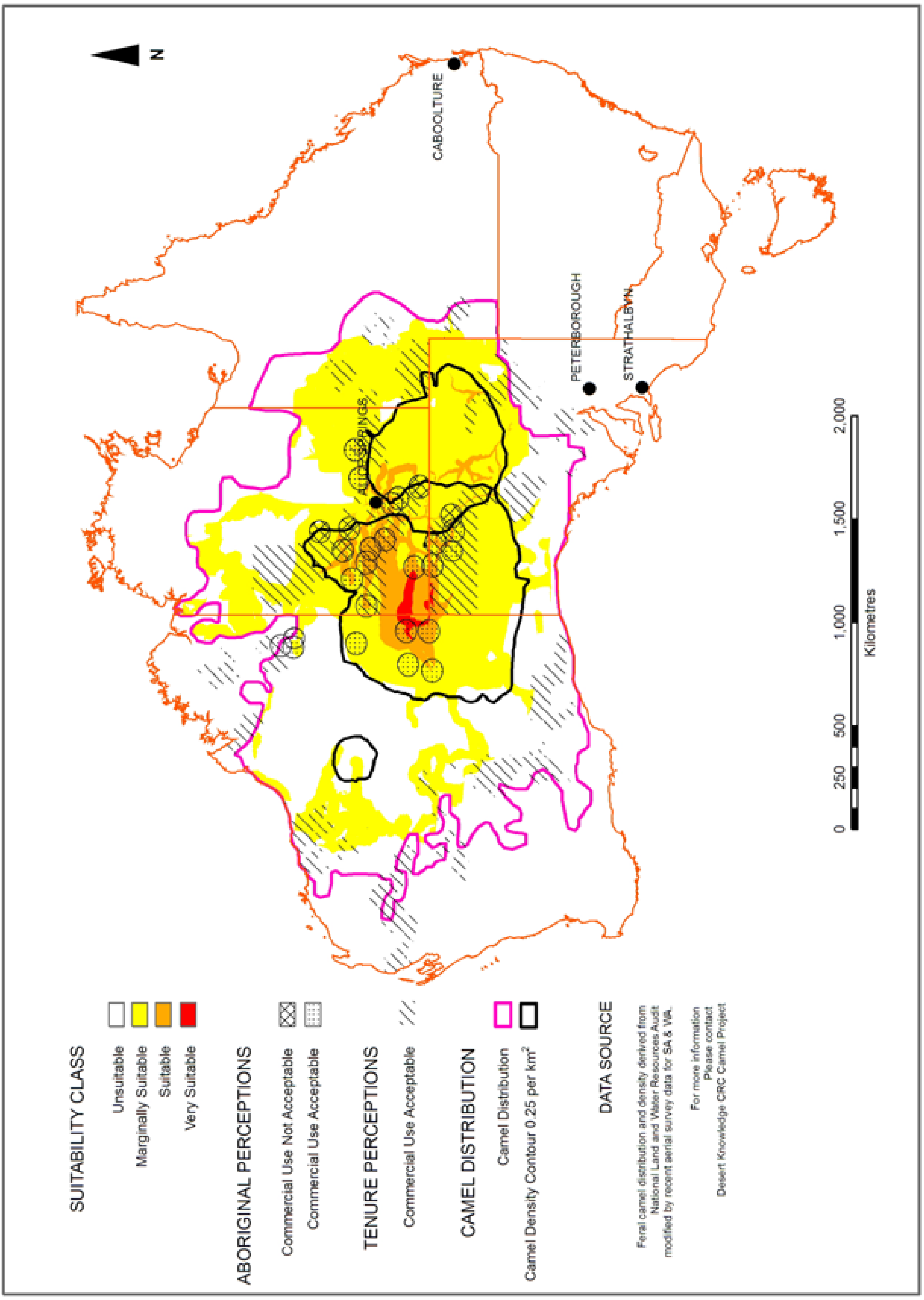


Figure 11.5: Feral camel management method suitability map – commercial extraction for human consumption

Note: With zero animal/km^2 density threshold applied and 0.25 animal/km^2 density contour indicated and location of abattoir applied.

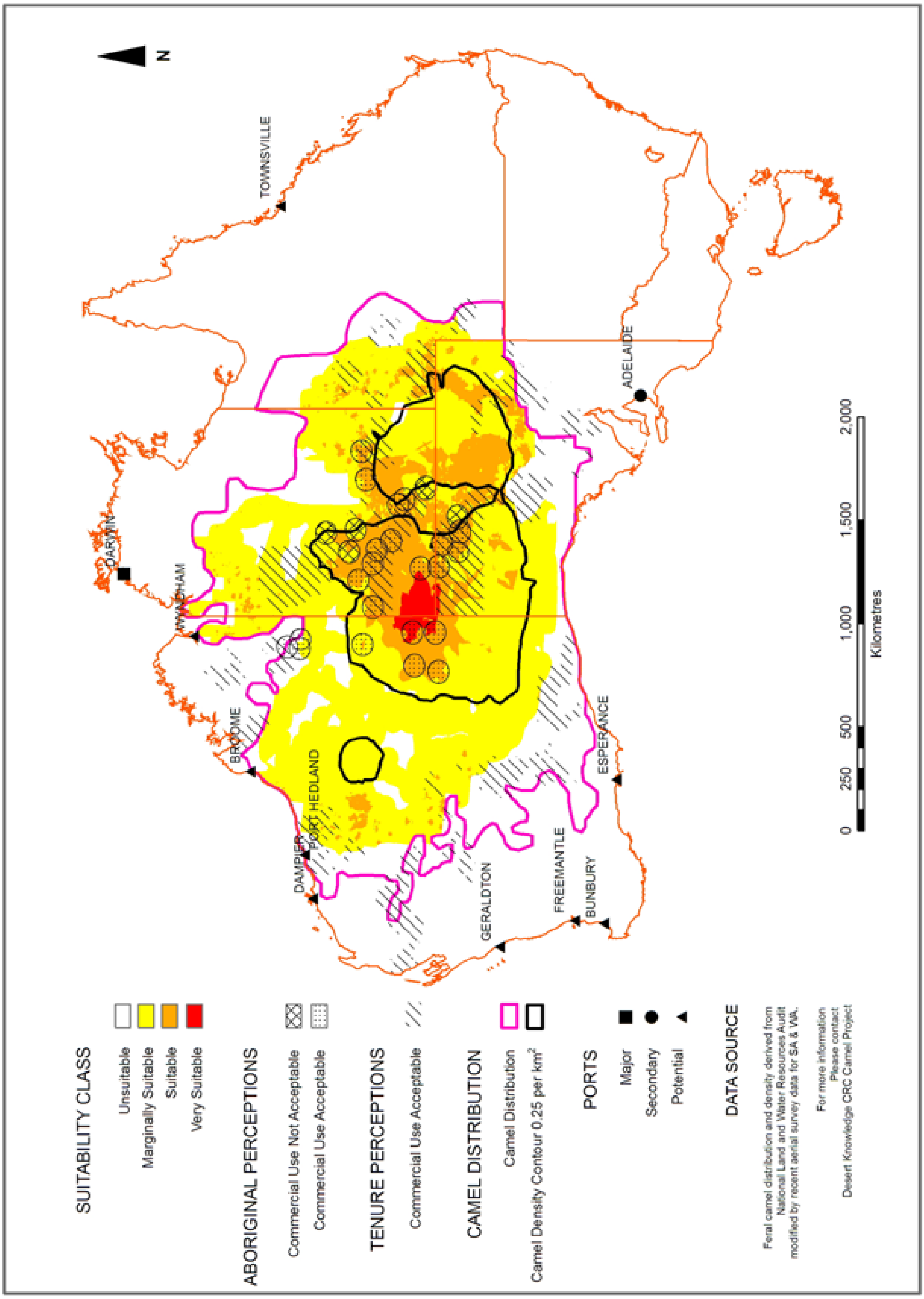


Figure 11.6: Feral camel management method suitability map – commercial extraction for live export

Note: With zero animal/km² density threshold applied and 0.25 animal/km² density contour indicated and location of ports applied.

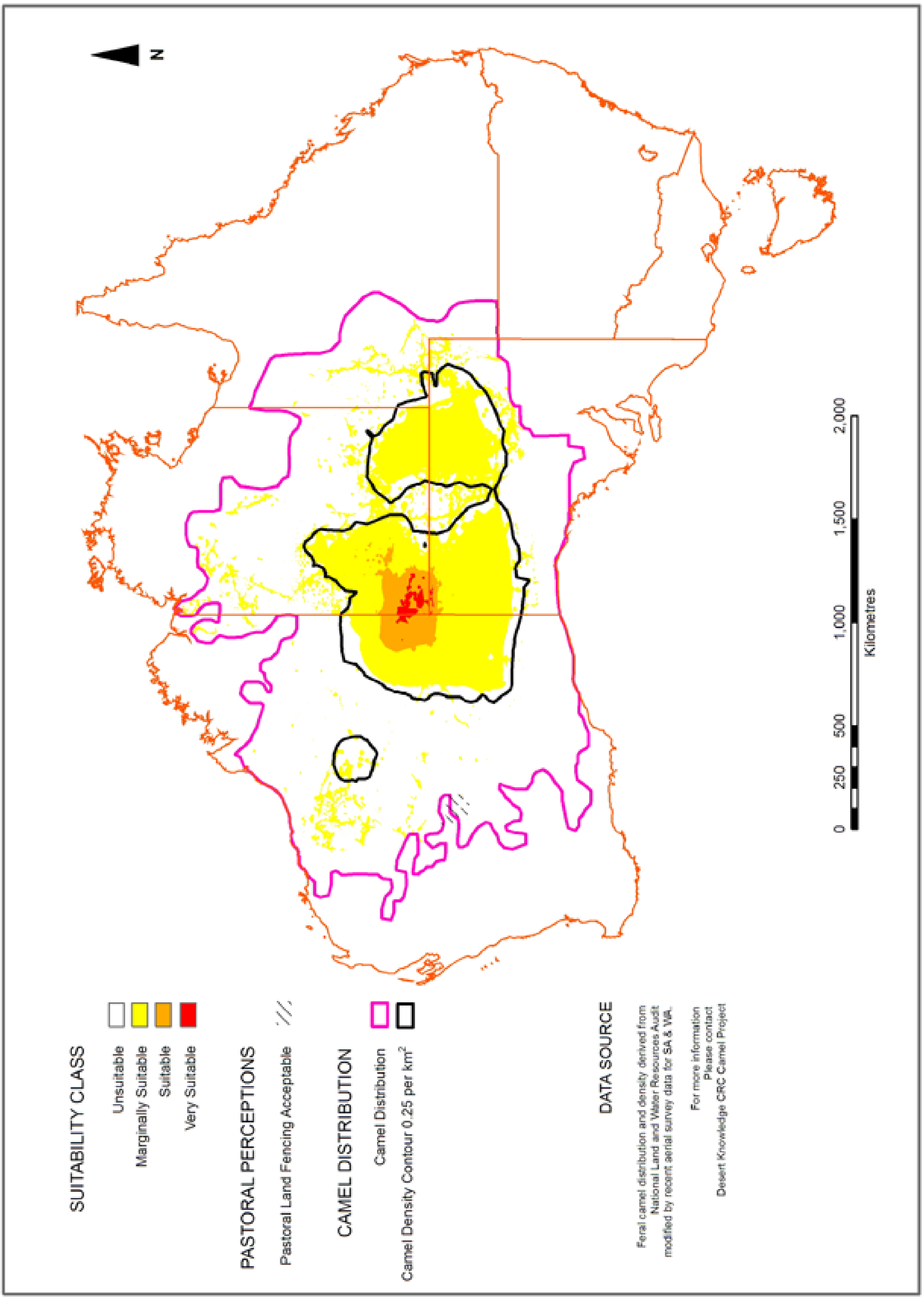


Figure 11.7: Feral camel management method suitability map – fencing

Note: With zero animal/km² density threshold applied and 0.25 animal/km² density contour indicated.

4.1.2 Ground culling – vehicle-based shooting of feral camels to waste

The Decision Support Tool indicated that the use of vehicle-based ground culling of feral camels would be classified as either a suitable or very suitable management method for less than 8% of the total camel distribution (Figure 11.2). As with aerial culling, there is a 'core' area identified as very suitable for ground culling and the actual extent of the 'core' area for ground culling is very similar to that for aerial culling, almost certainly a reflection of the influence of the high camel density (Appendix 11.1). The 'core' area takes in the eastern parts of the Great Sandy Desert in the NT and WA. It includes parts of the Petermann Aboriginal Land Trust in the NT, the Ngaanyatjarra Lands in WA, and the top portion of the APY Lands in SA. The area classified as suitable for ground culling is substantially less than that for aerial culling (6.5% verses 23% of the total camel distribution). The area suitable for ground culling is restricted primarily to the eastern parts of the Great Sandy Desert in the NT and WA, the southern Tanami Desert, and the Gibson Desert, taking in the Petermann and Haasts Bluff Aboriginal Land Trusts in the NT, the Ngaanyatjarra Lands in WA, and the top portion of the APY Lands in SA.

In all, over 90% of the Australian camel distribution has been classified as marginal or unsuitable for ground culling. The marginal suitability classification is likely due to logistical constraints on any structured ground culling operation at low density and where access to the resource is lacking. The exception to this would be fringing pastoral land, classified as marginal or unsuitable on the basis of very low or zero broadscale camel density, where opportunistic ground-based culling would be expected to play a role in long-term management of feral camel impacts (Saalfeld & Zeng 2008).

Given that almost 60% of the area classified as suitable or very suitable for ground culling is Aboriginal land, Aboriginal perceptions on the role of ground culling need to be taken into consideration in implementing this management method. Vaarzon-Morel (2008a) and Figure 11.2 indicate that there is some divergence in Aboriginal perceptions on the role of ground culling of camels. Four out of the 11 communities surveyed within the area classified as very/suitable for ground culling indicated that ground culling to waste would be acceptable if carried out away from the community or roads (Vaarzon-Morel 2008a, 2008b). The remainder indicated that ground culling to waste was not acceptable. Of the four communities that indicated that ground culling to waste would be acceptable if carried out away from the community, two were located within the 'core' area and all of the communities that indicated that ground culling to waste was not acceptable were located outside of the 'core' area.

4.1.3 Commercial extraction for pet meat

The Decision Support Tool identified a 'core' area classified as very suitable for commercial exploitation for pet meat covering an almost identical extent as the 'core' area for both aerial and ground culling operations (Figure 11.3). The 'core' is 54 000 km^2 in area and takes in eastern parts of the Great Sandy Desert in the NT and WA. It includes parts of the Petermann Aboriginal Land Trust in the NT, the Ngaanyatjarra Lands in WA, and the top portion of the APY Lands in SA. As with the non-commercial culling activities, this is less than 1.5% of the total Australian feral camel distribution. Here, the combination of high camel density, road access, and supporting infrastructure have been identified as providing the maximum capacity for commercial exploitation for pet meat.

The 'core' area is surrounded by an area assessed as suitable for pet meat activities. This area of 191 000 km^2 primarily surrounds the 'core' area but also includes a small area in the Simpson Desert region (<23 000 km^2). It falls well within the 0.25 animals/km^2 density contour and is almost completely within the 0.5 animals/km^2 density contour (Appendix 11.1), and is additionally limited by the availability of road access (Appendix 11.3), particularly in the Simpson Desert region and southern APY Lands. This area represents less than 6% of the total camel distribution and, when coupled with the 'core' area, gives a combined area of less than 8% of the total distribution. The suitable area covers extensive parts of the eastern Great Sandy Desert in both the NT and WA, the southern Tanami Desert, the Gibson Desert, and a very small part of the Simpson Desert. Almost all of the area is Aboriginal land and it takes in the Petermann and Haasts Bluff Aboriginal Land Trusts in the NT, the Ngannyatjarra Lands in WA, and much of the APY Lands in SA.

The remainder of the feral camel distribution was classified as either marginally suitable (approximately 1.99 million km^2 and 60% of the total Australain camel distribution) or unsuitable (approximately 1.1 million km^2 and 32% of the total Australain camel distribution) for pet meating operations. This is due to low camel density, a lack of road infrastructure (which limits access), and a lack of other critical infractructure including water points and yards. Under these circumstances, commercial exploitation for pet meat is probably not viable at the large scale or in the long-term (Zeng & McGregor 2008). This assessment does not preclude the possibility of local-scale areas within these classifications that would support commercial exploitation for pet meat on the basis of local high density aggregations of camels within areas that have low broadscale density estimates as used in the Decision Support Tool (discussed in section 3.3).

The survey of Aboriginal perceptions (Vaarzon-Morel 2008a, 2008b) indicated that the majority of communities supported the commercial utilisation of feral camels, and all of the surveyed communities within the areas classified as very suitable and suitable for commercial exploitation for pet meat indicated that commercial utilisation was acceptable (Figure 11.3). Commercial use is supported on most pastoral land (Zeng & Edwards 2008a), but there is limited support for commercial utilisation on conservation land and vacant Crown land (Zeng & Edwards 2008b, Lamb & Saalfeld 2008) due to the perception that commercial utilisation does not have the capacity to bring about rapid, large-scale reduction in impact.

4.1.4 Commercial extraction for human consumption

Figures 11.4 and 11.5 depict the suitability of areas within the Australian feral camel distribution where commercial exploitation for human consumption is suitable as determined by the GIS Decision Support Tool. The two figures are based on the same input data except that the location of abattoirs capable of processing camels for human consumption was included in the Decision Support Tool for Figure 11.5 but not for Figure 11.4. Differences between the two outputs are minor, indicating that the location of abattoirs had little or no impact on the determination of suitability as compared with the effects of density, road access, and other infrastructure support, and so the two outputs will be considered as one.

Density is the obvious major factor influencing the determination of the area suitable for commercial exploitation for human consumption and has produced an area of suitability (Figures 11.4 & 11.5) that corresponds substantially to the most suitable area for the previous methods (above). Total area classified as either very suitable or suitable covered 221 000 km^2 and fell completely within the 0.25 animals/km^2 density contour and almost completely within the 0.5 animals/km^2 density contour. It represents approximately 7% of the total camel distribution. Main areas included are the eastern Great Sandy Desert in both the NT and WA, the southern Tanami Desert, the Gibson Desert, and western fringes of the Simpson Desert. Almost all of the land covered by the area is Aboriginal land and it takes in the Petermann and Haasts Bluff Aboriginal Land Trusts in the NT, the Ngaanyatjarra Lands in WA, and the northern part of the APY Lands in SA.

The remainder of the feral camel distribution is classified as either marginally suitable or unsuitable for commercial exploitation for human consumption and, as for commercial exploitation for pet meat, this classification is determined mainly by camel density and road access. Areas with either higher camel density (greater than 0.25 animals/km^2) with restricted road access, or low camel density but with road access were classified as marginally suitable. Areas with low density and restricted access were classified as unsuitable. As already discussed for commercial exploitation for pet meat, this assessment does not preclude the possibility that local-scale, high density areas within these classifications would support commercial exploitation for human consumption (discussed in section 3.3).

Commercial use constraints from Aboriginal communities and other landholders will be, as previously, considered for commercial exploitation for pet meat, and the potential high return from commercial exploitation for human consumption (Zeng & McGregor 2008) could contribute to landholders preferring this form of commercial use over pet meat.

4.1.5 Commercial extraction for live export

Suitability distribution for commercial exploitation for live export (Figure 11.6) shows a similar, if slightly greater, distribution of area as both commercial exploitation for pet meat and commercial exploitation for human consumption.

As with both the previous methods, there is a 'core' area of about 41 000 km^2 centred on Petermann Aboriginal Land Trust in the NT, the Ngaanyatjarra Lands in WA, and the northern part of the APY Lands in SA which is classed as very suitable. A larger area (521 000 km^2) classified as suitable for commercial exploitation for live export surrounds this 'core', covering primarily Aboriginal and pastoral land through central Australia. The classification of 'suitable' is governed by density greater than 0.25 animals/km^2 and road access.

Commercial use constraints from Aboriginal communities and other landholders will be similar to those already identified for commercial exploitation for pet meat and human consumption. The very high return from commercial exploitation for live export (Zeng & McGregor 2008) could contribute to landholders preferring this form of commercial use over others; however, there are substantial constraints on live export (Zeng & McGregor 2008).

4.1.6 Fencing

Figure 11.7 identifies those areas that the Decision Support Tool classified as very suitable or suitable for fencing to be used for localised management. The area classified as suitable is almost completely restricted to the area where density is greater than 1.0 animals/km^2 (Appendix 11.1) and the area classed as very suitable to those areas within this range where wetlands occur. These classifications represent less than 3% of the total feral camel distribution in Australia, and correspond substantially to the 'core' area for both aerial and ground culling above.

The rest of the camel distribution is classified as marginally suitable for fencing where the density is greater than 0.25 animals/km^2 or where the density is less than 0.25 animals/km^2 and there are wetlands (25% of the distribution), or unsuitable for fencing to be considered a management option (the remaining 72% of the distribution).

Given that the use of fencing will almost certainly be restricted to localised applications (primarily 10s to 100s of hectares, see Saalfeld & Zeng 2008) and the relatively coarse resolution of the raster layers used in the Decision Support Tool (approximately 2800 km^2), the role of the model in respect of fencing has been restricted to identifying general areas where fencing has the potential to efficaciously mitigate expected high levels of camel impact at important sites (e.g. individual waterholes or cultural sites) by fencing them off.

4.2 Management zones based on Decision Support Tool outputs

Consideration of Figures 11.1–11.7 leads us to specify four broad management zones for feral camels in Australia. These are shown in Figure 11.8 and described as follows:

- Management Zone 1: covers the area of highest camel density. Total area covered is approximately 116 000 km^2 and takes in the eastern portion of the Great Sandy Desert across the NT–WA border. The area covers much of the Petermann Aboriginal Land Trust in the NT, the Ngaanyatjarra Lands in WA, and the very northern part of the APY Lands in SA. The Decision Support Tool identified the area as suitable for all of the available broadscale management methods based on feral camel density and access to the resource (proximity of roads, yards, bores, etc), but also identified that use of two of the non-commercial management methods – aerial and ground culling – would be constrained by the Aboriginal landholders. This area corresponds to an amalgam of MSAs 1 and 2 as described in section 3.1.

- Management Zone 2: this is an area of approximately 61 000 km^2 that covers much of the Simpson Desert. The area is primarily vacant Crown land in the NT and conservation land in SA. The Decision Support Tool identified the area as suitable only for aerial culling, and it is postulated that this is due to the high density of camels coupled with the complete lack of access for any of the other management methods, all of which require ground access to the resource. There should not be any landholder constraints on undertaking aerial culling in this area and it corresponds to MSA3a as described in section 3.1.
- Management Zone 3: this is a large area of approximately 785 000 km^2 and corresponds roughly to the 0.25 animals/km^2 density contour. The area covers most of central Australia and takes in the eastern Great Sandy Desert, the Gibson Desert, the northern half of the Victoria Desert, the southern half of the Tanami Desert, and the surrounds of the Simpson Desert. It also includes the southern half of the central pastoral belt from the NT extending into SA to south of Lake Eyre (Figure 11.8 and Appendix 11.2). This management zone covers the full suite of tenure classes addressed in the report: Aboriginal land, pastoral land, vacant Crown land, and conservation/other lands (Appendix 11.2). The Decision Support Tool indicated that all of the broadscale management methods are either suitable or marginally suitable for the management of feral camel impacts over almost the entire zone. There will be constraints on management methods due to landholder perceptions; non-commercial management methods are not acceptable across most Aboriginal land and commercial management methods are less preferred on vacant Crown land and conservation/other lands. This zone is an amalgam of MSAs 1, 2, 3a, 3b, and 3c as described in section 3.1, depending on land tenure and the specific level of suitability of the management method.
- Management Zone 4: this is the remainder of the Australian camel distribution and covers some 2.4 million km^2, slightly greater than 70% of the total distribution. Broadscale camel density throughout this area is estimated at less than 0.25 animals/km^2, excepting for a small area in north-west WA (Appendix 11.1). The Decision Support Tool indicated that all broadscale management methods were either marginally suitable or unsuitable for application over most of the Zone. The exception to this is that small patches of Zone 4 in the east and west were identified as being suitable for both aerial culling and live export. It should be pointed out that although the density of feral camels across Zone 4 was estimated as being generally low, there will be localised patches where camels occur at higher density than the average for the zone. These localised areas with higher density could further support limited application of the broadscale management methods (discussed in section 3.3 above). This zone largely corresponds to MSA4 as described in section 3.1.

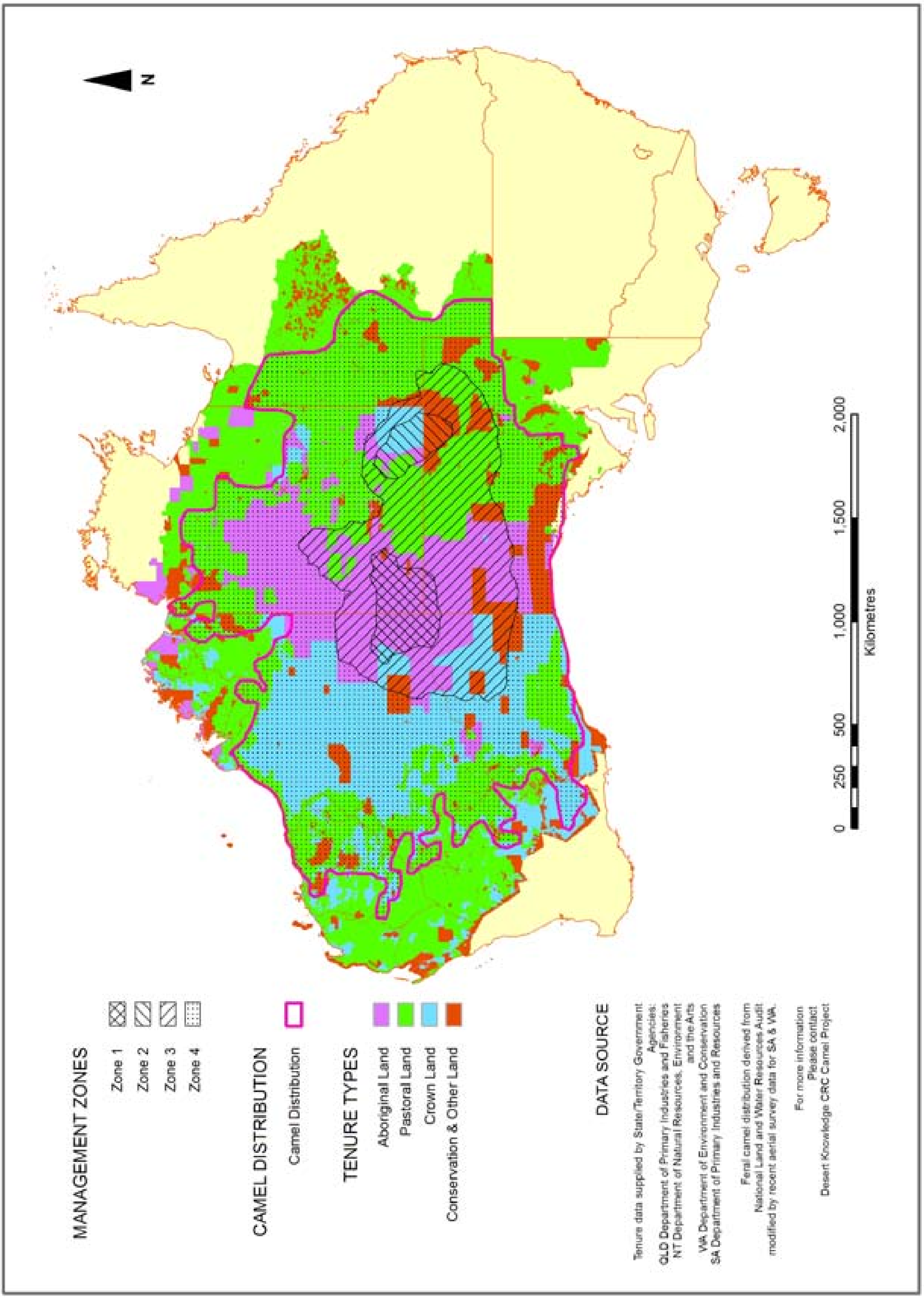


Figure 11.8: Feral camel impact management zones derived from GIS based Decision Support Tool

5. Discussion – a framework for the management of feral camel impacts

The four broad Management Zones (section 4.2 & Figure 11.8) described above provide the basis of a framework for the cross-jurisdictional or national management of feral camel impacts as a consequence of the range of constraints, restrictions, or limitations associated with each management method.

Management Zone 1 is based on the area of greatest camel density (greater than 1.0 animals/km^2) and as such represents the area of greatest concern. This is a consequence of the expectation that this would be the area of greatest broadscale camel impact due to the high density of camels (Edwards & Zeng et al. 2008). Management Zone 1 is comprised mainly of Aboriginal land with a small parcel of conservation land. While the area is classified as suitable for all available broadscale management methods, landholder constraints are likely to restrict immediately available management methods to those that involve the commercial utilisation of feral camels (Vaarzon-Morel 2008a, 2008b; Zeng & McGregor 2008). This reflects the position of Aboriginal people in and immediately surrounding the zone, who have indicated that they are not supportive of management methods that involve the shooting of animals to waste (Figure 5.2 in Vaarzon-Morel 2008a, Vaarzon-Morel 2008b; Figures 11.1 & 11.2). This position is not universal, with two communities within the zone – Warakurna and Papulankutja – and two nearby – Kanpa and Haasts Bluff – indicating they would give limited support to 'shoot to waste' if it were assessed as necessary and were carried out away from the communities (Vaarzon-Morel 2008a; Figures 11.1 & 11.2). It must also be remembered that the perception survey of Aboriginal people was based on a sample (Vaarzon-Morel 2008b), and on this basis the position of Aboriginal people in communities that were not surveyed should not be taken for granted. Within these constraints, Management Zone 1 is recommended as the most appropriate for any immediate introduction or expansion of commercial utilisation–based management methods such as commercial exploitation for pet meat, human consumption, and live export. Assessment of the effectiveness of these management methods should be ongoing and evaluation made of the need for alternative non-commercial methods. Any proposed introduction of such methods would require extensive consultation with the Aboriginal landholders within the zone. Fencing could be used in Management Zone 1 to mitigate expected high levels of camel impact at important sites (e.g. individual waterholes or cultural sites).

The area of next highest camel density is Management Zone 2. The density (greater than 0.5 animals/km^2) is sufficiently high to warrant concern about possible broadscale camel impacts (Edwards & Zeng et al. 2008). Management Zone 2 is a composite of land tenures and has been identified by the Decision Support Tool as suitable only for aerial culling, with no landholder constraints on the use of this management method. It is considered the most appropriate area for the immediate introduction of any proposed broadscale aerial control operation. Management Zone 2 is considered particularly suitable for conducting an index-manipulate-index type experiment to obtain accurate estimates of the biases associated with aerial surveys used to assess feral camel distribution and density. Limited information concerning the biases is one of the major concerns in respect of the accuracy of feral camel population estimates based on aerial survey data (Saalfeld & Edwards 2008). Fencing is considered only marginally suitable over most of Management Zone 2 but could be used to mitigate camel impact at important sites if warranted (e.g. individual waterholes or cultural sites).

Management Zone 3 supports lower densities of feral camels (ranging from 0.25 up to 1.0 animals/km^2 immediately surrounding Zone 1) than either of Management Zones 1 or 2. However, the minimum density of camels in the zone exceeds the recommended long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) required to mitigate broad-scale negative impacts (Edwards & Zeng et al. 2008) and there is a need for broadscale management across this zone. There was significant damage to infrastructure on pastoral leases in this zone in January–March 2007 (Edwards & Zeng et al. 2008). Management Zone 3 is a composite of land tenures.

he Decision Support Tool indicated that only some of Management Zone 3 was suitable for each of the available broadscale management methods, with the remainder being only marginally suitable for most methods. Specific landholder constraints are likely to limit what method can be applied at a particular location. These constraints will tend to follow broad tenure classifications, with non-commercial methods being unacceptable across most Aboriginal land and commercial methods of lower preference on government-managed lands (vacant Crown land and conservation land) (Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a). Fencing is considered only marginally suitable over most of Management Zone 3 but could be used to mitigate camel impact at important sites if warranted (e.g. individual waterholes or cultural sites). This zone is considered to provide the greatest capacity for the implementation of integrated multiple management actions across multiple land tenures and particularly the integration of commercial and non-commercial approaches on the same and/or adjoining landholdings.

The final zone, Management Zone 4, is a composite of land tenures. The camel density across the zone was estimated to be relatively low in comparison to the other zones (fewer than 0.25 animals/km^2 over most of the zone but with a small area in north-west WA having a density slightly above 0.25 animals/km^2). However, there was a problem with the Krigging process used to estimate camel densities for this zone, particularly on the margins of the zone (Saalfeld & Edwards 2008), and densities may be marginally higher than the estimates indicate. Despite this problem, camels are not considered to be causing serious broadscale damage to cultural and environmental values over most of the zone (Table 12.3) with the possible exception of the area in north-west WA having a density slightly above 0.25 animals/km^2. However, pastoral assets within this zone may need protection. Some cattle properties in the marginal region of the zone did report significant camel impacts (see Figure 7.10 in Edwards & Zeng et al. 2008) during the survey of pastoral properties (Zeng & Edwards 2008a). This highlights the fact that there are camels on the margins of the distribution where Krigging indicated that there were none, and that localised densities may be high enough to be causing a level of impact that warrants management action. All of the broadscale management methods were deemed either marginally suitable or unsuitable for application over most of Zone 4. The exception to this is that small patches of Zone 4 in the east and west were identified as being suitable for both aerial culling and live export. Reported camel impacts on fringing pastoral properties may best be addressed through a coordinated program of ground shooting providing that camels can be accessed by road (see Saalfeld & Zeng 2008). Fencing is considered unsuitable over most of Management Zone 4 but could be used to mitigate camel impact at important sites if warranted (e.g. individual waterholes or cultural sites).

This framework is further developed in Edwards & McGregor et al. (2008). The output from the Decision Support Tool and the framework developed here are not intended to address fine- or local-scale management. However, the Decision Support Tool is capable of addressing fine or local scale management issues with spatial input data of the appropriate scale. Data presented in Appendices 11.10–11.12 can be used to set priorities within management zones to mitigate the impacts of camels on biodiversity values.

6. Recommendations

- There should be an initial management focus on Management Zones 1, 2, and 3. Within these zones, the density of camels exceeds the recommended long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) required to mitigate broad-scale negative impacts (Edwards & Zeng et al. 2008).
- Subject to the constraints of Aboriginal landholders, Management Zone 1 is considered the most appropriate for any immediate introduction or expansion of commercial utilisation based management methods ie. extraction for pet meat, human consumption, and live export.

- Management Zone 2 is considered the most appropriate area for the immediate introduction of any proposed broadscale aerial control operation. It is considered particularly suitable for conducting an index-manipulate-index type experiment to obtain accurate estimates of the biases associated with aerial survey of feral camel distribution and density.
- Management Zone 3 is considered the most appropriate zone for the introduction of integrated multiple management actions across multiple tenures. It is considered suitable for simultaneous application of commercial and non-commercial management approaches on the same or adjoining landholdings.
- In Management Zone 4, management should be applied locally in situations where camel impacts are considered unacceptably high. In general, the density of camels is too low throughout most of Zone 4 to warrant widespread application of broadscale management approaches.
- That the GIS-based Multiple Criteria Decision Support Tool developed here be further enhanced and used for feral camel management planning at all scales from local through to national. The capacity of the model to function at a particular resolution is only limited by the resolution of the spatial data that it is based on.

7. References

Australian Bureau of Statistics 2006, *Community Housing and Infrastructure Needs Survey: Data Directory*, Australian Bureau of Statistics, ABS Catalogue No. 4710.0.55.001

Australian Nature Conservation Agency. 1996. *Directory of Important Wetlands in Australia,* Second Edition. Australian Nature Conservation Agency. Canberra.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H, Williams G, Edwards GP, McGregor M and Zeng B. 2008. Review of legislation and regulations relating to feral camel management (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 125–132. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Dörges B and Heucke J. 1995. 'Ecology, social organisation and behaviour of the feral dromedary *Camelus dromedaries* (L. 1758) in central Australia', Unpublished Report (translated from two PhD theses, submitted 1995). University of Braunschweig. Braunschweig, Germany.

Dörges B and Heucke J. 2003. *Demonstration of ecologically sustainable management of Camels on Aboriginal and pastoral land*, Final report on NHT Project No. 200046. Natural Heritage Trust. Canberra.

Drucker AG. 2008a. Economics of feral camel control in the central region of the Northern Territory (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 283–286. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Drucker AG. 2008b. *Economics of Camel Control in the Central Region of the Northern Territory,* DKCRC Research Report 52. Desert Knowledge CRC. Alice Springs.

Edwards GP, Saalfeld K, and Clifford B 2004, 'Population trend of camels in the Northern Territory, Australia', *Wildlife Research*, vol. 31, pp. 509–511.

Edwards GP, Zeng B and Saalfeld WK. 2008. Evaluation of the impacts of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 133–182. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, McGregor M, Zeng B, Saalfeld WK, Vaarzon-Morel P and Duffy M. 2008. Synthesis and key recommendations. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 331–360. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Zeng B, Saalfeld WK, Vaarzon-Morel P and McGregor M (Eds). 2008. *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Lamb D and Saalfeld K. 2008. *A GIS based decision support tool for feral camel management,* DKCRC Research Report 53. Desert Knowledge CRC. Alice Springs.

Norris A and Low T. 2005. *Review of the management of feral animals and their impact on biodiversity in the Rangelands: A resource to aid NRM planning*. Pest Animal Control CRC Report 2005. Pest Animal Control CRC. Canberra.

Peeters PJ, Jennings S, Carpenter RJ and Axford G. 2005, *Assessing the abundance and impacts of feral camels in the Great Victoria Desert*. A report to the Aboriginal Lands Integrated Natural Resource Management Group. Department for Environment and Heritage. South Australia.

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK and Zeng B. 2008. Review of non-commercial control methods for feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 185–220. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008a. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008b. *Key stakeholder perceptions of feral camels: Aboriginal community survey*, DKCRC Research Report 49. Desert Knowledge CRC. Alice Springs.

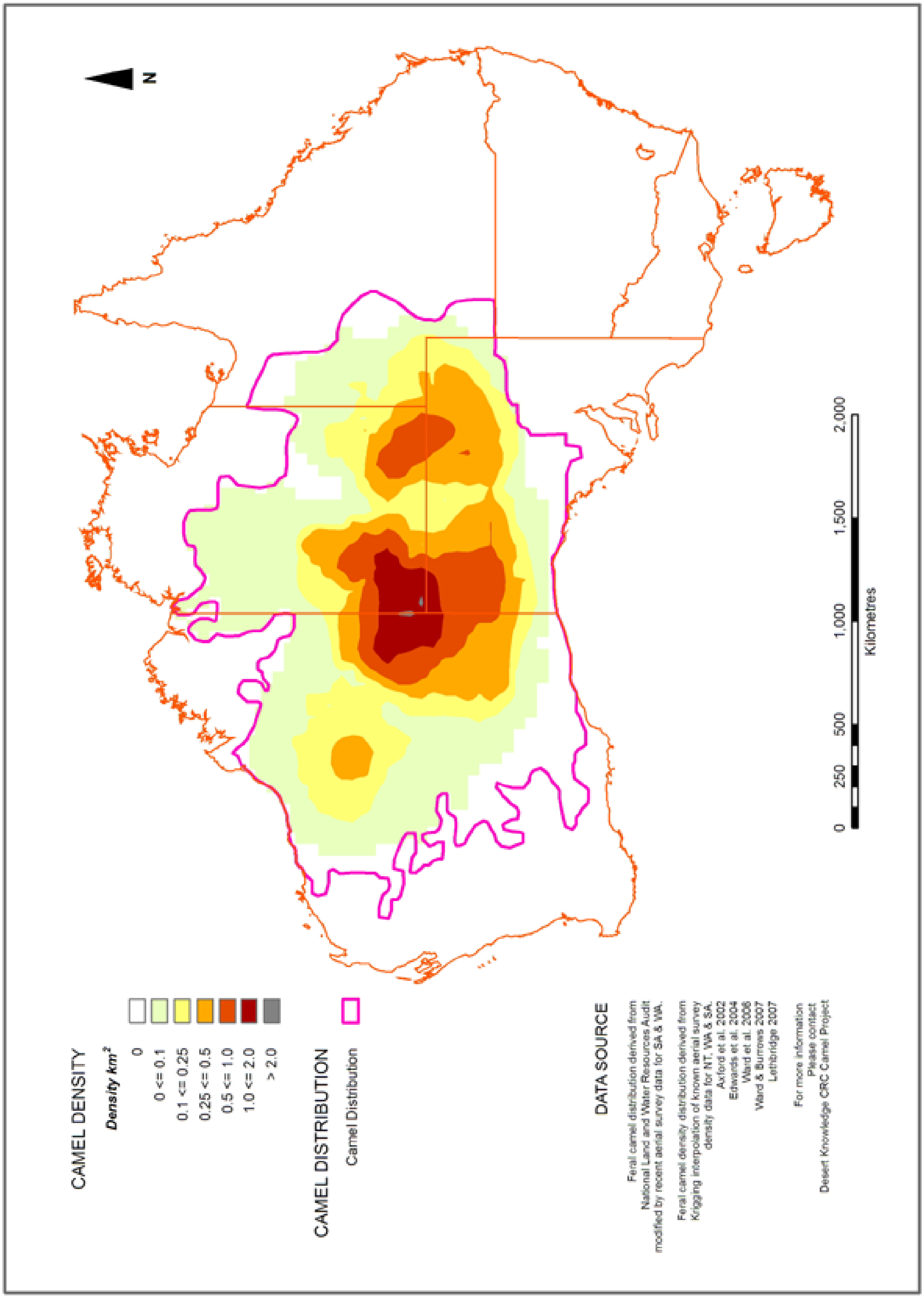
Zeng B and Edwards GP. 2008a. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008b. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

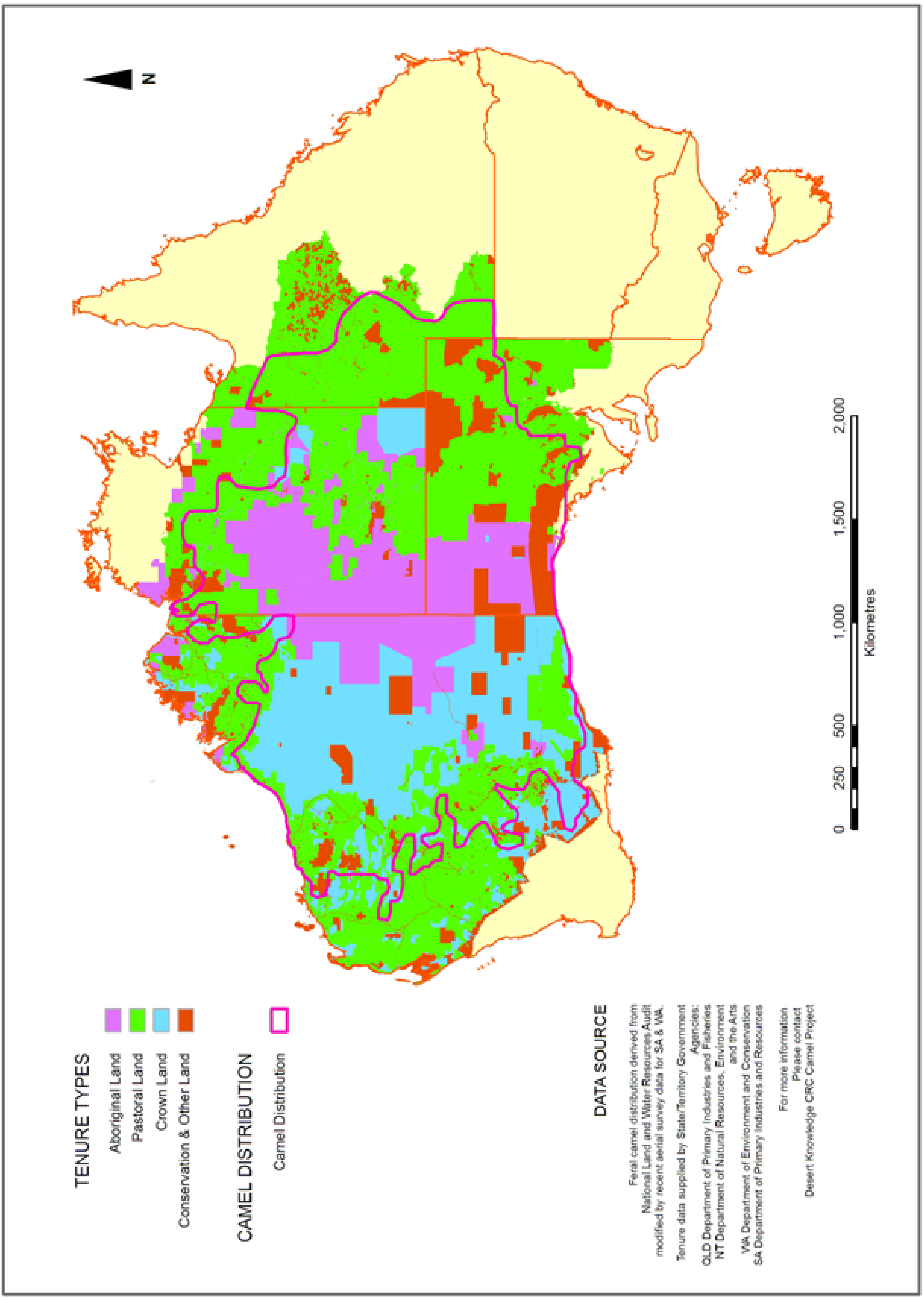
Zeng B and McGregor M. 2008. Review of commercial options for management of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 221–282. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

8. Appendices

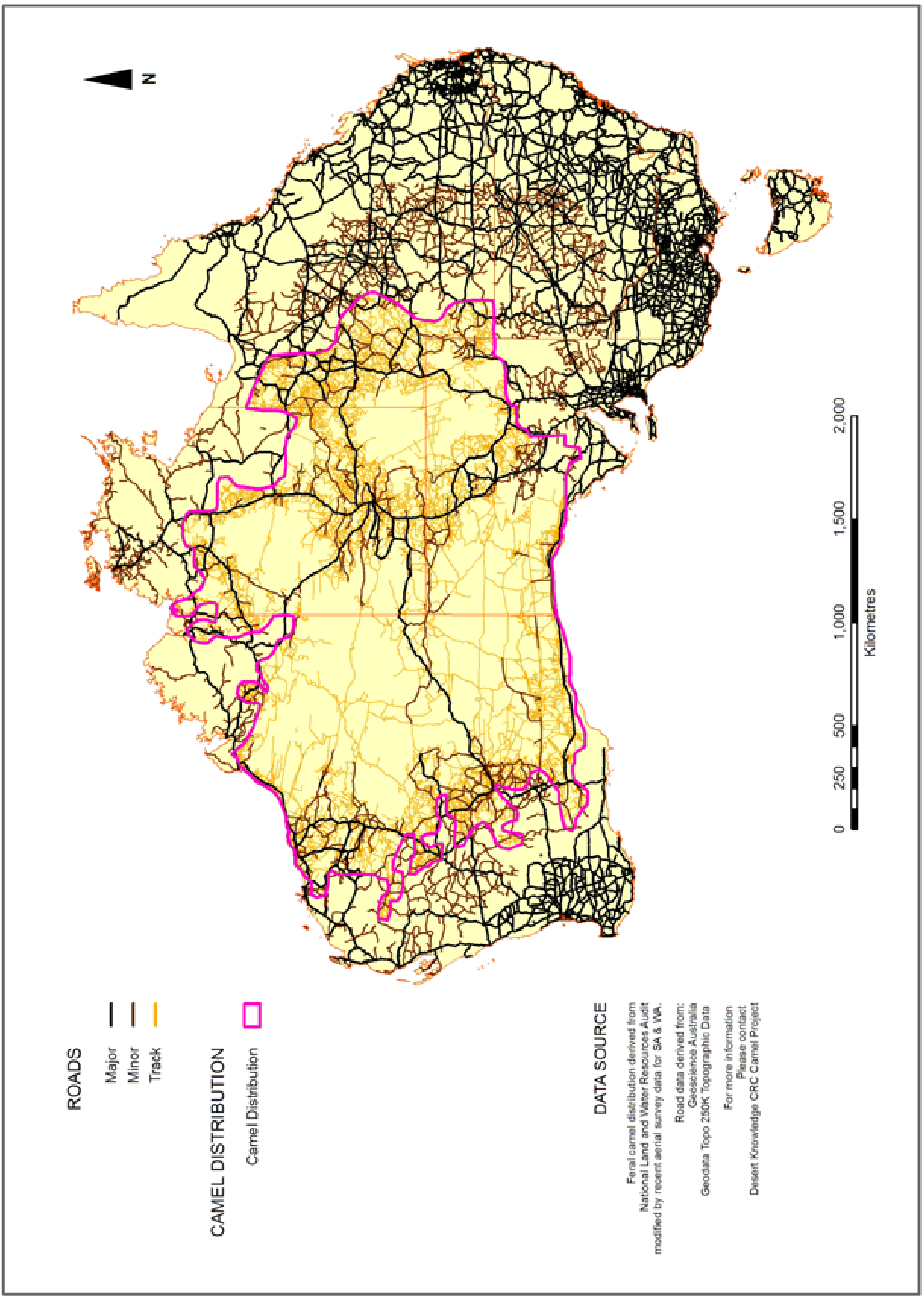
Appendix 11.1: Camel density – spatial layer of camel density across the Australian camel distribution



Appendix 11.2: Land tenure – spatial layer of land tenure types across the Australian camel distribution

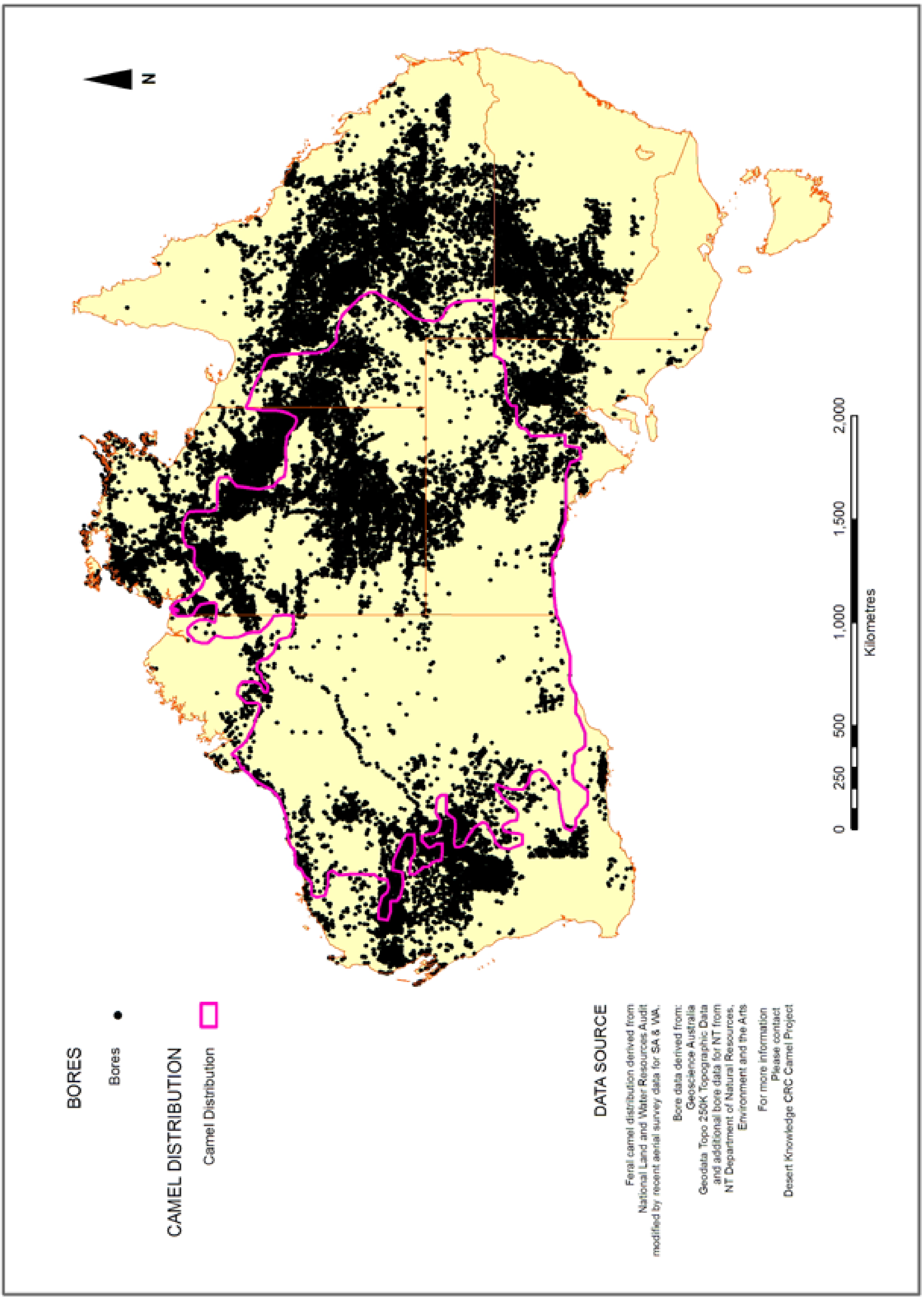


Appendix 11.3: Roads – spatial layer of Australian road network



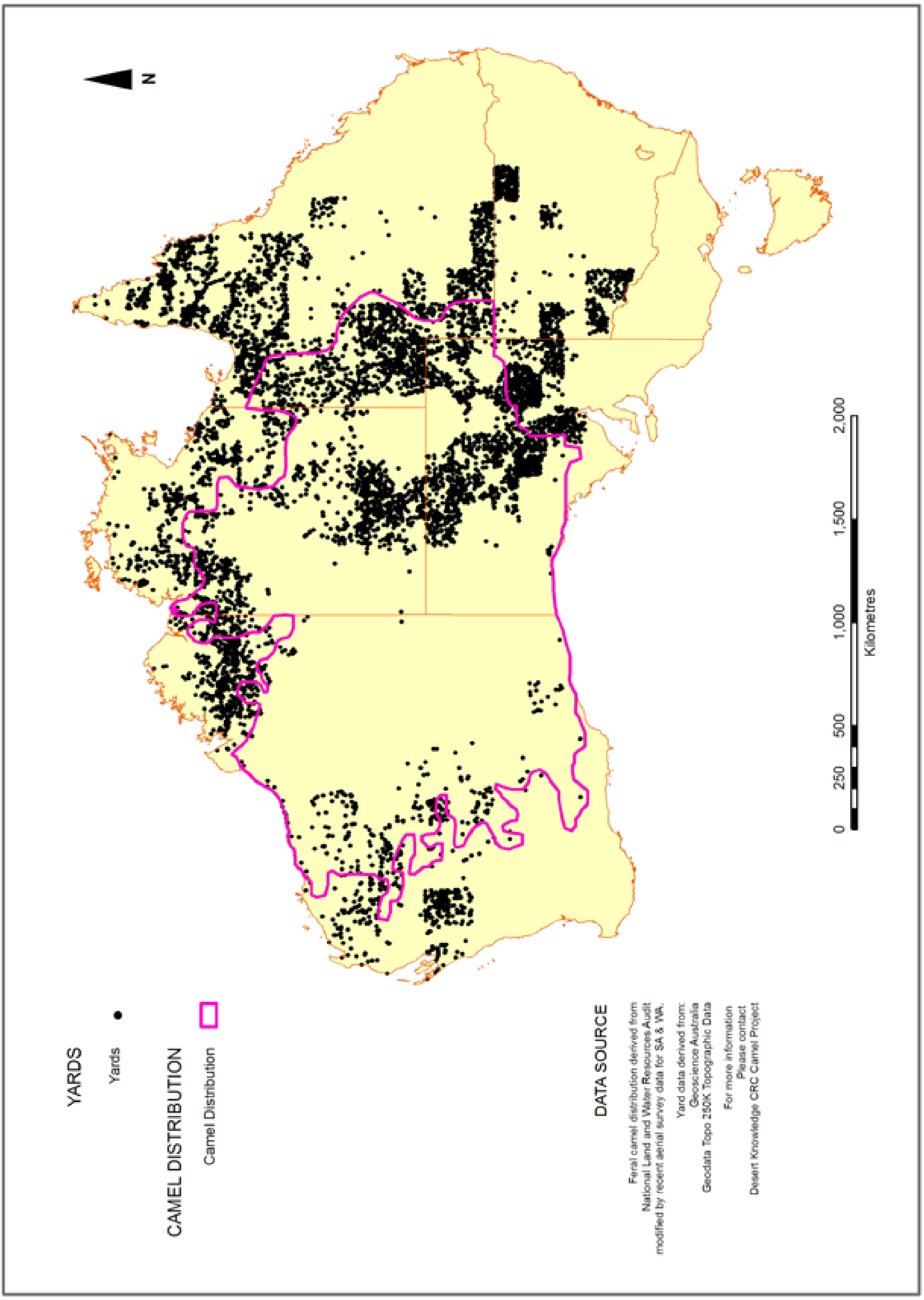
Note: Derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – feature class ‘roads’ – polyline location of roads.

Appendix 11.4: Bores – spatial layer of Australian bores



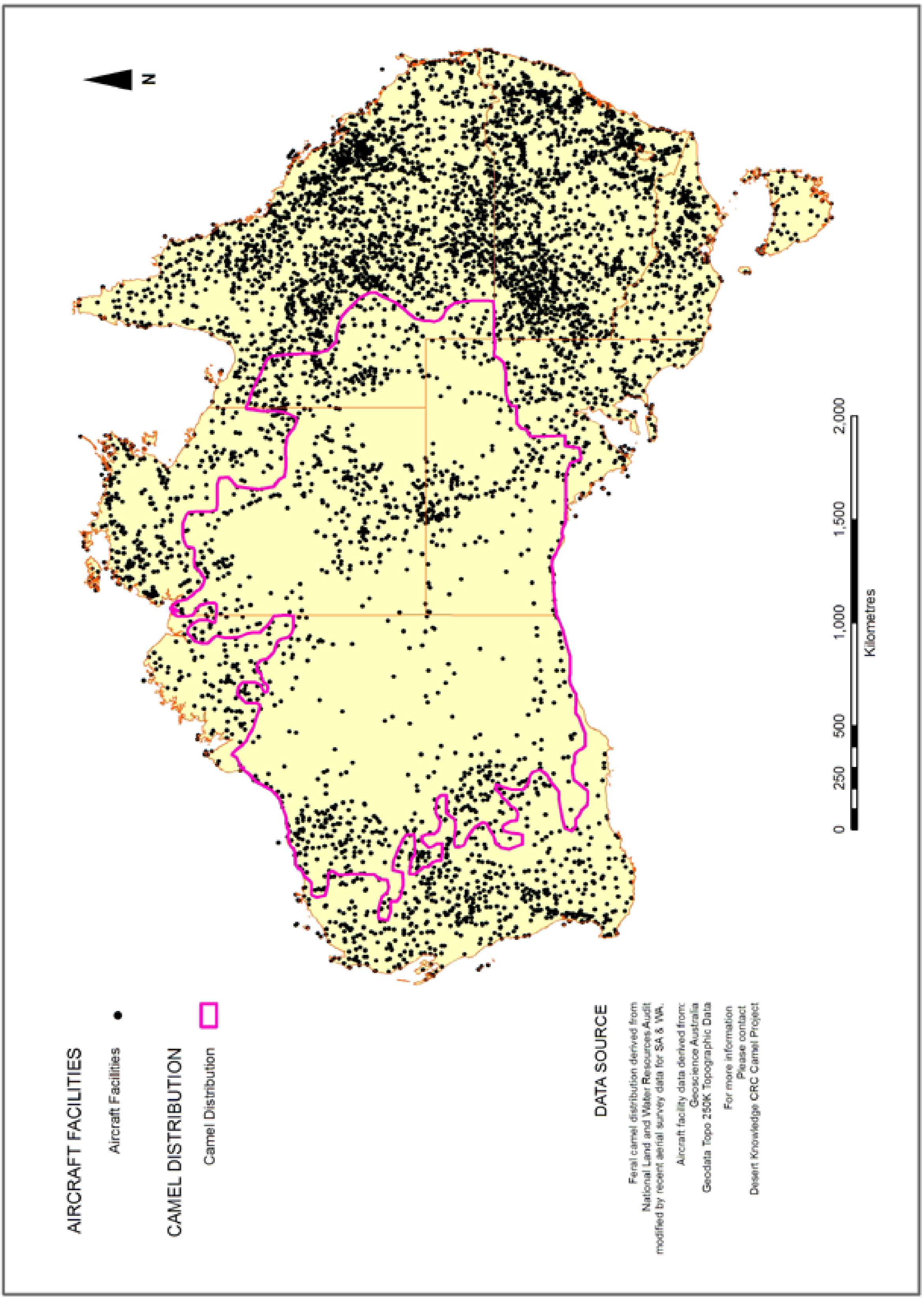
Note: Derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – feature class 'bores' – point location of bores.

Appendix 11.5: Yards – spatial layer of Australian yards



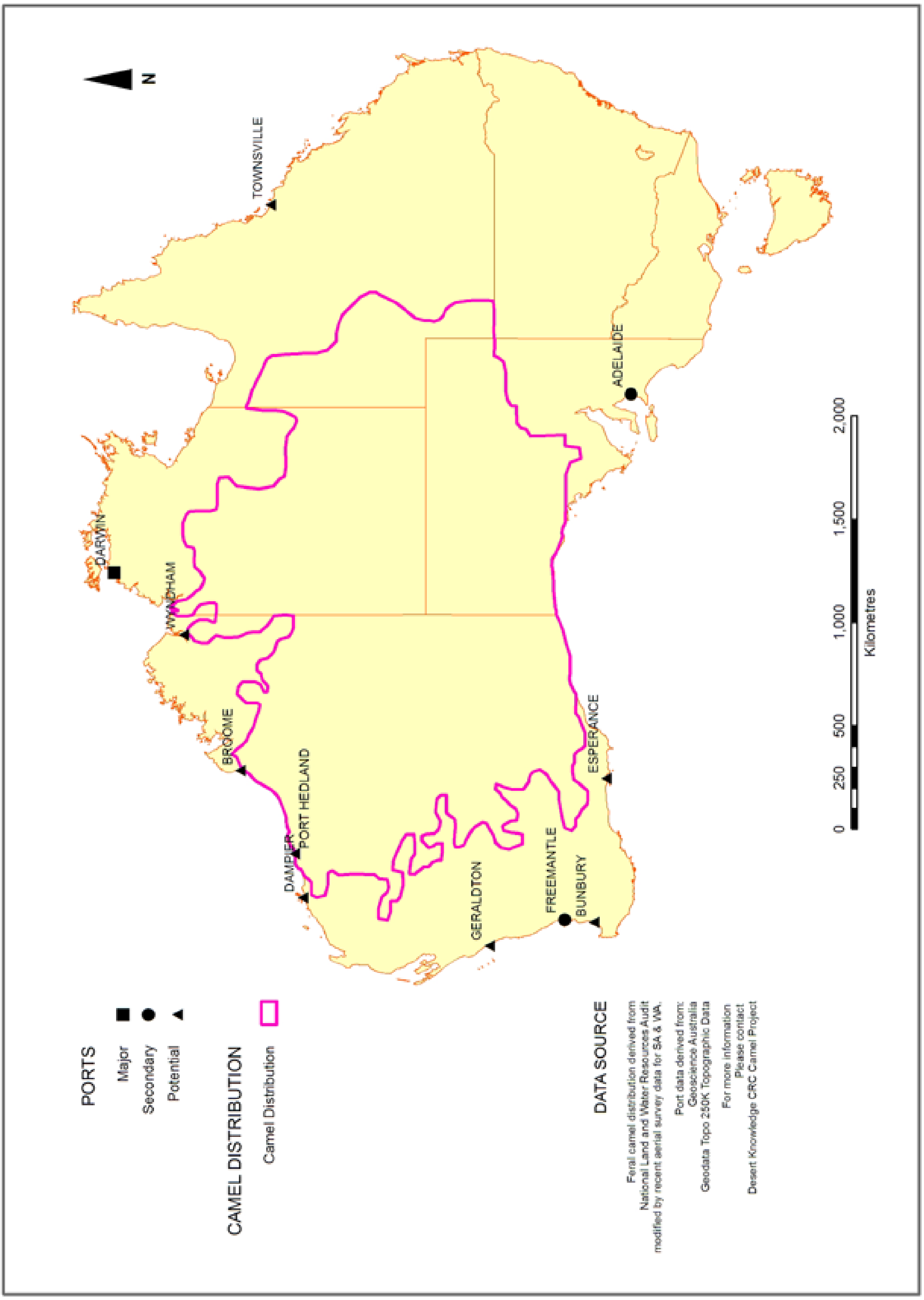
Note: Derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – feature class 'yards' – point location of yards.

Appendix 11.6: Aircraft facilities – spatial layer hof Australian airstrips

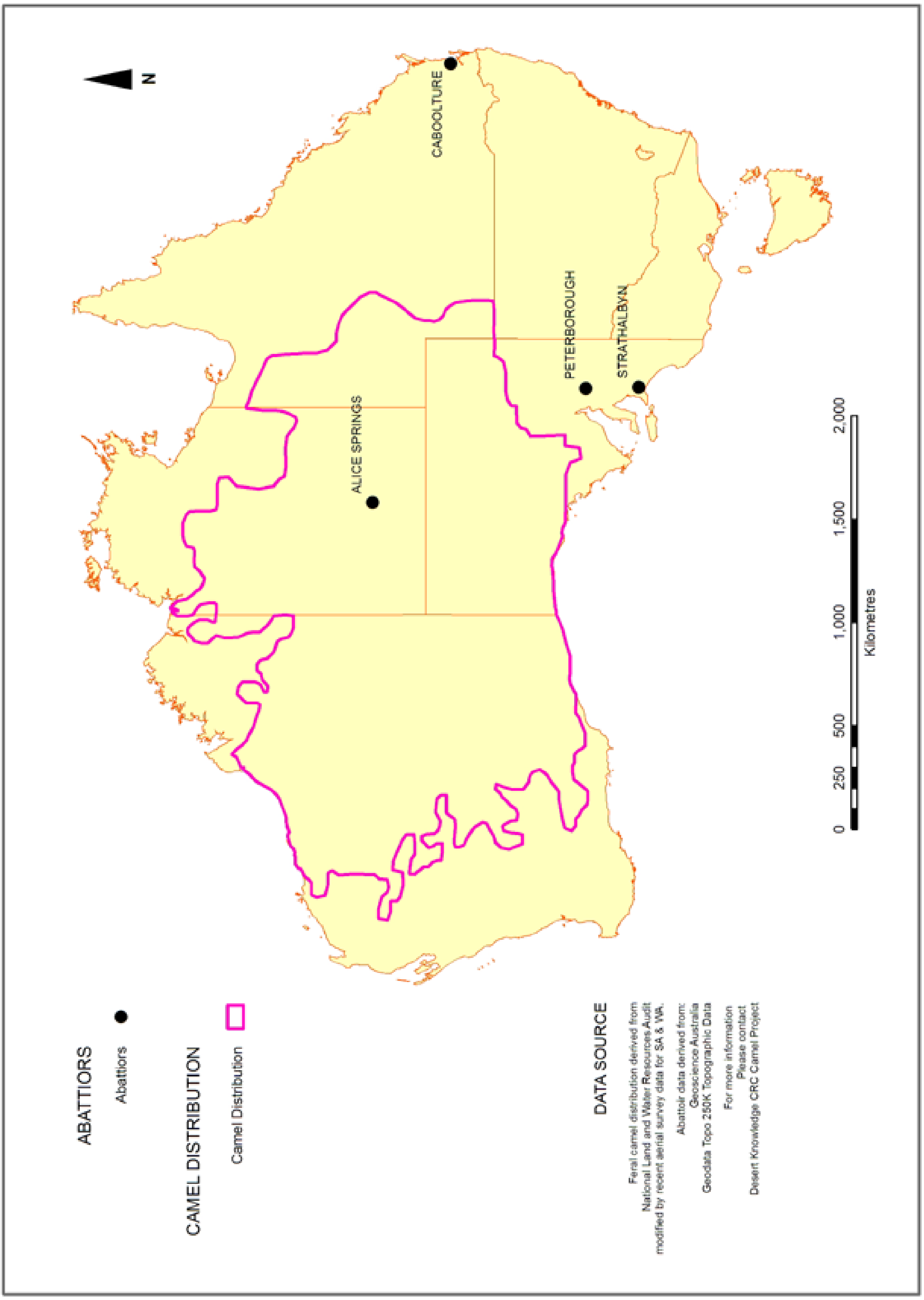


Note: Derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – feature class 'AircraftFacilityPoints' – point location of aircraft facilities including airstrips.

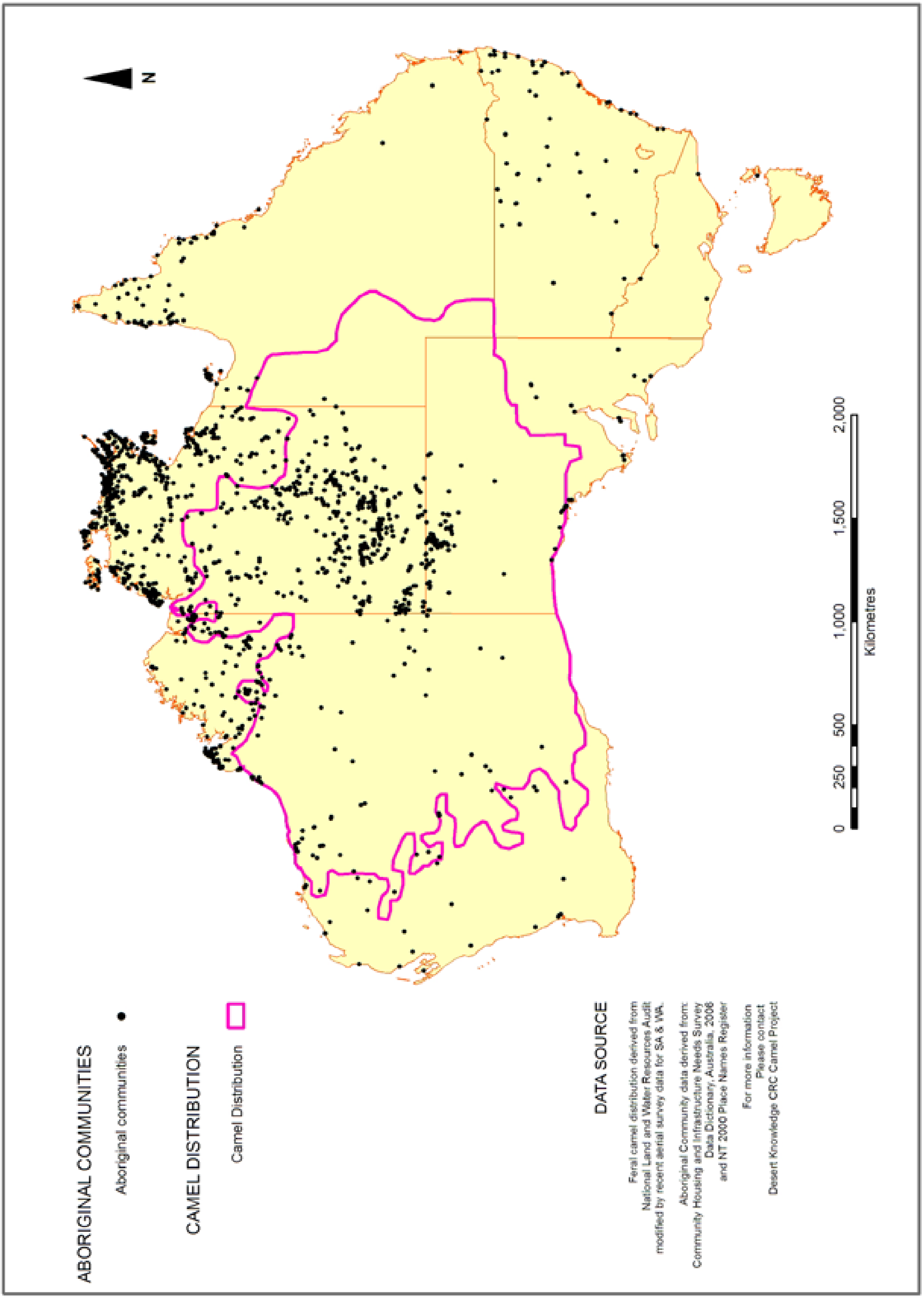
Appendix 11.7: Ports – spatial layer of point locations of Australian ports able to handle live export of camels



Appendix 11.8: Abattoirs – spatial layer of point locations of abattoirs in Australian able to process camels for human consumption

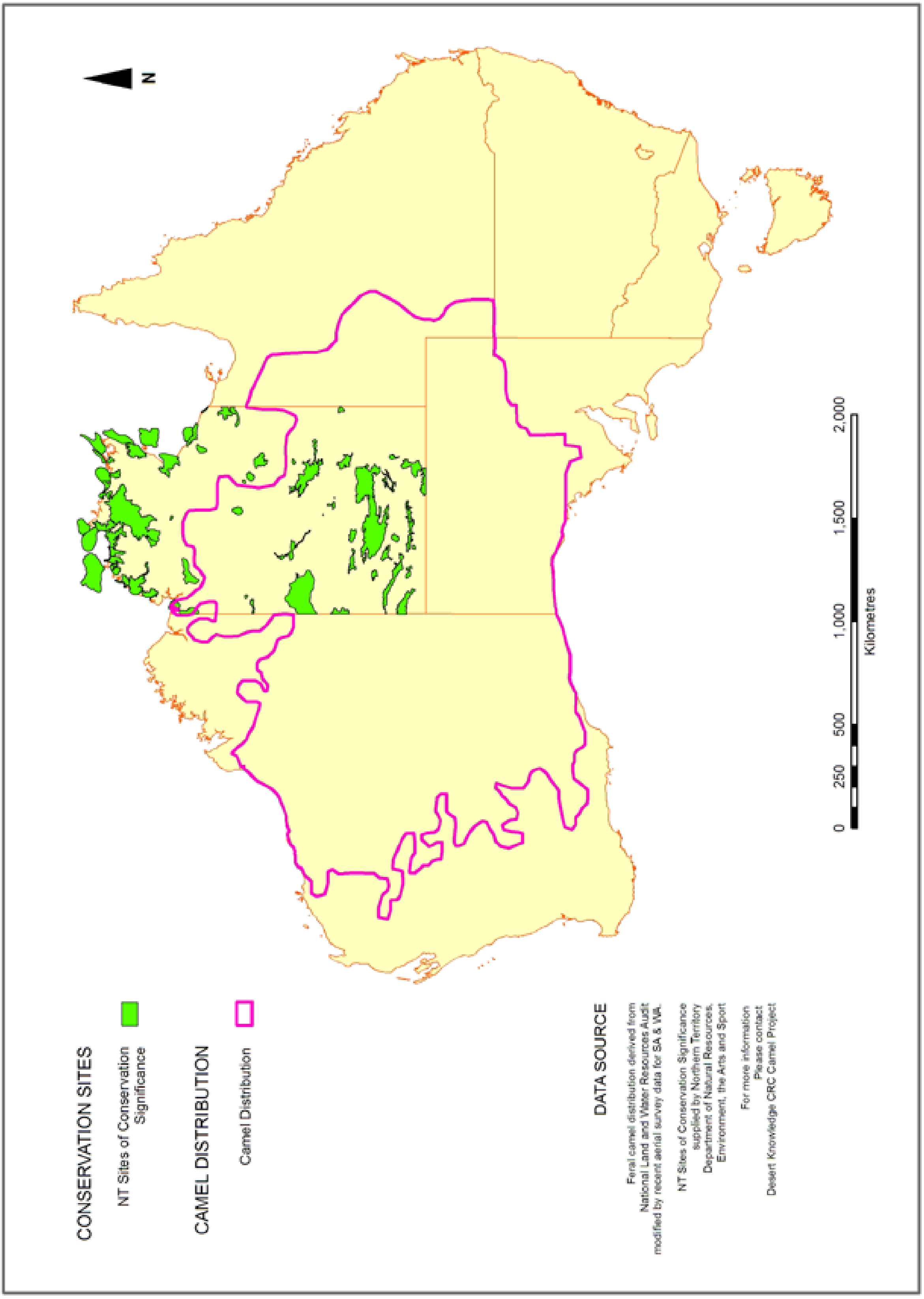


Appendix 11.9: Aboriginal communities – spatial layer of point locations of Aboriginal and Torres Strait communities in Australia other than major population centres (>50% Aboriginal and Torres Strait Islander)



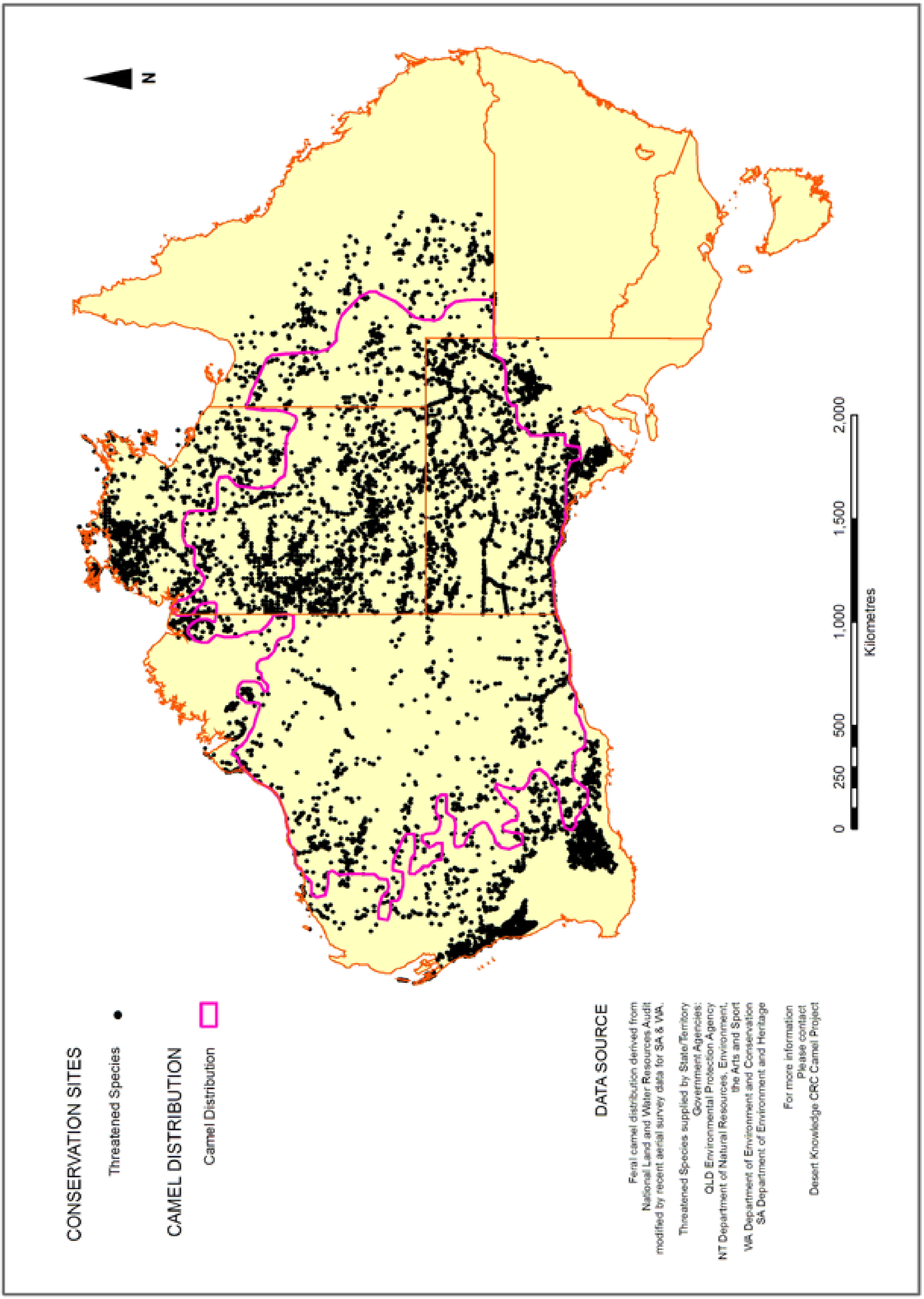
Note: Derived from Community Housing and Infrastructure Needs Survey Data Dictionary, Australia, 2006 (Australian Bureau of Statistics and Geosciences Australia) and with additional Northern Territory locations Aboriginal communities in the NT. Derived from 2000 Place Names Register. Aboriginal Communities is all places where ‘Data_type’ = ‘Aboriginal Community’.

Appendix 11.10: Conservation significance – sites of conservation significance in the NT

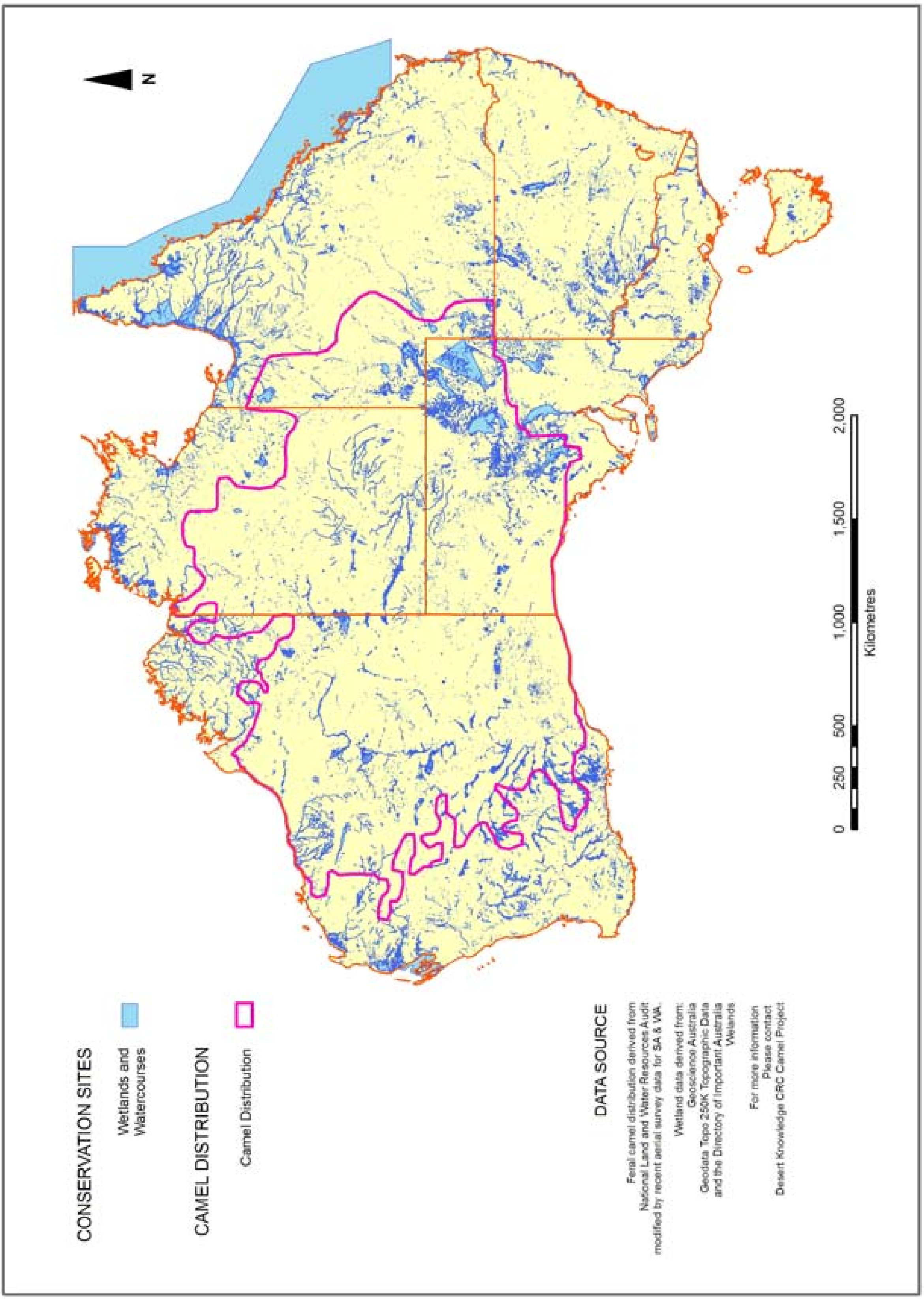


Note: Based on integration and synthesis of available NT conservation data to generate polygon layer of sites of conservation significance (only available for NT).

Appendix 11.11: Conservation significance – location of threatened species records from each jurisdiction



Appendix 11.12: Conservation significance – hydrography layer



Note: Derived from Geoscience Australia Geodata Topo 250K Series 3 Topographic Data medium scale vector representation of Australia topography – hydrography features clipped by *A Directory of Important Wetlands in Australia*.

Chapter 12:

Synthesis and key recommendations

GP Edwards

M McGregor

B Zeng

WK Saalfeld

P Vaarzon-Morel

M Duffy

Contributing author information

Glenn Edwards: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Murray McGregor: Desert Knowledge Cooperative Research Centre and Curtin University of Technology, PO Box 3971, Alice Springs, Northern Territory 0871, Australia

Benxiang Zeng: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Keith Saalfeld: Department of Natural Resources, Environment, The Arts and Sport, PO Box 1120, Alice Springs, Northern Territory 0871, Australia

Petronella Vaarzon-Morel: Consulting anthropologist, PO Box 3561, Alice Springs, Northern Territory 0871, Australia

Michael Duffy: Consultant, PO Box 41102, Casuarina, Northern Territory, 0811.

Contents

Tables

Figures and graphs

List of shortened forms

APY	Anangu Pitjantjatjara Yankunytjatjara
GIS	Geographic Information System
MBI	Market Based Instrument
NRM	Natural Resource Management

Acknowledgements

This report is Chapter 12 of the final report for the project 'Cross-jurisdictional management of feral camels to protect NRM and cultural values'. The project was funded by the Australian Government. The views expressed herein do not necessarily represent the views of DKCRC or its participants.

We thank John Gavin, Phil Gee, Neil Burrows, Jan Ferguson, Lorraine Rosenberg, Julia Curtis, Matt Salmon, and Leslie Russell for providing useful comments on a draft of this chapter.

We sincerely thank Andrew Drenen, Frank Keenan, Lorraine Rosenberg, Neil Burrows, Peter Seidel, Phil Gee, Quentin Hart, Robin Mills, Tony Pople, and Troy Coe for being part of the steering committee for the entire research project, and in particular John Gavin for chairing the committee.

We thank Eleanor Dennis and Ange Vincent for the role they played in administering the project, and Ruth Davies and her editorial team for the considerable amount of work they did in editing the entire report and the supporting reports and arranging final publication. Bo Raphael, James Wright, and Jeanine Baker provided useful comments on early drafts of most of the chapters of the final report.

Chapter 12: Synthesis and key recommendations

1. Summary

Feral camels are well adapted to the conditions found in desert Australia and have now occupied 3.3 million km^2. Feral camels are one of the 73 or so species of introduced vertebrates occurring on mainland Australia that do not meet the criteria to justify eradication effort. For such species, the management options are containment, control, or no management (*Australian Pest Animal Strategy* 2007).

Because they occur in sparsely populated areas, feral camels are only noticed when their activities intersect with remote Aboriginal people, pastoralists, and the tourism and mining industries. The significant damage that camels have done, and are currently doing, to the fragile ecosystems, cultural sites, isolated communities, and pastoral enterprises of desert Australia has gone largely unnoticed by the bulk of Australia's population. The current estimated population of about one million feral camels is doubling approximately every nine years (Saalfeld & Edwards 2008) and there is evidence that impacts will increase along with the population (Edwards et al. 2008). If we do not act now to mitigate the damage being caused by feral camels, irreparable damage may be done, particularly to environmental and cultural values, across much of desert Australia. The longer we take to act, the more it will cost to manage and repair the negative impacts of feral camels.

Management of the impacts of pest animals should be informed by a risk management approach and be strategic in determining where management should occur, at what time, and what techniques should be used (*Australian Pest Animal Strategy* 2007). It requires coordination at the appropriate scale among all levels of government in partnership with industry, land managers, and the community (*Australian Pest Animal Strategy* 2007). The current management of feral camels, being largely ad hoc (Edwards et al. 2004), fails to adequately meet any of these criteria.

If we are to develop a strategic, coordinated risk management approach to mitigating the impacts of feral camels, it must be done at the national scale because:

- There is a large population of camels occurring over a large area which includes parts of Western Australia (WA), South Australia (SA), Queensland (Qld), and the Northern Territory (NT) (Saalfeld & Edwards 2008).
- Camels are very mobile animals that can move over large distances in relatively short time periods (Saalfeld & Edwards 2008).
- Many camels occur in very remote areas that are sparsely populated by people (Saalfeld & Edwards 2008, Saalfeld et al. 2008).
- There are differing perceptions on feral camels and their impacts (Zeng & Edwards 2008a, 2008b; Vaarzon-Morel 2008a).
- Camels are considered both a pest and a resource (Edwards et al. 2008), which can lead to conflicting goals between the various stakeholders in respect of their management.

The research described in this report was funded by the Australian Government. It was conducted with the overarching aim of developing a national management framework which will lead to a reduction in camel numbers to a level that reverses their current population growth trajectory and reduces their impacts on natural resource management (NRM), economic, and social-cultural values.

The key **outputs** of the research were:

1. Detailed analysis of management system options that lead to a significant lowering of camel numbers and resulting improvement in economic, environmental, and social/cultural values

2. Improved understanding and documentation of the cultural and other barriers to different feral camel management options
3. An analysis and documentation of the role of at least two alternative market-driven approaches to camel control that can help to mitigate the negative impacts of the species
4. Development of a framework for the cross-jurisdictional management of the negative impacts of feral camels.

The overarching aim of developing a management framework for addressing the negative impacts of feral camels was achieved through a group of well-integrated sub-projects, based on a collaboration between different stakeholder groups, in a range of jurisdictions, working on a series of related projects across the country. The research was undertaken through five core sub-projects:

1. Evaluation of key stakeholder perceptions: This work focused on Aboriginal, conservation, and pastoral land owners and managers within the camel's range.
2. Evaluation of the impacts of feral camels: This work adopted a triple bottom line approach in considering economic, environmental, and social (including cultural) criteria.
3. Evaluation of commercial approaches that could assist in managing the negative impacts of feral camels: This work considered aspects such as the live export of camels and the use of camels for pet meat and for human consumption.
4. Evaluation of the non-commercial approaches that are or could be used in the management of the negative impacts of feral camels: This work considered aspects such as aerial culling, ground culling, and fencing. A review of possible chemical, biological, and fertility control options for managing the negative impacts of feral camels was also conducted by a research team based at the Invasive Animals Cooperative Research Centre.
5. Development of a framework for the cross-jurisdictional management of the negative impacts of feral camels. In developing the framework, the following tasks were undertaken:
    a. The compilation of spatial data relevant to the management of feral camels and their impacts
    b. The development of a Multiple Criteria Decision Support Tool for Feral Camel Management based on a Geographic Information System (GIS).

The following additional work was undertaken for the project:

1. A review of legislation to identify possible barriers to the cross-jurisdictional management of feral camels and their impacts. A team based at Charles Darwin University and led by Stephen Garnett undertook this research.
2. Modelling of options for management of feral camels in central Australia: Stephen McLeod, from New South Wales Department of Primary Industries, and Anthony Pople, from Queensland Department of Primary Industries and Fisheries, undertook this work.
3. An economic analysis of camel control in the central region of the NT: Adam Drucker, from Charles Darwin University, undertook this work.

The following discussion summarises the research outputs of all work undertaken for the project and provides key recommendations for the effective cross-jurisdictional management of feral camels and their impacts. Preceding chapters of the final report contain a much higher level of detail in relation to the work undertaken and may include additional recommendations pertaining to individual research components.

2. Current status

2.1 Feral camel distribution

The camel played an important role in the development of central Australia in both the nineteenth and early twentieth centuries. The replacement of the camel by the motor vehicle in the early twentieth century resulted in large numbers of animals being released into the wild and the subsequent establishment of a feral population in arid Australia.

Monitoring of Australia's camel population was haphazard at best until the 1980s. Since that time, a number of systematic aerial surveys of camel distribution and abundance have been carried out across substantial areas of the camel's distribution.

The current distribution of the camel covers much of arid Australia. Up to 50% of Australia's rangelands are reported as having camels present, with the arid regions of WA, SA, the NT, and parts of Qld being affected.

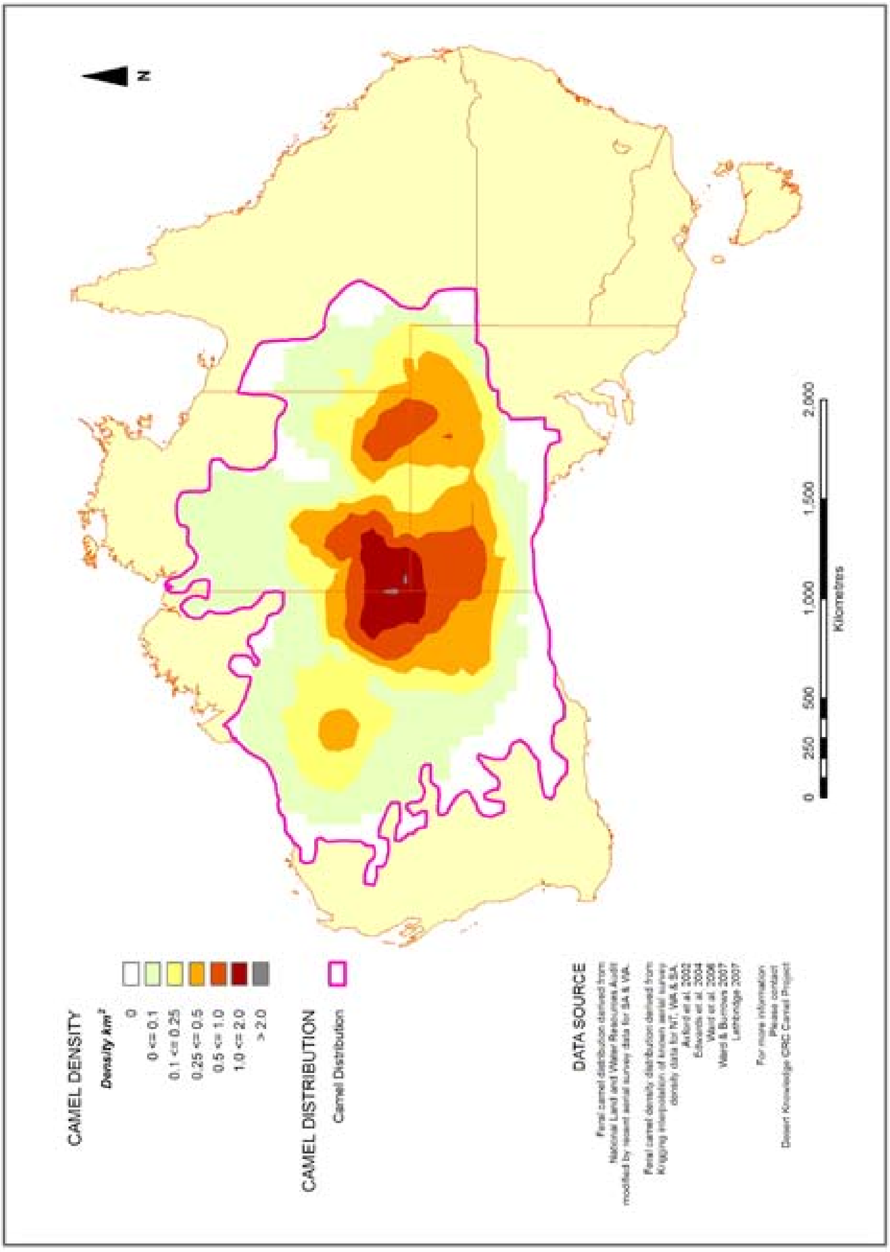


Figure 12.1: Density distribution of camels across the range of the camel in Australia derived from Krigging interpolation of known aerial survey densities extrapolated forward to 2008

The research reported here supports a current minimum population estimate for the feral camel in Australia of approximately one million animals covering an area of some 3.3 million km^2 at an overall density of 0.29 camels/km^2. Densities vary, and modelling of available data indicates that two substantial areas of high density are present, one centred on the Simpson Desert and the other on the Great Sandy Desert (Figure 12.1). The high density area covering the eastern part of the Great Sandy Desert has predicted densities in the range of 0.5 to greater than 2 animals/km^2 and that on the Simpson Desert in the range 0.5–1.0 animals/km^2.

The estimates of population size and density distribution for feral camels provided here are the best available. However, these could be improved. An underlying problem with all the aerial survey data is that it contains a negative bias that cannot currently be corrected for. This bias arises because some camels are hidden from view during surveys, resulting in an undercount of the actual number of camels present. Up until now, aerial surveys have tended to focus on areas of perceived high density. The low density areas on the periphery of the camel distribution have not been formally surveyed and this led to problems in the Krigging process used to estimate density distribution (see Saalfeld & Edwards 2008).

Another problem with the current aerial survey data is that some of it is up to seven years old. Although we projected data forward to 2008, it is possible that the pattern of camel density distribution has changed since surveys were completed. Feral camels are very mobile animals that can move up to 70 km in a day (Grigg et al. 1995) and move over areas of many thousands of square kilometres over a 12-month period (Edwards et al. 2001). Lastly, there is only limited coordination between the jurisdictions in conducting aerial surveys for camels. The exception is the recent survey involving SA and WA. With a little more coordination, more representative coverage of the camel range could be achieved, providing a better national picture of density distribution and overall population size.

Key recommendation 1: That the broadscale aerial survey database of feral camel distribution and abundance be expanded by implementing aerial survey in areas not previously covered in order to improve estimation of density distribution for feral camels.

Key recommendation 2: That research be undertaken to address the issue of environmental bias associated with current aerial survey estimates of feral camel population distribution and abundance. This could be achieved by conducting a survey in an area, then removing a significant number of the camels in the area, then resurveying the area (i.e. an index-manipulate-index experiment).

Key recommendation 3: That a national database be created incorporating all available aerial survey data related to feral camels from all jurisdictions, with data incorporated at the finest spatial scale available, and that this database be supported by all jurisdictions.

Key recommendation 4: That efforts are made to achieve a better understanding of the factors influencing the movement patterns and population distribution of feral camels at the local to regional scale. This would allow static aerial survey data to be more accurately projected forwards and facilitate the development of a dynamic model of feral camel density distribution.

Key recommendation 5: Investigate different methods of survey that may yield accurate data over large areas at minimal cost.

2.2 Modelling population dynamics

Modelling of camel population dynamics gives a population growth rate of about 8 % per year, although the actual rate is highly sensitive to the estimate for adult survival (McLeod & Pople 2008). On the basis of this rate of increase, a population doubling time of about nine years is likely, and this is reflected in long-term aerial survey data from the NT (Edwards et al. 2004). Although this rate is relatively slow when compared to that of smaller-bodied mammals, on the basis of the current

Australian camel population estimate this rate indicates potential for increase at about 80 000 camels per year and accelerating, due to the exponential nature of population increase and to camels not having met the potential carrying capacity of the land (McLeod & Pople 2008).

Camels appear to use most available habitat, with use reflecting seasonal influences related to food availability and breeding. Habitat types not used to any measured extent include mountain ranges and salt pans/lakes, although camels have been reported from both of these habitats. Camels use almost all available food sources with a clear suite of preferred species and are subject to limited mortality other than natural mortality associated with age and perhaps prolonged drought events.

Few of the resources needed by camels appear to be limiting at current population densities, with the possible exception of water. Increased water stress during hot dry summers is proposed as the causal factor for the encroachment of camels into remote central Australian communities in recent years. Camels were reported trying to obtain access to water by entering communities and damaging water-related infrastructure including bores, taps, and air conditioning units.

2.3 The science of vertebrate pest control

Over the last 15 or so years, there has been a paradigm shift in the area of vertebrate pest control. The shift has been from animal control to animal damage control (Hone 2007). This shift recognises the fact that pest abundance by itself is not actually the problem; rather, it is the harmful impacts of the pest that are the problem (Hone 2007). Accordingly, the aim of vertebrate pest control should be to mitigate the damaging impacts of pests rather than controlling the pests themselves (Hone 2007, *Australian Pest Animal Strategy* 2007). Invariably there is a positive relationship between pest abundance and degree of impact, so damage mitigation involves reducing pest abundance (Hone 2007). Often there is a threshold pest density below which damage is either non-existent, negligible, or tolerable. The presence of a threshold means that not all pests have to be removed in order to mitigate damage (Hone 2007).

2.4 Negative impacts of feral camels

In Australia, the harmful impacts of pest animals fall into three main categories: economic, environmental, and social/cultural (Hart & Bomford 2006; *Australian Pest Animal Strategy* 2007). The negative impacts of feral camels cut across all three of these damage categories and are of national importance as they affect rare and threatened species, ecosystem services, and the Australian economy.

Negative economic impacts of feral camels mainly include:

- Direct control and management costs: assessed in this report as $2.35 million per year (over the period July 2005–June 2007).
- Impacts on livestock production through competition with stock for food and other resources: assessed in this report as $3.42 million per year (over the period July 2005–June 2007).
- Damage to infrastructure, property, and people. Pastoral lands suffer major damage to fences, yards, and water troughs; government agencies and remote settlements suffer major damage to buildings, fixtures, fences, and bores; individuals suffer damage primarily through vehicular collisions involving feral camels: assessed in this report as $5.51 million per year (mainly over the period July 2005–June 2007).

Negative environmental impacts of feral camels include:

- Damage to vegetation through feeding behaviour and trampling and subsequent erosion: no quantifiable dollar value has been determined in this report but the impacts are thought to be moderate.

- Suppression of recruitment in some plant species. It is considered that camels have the ability to cause the local extinction of highly preferred species like the quandong (*Santalum acuminatum*), curly pod wattle (*Acacia sessiliceps*), and bean tree (*Erythrina vespertilio*) (Dörges & Heucke 2003): no quantifiable dollar value has been determined in this report but the impacts are thought to be significant.
- Damage to wetlands through fouling, trampling, and sedimentation. The ability of wetlands to act as refugia for many types of aquatic and terrestrial wildlife, particularly during droughts, is being undermined by the impacts of feral camels: no quantifiable dollar value has been determined in this report, but the impacts are thought to be significant.
- Competition with native animals for food and shelter: no quantifiable dollar value has been determined in this report, but the impacts are thought to be significant.
- Contribution to greenhouse gas emissions and hence impact on global climate change: assessed in this report as $13.87 million per year, assuming each camel emits 0.97 t of CO_2 per year (see Drucker 2008a), a value of $15 per ton of CO_2 emitted (see Drucker 2008a) and a total population of 953 000 camels (Saalfeld & Edwards 2008).

Negative social/cultural impacts of feral camels include:

- Damage to sites that have cultural significance to Aboriginal people. Water places in particular (water holes, rock holes, soaks, springs, etc.) are special places for desert Aboriginal people and many, but not all, are sacred sites (Yu 2002). Thus, the negative impacts of camels on wetland areas also have a very important social/cultural dimension: no quantifiable dollar value has been determined in this report, but the impacts are thought to be significant.
- Destruction of bush tucker resources: no quantifiable dollar value has been determined in this report, but the impacts are thought to be moderate.
- Reduction of people’s enjoyment of natural areas: no quantifiable dollar value has been determined in this report, but the impacts are thought to be significant.
- Causing a general nuisance and creating dangerous driving conditions in residential areas of remote settlements: no quantifiable dollar value has been determined in this report, but the impacts are thought to be significant.

Camels could potentially be epidemiologically involved in the spread of diseases such as bluetongue, Rinderpest, Rift valley fever, surra (trypanosomosis), and bovine tuberculosis if outbreaks of these diseases occurred in Australia (Brown 2004; Robert Henzell 2008, SA Animal and Plant Control Group, pers. comm.).

The climate change forecast for arid Australia to 2030 is for a temperature increase of 1–1.2^{o}C, higher frequency of hot days, a decline in rainfall of between 2–5%, higher evaporation rates, and higher frequency of droughts (CSIRO 2007). Under this scenario, even if camel populations remain static, the negative impacts of camels are likely to be exacerbated. Water will be a scarcer resource and camels will put more pressure on water resources on pastoral leases, in remote settlements, and in wetlands. As droughts increase in frequency, so too will the frequency of camels moving en masse onto pastoral leases and into remote settlements in search of water. Wetlands will become increasingly important as refugia in arid Australia as the frequency of droughts increases and this will magnify the effects of feral camels on environmental values. The exotic disease risk associated with feral camels is also likely to increase if camels are brought into closer contact with stock as they seek out scarcer water resources.

2.5 Positive impacts of feral camels

Feral camels can have both positive economic and environmental impacts. Landholders can derive economic benefit from feral camels by using them for meat or by selling them for uses which include pet meat and meat for human consumption. The economic benefit from the sale of camels by landholders accrues along the supply chain as transporters, wholesalers, agents, meat processors, and meat marketers handle the product. Small numbers of feral camels are also used in the tourism industry. Many Aboriginal people believe that feral camels should be used to provide benefits to local people, including income and jobs (Vaarzon-Morel 2008a, 2008b). Camels have also been used for woody weed control in Qld.

2.6 Density/damage relationship

There is a positive density/damage relationship for camels and infrastructure on pastoral properties, which is likely to hold true for environmental variables and cultural/social variables as well (Edwards et al. 2008). There are real gains to be made in maintaining camel densities on pastoral leases at <0.3 camels/km^2. The amount of damage tends to flatten out at densities between 0.1–0.2 camels/km^2, at levels of about $5000–6000 over two years. For most pastoralists, this may be a tolerable level of damage. Camel densities also need to be kept at or below 0.3 camels/km^2 in order to safeguard the survival of tree species that are extremely susceptible to high levels of camel browsing.

Therefore, irrespective of climate change, the magnitude of the negative impacts of feral camels will increase if the population is allowed to continue to increase. Furthermore, the likelihood that camels would be epidemiologically involved in the spread of exotic diseases (if outbreaks of these diseases occurred in Australia) is also very likely to increase with population density.

2.7 Net economic cost of the impacts of feral camels

The negative economic impacts of feral camels (excluding carbon emissions) outweigh the positive economic impacts by a factor of about 18 (Table 12.1). The net economic impact is -$24.53 million annually (assessed over the period July 2005 – June 2007 for the most part) taking greenhouse emissions into account and -$10.67 million annually without accounting for greenhouse emissions.

Table 12.1: The annualised monetary value of the economic impacts of feral camels

Impact	Value
POSITIVE	
Selling and eating camels	$0.62 million
Control of woody weeds	Not quantified
NEGATIVE	
Direct control and management costs	-$2.35 million
Impacts on livestock production	-$3.42 million
Damage to infrastructure, property, and people	-$5.51 million
Damage to vegetation through feeding behaviour and trampling and subsequent erosion	Not quantified
Suppression of recruitment in some plant species	Not quantified
Damage to wetlands through fouling, trampling, and sedimentation	Not quantified
Competition with native animals for food and shelter	Not quantified
Contribution to greenhouse gas emissions	-$13.87 million
Damage to sites that have cultural significance to Aboriginal people	Not quantified
Destruction of bush tucker resources	Not quantified
Reduction of people's enjoyment of natural areas	Not quantified
Causing a general nuisance and dangerous driving conditions in residential areas of remote settlements	Not quantified
Net quantifiable cost/benefit	**-$24.53 million**

Note: The positive economic impacts are those for landholders, not those that accrue along the commercial supply chain.

Key recommendation 6: The management of feral camels should focus on mitigation of negative impacts. As there is a positive relationship between camel density and degree of damage, reducing camel density is an important strategy in achieving damage mitigation.

Key recommendation 7: There is a need to quantify the density/damage relationship for feral camels for response variables (particularly environmental and cultural variables) for which the relationship is not known across a range of environments and with particular emphasis on identifying the threshold density below which impacts are negligible.

Key recommendation 8: Feral camels be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.

3. Current management issues

3.1 Current approaches to managing the negative impacts of feral camels

Current approaches to managing the negative impacts of feral camel are either geared towards reducing populations (thereby, hopefully, reducing impacts) or controlling the movements of camels to keep them away from important assets. A number of methods have been used to reduce populations, including commercial methods (harvesting for pet meat, human consumption, or for live export) and non-commercial methods (aerial shooting and ground-based shooting). Direct asset protection can also be considered a non-commercial method and has been achieved through the construction of fences that exclude camels from particular areas or devices that prevent camels from having complete access to an area. However, up until now, application of these approaches has been generally small scale and ad hoc and has lacked both coordination and integration (Edwards et al. 2004). It is estimated that between 15 000 and 26 000 feral camels are removed each year using a combination of aerial and ground shooting and commercial harvest. In addition, only a small number of small wetlands, covering only a few hectares, are fenced each year to exclude camels. Considering that the estimated population of one million feral camels increases exponentially at a rate of about 8% per year (i.e. approximately 80 000 new camels added this year alone) and that there are many thousands of hectares of wetlands (and other assets) to protect, it is clear that existing management methods fall far short of mitigating the negative impacts of feral camels.

With the exception of SA, there is currently very little collaboration between neighbouring landholders in managing the impacts of feral camels. However, there is some collaboration between government agencies in different jurisdictions in assisting each other with regional-scale shooting programs (e.g. SA and the NT) and population counts (e.g. SA and WA).

Ultimately, effective management of feral camels and their impacts will involve the integration of all available control methods, both non-commercial and commercial, and the development of a strategic and integrated management framework that works across jurisdictions, tenures, boundaries, and industry sectors, and prescribes clear management targets. An important starting point will be to ensure that legislation across jurisdictions is aligned to allow such a management framework to be implemented.

3.2 Legislation issues that cause inefficiencies in the management of feral camel impacts

The management of feral camels and their impacts is governed by a range of legislative instruments at both the Commonwealth and state/territory level. Carey, O'Donnell, Ainsworth, Garnett, Haritos and Williams (2008) identified a range of legal inconsistencies and 'grey areas' that could impede the effective cross-jurisdictional management of feral camels and their impacts and that need to be clarified or ameliorated. These are in the areas of ownership of feral camels, the legal obligation to control, the right of access to land to control feral camels, movement of firearms across state/territory borders, the fencing of waterholes, and the classification of camels as game meat and as stock animals. Their study makes a series of recommendations to address these issues (see Carey, O'Donnell, Ainsworth, Garnett, Haritos, Williams, Edwards, McGregor and Zeng 2008 for discussion and Carey, O'Donnell, Ainsworth, Garnett, Haritos and Williams 2008 for details).

Key recommendation 9: Legislation be harmonised across all jurisdictions to remove barriers to effective cross-jurisdictional management of the negative impacts of feral camels.

3.3 Commercial use of feral camels

Internationally there is a significant camel industry based on meat, live animals, and by-products. In Australia, by contrast, the industry has struggled to gain momentum because it has been based on the ad hoc harvest of a feral animal herd that is located in very remote parts of the country and is a long distance from domestic markets, let alone international markets. The lack of appropriately located and accredited processing abattoirs has also been a significant obstruction for the industry. The harvesting of feral camels started in the late 1980s, and by 2007 it was estimated that the Australian camel industry harvested around 5000–6000 camels per year: 3600–4600 for pet meat, fewer than 400 for live export and 1000 for mainly domestic human consumption. The camel industry in Australia is still very small when compared internationally. However, the size of the feral camel resource of approximately one million animals makes the Australian herd the fifth largest in the world behind Somalia, Sudan, Ethiopia, and Mauritania.

There is potentially a large market for camel products, and a well-developed camel industry could provide an important mechanism to address the negative impacts of feral camels by strategically reducing populations at locations where commercial approaches are viable. A well-developed camel industry could also provide much-needed employment and economic activity in arid Australia. However, a well-developed camel industry will take some time to evolve. The large-scale population reductions that are needed to mitigate camel impacts in the short term cannot be achieved with commercial methods alone. Rather, a combination of commercial and non-commercial methods will be required.

Of the commercial methods investigated in this research, the slaughtering of feral camels for pet meat seems most likely to make the greatest contribution to managing the impacts of feral camels in the immediate future, followed by a meat industry for human consumption and live export. Pet meating is attractive as it involves minimal capital infrastructure to develop and could quickly provide livelihoods for Aboriginal people. However, the contribution from commercial activities will depend on the development of secure markets that are prepared to pay the real costs of harvesting and transport.

The camel industry at present is not organised and lacks some key components to allow it to develop. The key missing elements are the lack of suitable capital infrastructure for harvesting, transporting, and processing animals; incomplete information on potential markets including meat for human consumption and pet meat; no collective vision on how the industry should develop; and a lack of dialogue and consultation with land owners.

In many Aboriginal communities there has been considerable discussion about the development of the camel meat industry and other uses of feral camels (e.g. for pet meat). This has contributed to a perception that feral camels are a resource rather than a pest in remote desert settlements (Gee & Greenfield 2007). Aboriginal people and pastoralists are keen to take up opportunities presented by the commercial utilisation of camels and see it as an opportunity for local economic development, employment, capacity building, and empowerment (refer to Zeng & Edwards 2008a, Vaarzon-Morel 2008a). They generally would like to be directly involved in the industry rather than see economic benefits go to external businesses.

The camel industry in Australia must have a unique structure because commercial utilisation would also form part of a national framework designed to mitigate the negative impacts of feral camels. There is clearly a market failure in play at present that has allowed camel numbers to increase in an uncontrolled manner as society has not factored in the non-market impacts of feral camels on Australia's natural and cultural resources. A market-based instrument (MBI) approach is currently being trialled in SA and may help to deal with this market failure. However, the MBI approach should focus on the removal of feral camels from the landscape as the 'market' that is in need of stimulation, not the commercial utilisation of feral camels. As such, the use of MBIs should be limited to situations where the commercial extraction of feral camels is a strategic component of a wider cross-jurisdictional feral camel management plan and not as a subsidy for the establishment of a new industry.

The farming of camels could support a sustainable alternative pastoral industry but would not contribute directly to the management of feral camel impacts, because camel farming would establish and maintain a permanent domesticated population of camels. However, it could make an indirect contribution by increasing the value of feral camels that are commercially harvested and by increasing the imperative to manage feral camels from a disease transmission perspective. Given that farming will need to occur to ensure a sustainable camel industry in the long term, it will be important to put appropriate regulatory structures in place that ensure that domesticated animals are contained so they cannot return to the feral herd and are traceable through electronic tagging in the same way as cattle.

Live camel export, meat for human consumption, and pet meat are the major commercial enterprises that would contribute directly to feral camel population reduction and hence impact mitigation. While there should be a focus on continuing to enlarge the international market, the domestic market must also be considered. Other commercial uses for feral camels – such as the production of milk, skin, and game meat; the development of camel tourism; camel farms; and their use for undertaking weed control – would contribute very little to reducing the impacts of feral camels. However, the multiple-use of camels would increase the economic viability of a camel industry.

Key recommendation 10: The commercial utilisation of feral camels can, and should, be integrated into a national strategy to manage the negative impacts of the species.

Key recommendation 11: There is a need to develop critical capital infrastructure, particularly export-accredited abattoirs to support the development of commercial activities.

Key recommendation 12: The use of a market-based instrument (MBI) approach should be trialled across tenures and jurisdictional boundaries, but these should only be used to encourage the reduction in feral camel impact and should not be seen as a subsidy for the establishment of a new industry.

Key recommendation 13: Any future commercial operations on Aboriginal land (and other tenures) should be underpinned by business models that foster the involvement of local people. Such models should provide for training, including mentoring in business management, and flexible employment (see also Key recommendation 20).

Key recommendation 14: A national peak body should be established to coordinate the camel industry's development. The role of the peak body would be to speak for the commercial industry; advise government on the needs of the industry in terms of legislation and regulation, capital infrastructure, training, market development, and research based on an industry strategic plan; research potential markets for camel products; facilitate communication, information sharing, and cooperation among the industry participants; and develop a dialogue between the industry, land managers, and government.

3.4 Non-commercial approaches

As stated above, non-commercial methods currently used to manage the impacts of feral camels are aerial platform (helicopter) shooting, ground-based shooting, and exclusion fencing (including barriers that allow for partial access). Of these three methods, aerial shooting and ground-based shooting are considered to have application in the broadscale management of feral camel impacts through population reduction. For feral camels, broadscale management is defined as that which occurs at scales of greater than 10 000 km^2. Given the feral camel's considerable mobility and the large range occupied (see above), this is considered the minimum area over which management would need to occur to be effective in mitigating impacts on important values. It is estimated that between 10 000 and 20 000 feral camels are removed from the population each year using aerial and ground-based shooting (Saalfeld & Zeng 2008). Live camel export, meat for human consumption and pet meat are the commercial enterprises considered to have application in the broadscale management of feral camels and their impacts (see section 3.3)

Of the three non-commercial methods, aerial shooting is the most widely implemented by management agencies. The cost range for aerial shooting reflects the availability of animals at different densities. Although the detailed nature of the management cost/density relationship is unknown for camels, indicative costs are \$20–30 per animal at high density (densities greater than 0.3 animals/km^2); \$40–100 per animal for densities in the range 0.3–0.1 animals/km^2; and a cost per animal >\$100 for densities less than 0.1 animals/km^2. Aerial shooting from helicopters can achieve quick and effective broadscale damage mitigation through large population density reductions over relatively short time periods (weeks to months) and is the only available management method that can be used in very remote or inaccessible areas. For these reasons, aerial shooting is regarded as the non-commercial management method with the greatest applicability to broadscale feral camel damage mitigation (Saalfeld & Zeng 2008). Aerial shooting programs must be designed to remove the required number of animals to reduce negative impacts to acceptable levels. In order to achieve this objective, initial and final population densities must be known, requiring pre- and post-control population monitoring. The high cost of aerial shooting at low population densities means that other approaches may be required in these situations.

The majority of ground-based shooting is opportunistic in nature and implemented individually by pastoralists rather than by management agencies. The limitations of ground-based shooting compared with aerial shooting include restricted access to animals, reduced ability to follow up wounded animals and reduced ability to remove large numbers of animals in short time frames. For these reasons, ground-based shooting is considered to be of limited applicability in broadscale situations where damage mitigation requires the removal of large numbers of camels or where access is difficult. It is best suited to a long-term management role of maintenance of relatively low density populations in accessible areas in combination with other management activities.

The use of exclusion fencing has been limited to a number of waterholes of both cultural and conservation significance in central Australia. While exclusion fencing is successful in protecting high-value cultural and environmental assets, the high cost of fence installation and maintenance largely prohibits its use in areas greater than a few hectares. Exclusion fencing is not considered to be a broadscale management tool.

Key recommendation 15: Aerial shooting be regarded as the non-commercial control method with the greatest applicability to the broadscale reduction of the negative impacts of feral camels. Ground-based shooting is considered to be of limited applicability in broadscale situations where damage mitigation requires the removal of large numbers of camels or where access is difficult. It is best suited to a long-term management role of maintenance of relatively low density populations in accessible areas in combination with other management activities. Exclusion fencing is not considered to be a broadscale management tool but is suitable for protection of small areas having high cultural or environmental value.

Chemical (poison), biological, and fertility controls are not currently in use but could have potential application in addressing the negative impacts of feral camels. A review undertaken for this project (Lapidge et al. 2008) has identified a number of potential avenues for further consideration.

Key recommendation 16: Techniques and opportunities for chemical, biological, and fertility control of feral camels should be investigated as a means of reducing their negative impacts.

4. Guiding principles in managing the impacts of feral camels – a new way to do business

As stated above, management of the impacts of pest animals should be informed by a risk management approach and be strategic in determining where management should occur, at what time, and what techniques should be used (*Australian Pest Animal Strategy* 2007). It requires coordination at the appropriate scale among all levels of government in partnership with industry, land managers, and the community (*Australian Pest Animal Strategy* 2007). The current management of feral camels, being largely ad hoc (Edwards et al. 2004), fails to adequately meet any of these criteria. There is, therefore, a need to develop a new paradigm for managing the impacts of feral camels that is based on the characteristics of the animal and the physical and socio-cultural environment within which feral camels are found. Based on the research described in this report, this paradigm should be based on the following principles:

4.1 Focus on impacts

Key recommendation 6 noted that the management of feral camels should focus on mitigation of negative impacts, not reduction in the number of camels per se. However, as there is a positive relationship between camel density and degree of damage, reducing camel density is an important strategy in achieving damage mitigation. For a species such as the camel, which has a large body size and a relatively slow rate of population increase, the best strategy for reducing population density is to target adult survival, not reproductive output (McLeod & Pople 2008).

Key recommendation 8 stated that feral camels need to be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.

4.2 One size does not fit all

Recognition that one size does not fit all is an important starting principle. Not all management methods will be acceptable to all land owners/managers and not all approaches are suited to all areas. While most pastoral and conservation landholders are comfortable with shooting to waste, many Aboriginal people are not. Many pastoral and conservation landholders are more interested in mitigating the impacts of feral camels as opposed to making money out of them. In contrast, many Aboriginal people want jobs based wholly or in part on managing camels and their impacts. This means that there are constraints on the implementation of some management methods which limit their applicability in certain parts of the landscape.

4.3 Collaboration: A cross-jurisdictional, cross-tenure, cross-boundary, and cross-sectoral approach

Collaboration is fundamental to successful mitigation of camel impacts and there is a need for collaboration at all levels. This includes cross-jurisdictional, cross-tenure, cross-boundary, and cross-sectoral collaboration. In the course of this research we have found a significant level of support from both private and public sector land managers and organisations for managing the negative impacts of feral camels.

Feral camels are highly mobile animals and are currently found across the following jurisdictions: Qld, NT, SA, and WA (Figure 12.1). They are also found across all of the tenure types found in desert Australia (Figure 12.2), with the highest densities found on Aboriginal-managed lands, followed by vacant Crown land, and areas managed for conservation values (Table 12.2).

Aboriginal land managers, pastoralists, and conservation land managers are all key stakeholders in the management of feral camels and their impacts. All of these stakeholder groups see a need to control feral camels and their impacts, and they currently play an active and important role in this regard. Our research has found that they are willing to engage in collaborative management approaches. Pastoralists favour culling and commercial use management options, but, like conservation land managers, they are comfortable using all of the available methods and are willing to consider new ones.

Table 12.2: Estimated feral camel population abundance and density for each of the major tenure classifications within the Australian camel distribution

Tenure classification	Area (km^2)	Population (%)	Density (camels/km^2)
Aboriginal	783 000	415 000 (43%)	0.53
Pastoral	1 399 000	210 000 (22%)	0.15
Vacant Crown land	813 000	236 000 (25%)	0.29
Conservation/other	335 000	94 000 (10%)	0.28

Many Aboriginal people, particularly those who live in high density camel areas, see a need to harvest feral camels and control their impacts. While there are currently only a small number of Aboriginal people involved in these activities, there are individuals who have broad experience working with camels and possess relevant skills and knowledge, which they are keen to use in feral camel management programs on Aboriginal land. It is important to both recognise and build on this knowledge and interest base when developing and implementing management plans to address the negative impacts of feral camels.

Our research has found that Aboriginal people lack the necessary support and resources to play a greater role in feral camel impact management. In particular, they lack detailed and accessible information about feral camel management issues, meaning they cannot make fully informed decisions about management options and ways to develop and implement management programs and activities. They are keen to obtain more information on these matters and associated training.

The majority of Aboriginal people interviewed for this project were not comfortable with all of the methods available to manage the negative impacts of feral camels. However, the Aboriginal 'community' is not homogenous. There are diverse perspectives emerging in response to transformations being brought about by feral camels on Aboriginal land. The research shows that people with greater camel management experience tend to have different attitudes from others. At the present time, the range of camel management approaches is not generally available to Aboriginal communities (Vaarzon-Morel 2008a).

Key recommendation 17: Development of collaborative structures is fundamental to the successful mitigation of feral camel impacts and there is a need for collaboration at all levels. This includes cross-jurisdictional, cross-tenure, cross-boundary, and cross-sectoral collaboration.

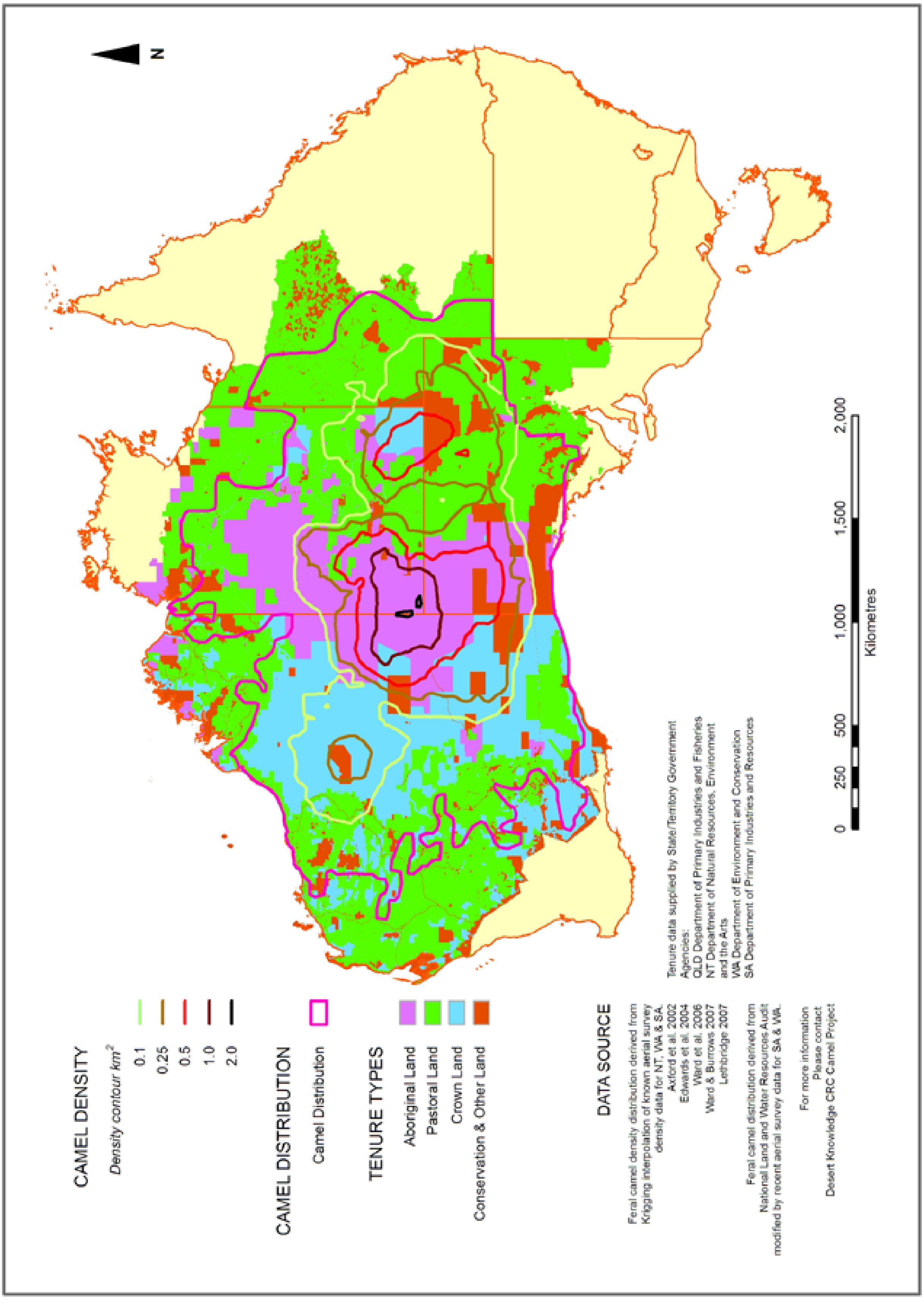


Figure 12.2: Tenure types within the Australian feral camel distribution with feral camel density contours overlain

Note: Contour intervals are 0.1, 0.25, 0.5, 1.0, and 2.0 camels/km².

4.4 Stakeholder engagement

There are a large number of people (including Aboriginal people, pastoralists, and conservation land managers) living within the feral camel's range who are able and willing to engage in managing the negative impacts of feral camels. Where appropriate, this goodwill and these skills should be used in order to achieve agreed/desired outcomes. This is not simply a matter of providing information but of working with people in a participatory way so that they take ownership of issues and solutions. Such engagement and subsequent ownership of the solution(s) is fundamental to successful mitigation of camel impacts.

It is essential that government agencies engage with Aboriginal people, communities, and organisations representing Aboriginal land interests in developing and implementing a cross-jurisdictional management framework for managing feral camels and their impacts. Aboriginal people are interested and willing to engage in collaborative management programs. However, interest varies within and among communities throughout the feral camel range. It is also predicated on the meaningful engagement of Aboriginal people in the programs and the creation of opportunities, support, and investment in areas such as jobs, income, resources, and training.

Key recommendation 18: Ensure that the willingness and capacity of Aboriginal people, pastoralists, and conservation land managers to engage in feral camel impact management and their intimate knowledge about such impacts and camel presence are harnessed when developing and implementing a cross-jurisdictional management approach, by undertaking appropriate consultations and providing necessary support and opportunities for collaborative engagement. Consultations involving people with customary interest in land and involving other community members must be undertaken and coordinated by representative bodies charged with managing Aboriginal land and should focus on the negative impacts that camels are having and how these might be addressed.

4.5 Communication

Communication is fundamental to successful mitigation of camel impacts. A communication strategy will need to be developed to disseminate information in culturally appropriate formats to all relevant stakeholders. This strategy should provide for two-way communication. The key elements of such a strategy are as follows:

- Provide feedback on the findings of this camel project to those who have been involved in the form of targeted printed material in the appropriate format, meetings, and workshops.
- Provide information on the cost and benefits of both commercial and non-commercial management options to stakeholders.
- Provide Aboriginal people and communities interested in feral camel impact management projects with support and assistance in the form of information, resources, and training. This should include support for Aboriginal groups that want to operate independent 'flexible capture' programs.
- Recognise that people living outside the camel range have a stake in the decisions being made about feral camel impact management. There will be a need to develop a communications campaign that explains the magnitude of the feral camel problem and nature of the management solutions.

Key recommendation 19: Develop a communications strategy aimed at informing all stakeholders, including those not directly impacted, of the magnitude of the feral camel problem, and the options for impact mitigation, including the costs and benefits (quantitative and qualitative) of the management options. The communications strategy must be professionally developed and appropriately targeted at the intended audience.

4.6 Address multiple threats

NRM programs should address multiple threats and consider unintended consequences and flow-on effects. It is often the case that NRM requirements in a particular locality cover a range of needs in addition to mitigating the negative impacts of pest animals. For example, there may also be a need to manage weeds, conduct fire management, implement erosion control, etc. Similarly, there may be a concurrent need to address the impacts of more than one pest animal at a particular locality. Considerable efficiencies may be gained through integrating NRM actions into a single work program, particularly if work in remote areas is involved.

Consideration also needs to be given to non-intended consequences of any management actions. There is increasing evidence that management actions taken to mitigate the impacts of vertebrate pests can have unintended or flow-on effects. For example, the shooting of large numbers of camels to waste provides carrion which may favour population growth in foxes. This unintended effect may have adverse impacts on native fauna at risk due to fox predation.

4.7 Livelihood development

Development of livelihoods is a legitimate and desirable outcome of managing the impacts of feral camels, and a range of opportunities exist. These are associated with existing commercial approaches (e.g. pet meating, meat for human consumption, etc.), ecotourism, and NRM. Jobs in NRM could be usefully underpinned by custodianship models linked to biodiversity offset programs or the Caring for Country initiative (see http://www.environment.gov.au/indigenous/index.html). The Caring for Country initiative capitalises on the fact that there is a lot of remote country that needs management (on behalf of all Australians) and that there are Aboriginal people with skills in NRM living in that country who can do the job. The Caring for Country initiative is a multiple payoff initiative. It not only places Aboriginal people in appropriate and meaningful jobs that use their skills, it keeps people on country, builds self esteem, and also promotes health and wellbeing. This research has identified potential NRM livelihood opportunities in the areas of reducing populations to mitigate impacts, monitoring of populations before and after management intervention to reduce numbers, monitoring the reduced impact that results from removing camels and collecting data to allow improved decision making in targeting areas for non-commercial management approaches. Aboriginal Ranger programs are considered a model under which these opportunities could be developed.

Recent research reported by the DKCRC has found that activities such as looking after the landscape, hunting, fire management, and pursuing arts and crafts related to country all have a payoff in terms of reducing the impact of chronic disease in remote Aboriginal settlements. They benefit the community itself – but they also benefit the wider Australian community through improved NRM values and health and wellbeing. The saved health cost associated with treatment for three chronic diseases – blood pressure, renal disease, and diabetes – has been calculated at $120 000 a year, for a net present value of savings over 25 years of $2 million for a settlement of 1200 people (DKCRC 2008).

Key recommendation 20: Both commercial and non-commercial approaches to the management of feral camel impacts provide opportunities for local economic development, employment, capacity building, and empowerment. The overwhelming benefits of employing land managers, especially Aboriginal people and pastoralists in Caring for Country type initiatives, should be recognised as an activity that has national significance and is in need of sustained investment.

4.8 Sustained investment model

Sustained investment models are needed to support camel impact management. In the spirit of the collaborative approach mentioned above and the importance of stakeholder ownership, investment models should ideally be based on private–public partnerships. Initially there may be a need for an injection of public resources to kick-start management at the appropriate scale to address critical impact issues. MBIs may be useful vehicles for achieving this purpose. However, as the level of threat abates and becomes acceptable, there should be increasing private investment in maintenance management and monitoring to maintain asset protection in perpetuity.

Key recommendation 21: Any proposed program to manage the negative impacts of feral camels must be fully resourced (including all monitoring requirements) so that it can produce the desired outcomes.

As part of this research a cost/benefit analysis based on a bio-economic model was developed to evaluate specific feral camel control strategies and impact abatement in the central Region of the NT (Drucker 2008b). Two different aerial control strategies were modelled. Strategy 1 involved annual removals, while strategy 2 involved periodic removals only when a specific feral camel density was reached. Given the large positive net economic value of population reduction to achieve damage mitigation and the robustness of the overall findings of the modelling, there would appear to be a very strong argument for considering the immediate implementation of a full-scale, long-term feral camel control program. The difference between the economic benefits under the different strategies suggests that a control strategy based on annual removals is almost always likely to be preferred. We can therefore conclude that the magnitude of the benefits arising from a given control strategy should play a key role in control strategy choice.

5. Framework for the cross-jurisdictional management of the impacts of feral camels

The principles outlined above were used in developing the following framework for the cross-jurisdictional management of the impacts of feral camels. The framework divides the camel distribution into four management zones.

5.1 Management Zones

The framework for the cross-jurisdictional management of the impacts of feral camels is underpinned by identification of four broad Management Zones (Figure 12.3) as described in Saalfeld et al. (2008). These Management Zones were defined on the basis of the range of constraints, restrictions, or limitations associated with available broadscale methods for reducing populations (i.e. aerial culling, ground culling, commercial extraction for pet meat, commercial extraction for human consumption, and commercial extraction for live export) and the perceived need for management intervention aimed at reducing impacts.

Management Zone 1: This zone supports the highest densities of feral camels (>1.0 animals/km^2) and is the zone of greatest broadscale camel impact. It is approximately 116 000 km^2 in size and encompasses much of the Petermann Aboriginal Land Trust in the NT, the Ngaanyatjarra Lands in WA, and the very northern part of the A<u>n</u>angu Pitjantjatjara Yankunytjatjara (APY) Lands in SA. Values that are under threat as a result of feral camels include wetlands, native vegetation, cultural sites, bushtucker, and infrastructure in Aboriginal communities (Table 12.3). There was significant damage to infrastructure on Aboriginal communities in this zone in January–March 2007 (Edwards et al. 2008). All of the available broadscale management methods can be applied in Zone 1 to effect damage mitigation through population reduction. However, aerial and ground-culling options would need to be negotiated with the Aboriginal landholders if they were to be adopted in this zone. Exclusion fencing could be used in the zone to mitigate expected high levels of camel impact at important local sites (e.g. individual waterholes or cultural sites).

Management Zone 2: This zone supports the second highest densities of feral camels (greater than 0.5 animals/km^2). Densities are considered sufficiently high to warrant concern about possible broadscale camel impacts (Edwards et al. 2008) and the zone contains a range of values that are believed to be under threat as a result of feral camels (Table 12.3). The zone is approximately 61 000 km^2 in size and encompasses much of the Simpson Desert. The area is suitable only for aerial culling and there should be few if any landholder constraints on undertaking aerial culling in this area to effect damage mitigation through population reduction. Exclusion fencing is considered only marginally suitable over most of the zone but could be used to mitigate camel impact at important local sites if warranted (e.g. individual waterholes or cultural sites).

Table 12.3: Values within the management zones that are under threat as a result of feral camels

Value	Zone 1	Zone 2	Zone 3	Zone 4
Wetlands	XXXXX	XX	XXX	X
Drainages		XXXXX	X	X
Bush tucker	XXXXX	XXXXX	XX	X
Native vegetation	XXXXX	XXXXX	XXX	X
Cultural sites	XXXXX	XXX	XXX	X
Community infrastructure	XXXXX		XX	X
Pastoral infrastructure*		XXX	XXX	XX
Conservation reserves	XXXXX	XXXXX	XXX	X
Vehicles/people in vehicles	XXXXX		XX	X
Cattle production**		XX	XX	X
Archaeological sites		XX	XX	X

*See Figure 7.10 (Edwards et al. 2008)

** Perception-based impact (see Zeng & Edwards 2008a, Edwards et al. 2008)

Note: Number of Xs indicates magnitude of current threat: the more Xs the higher the threat.

Management Zone 3: This zone is a large area of approximately 785 000 km^2 and corresponds to about 23% of the total Australian camel distribution. It covers most of central Australia and includes the full suite of tenure classes addressed in the report: Aboriginal land, pastoral land, vacant Crown land, and conservation/other lands. Camel densities vary across the zone from 0.25 up to 1.0 animals/km^2 (immediately surrounding Zone 1). Although the camel density in the zone is not as high as in Zones 1 and 2, the minimum density of camels in the zone exceeds the recommended long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) required to mitigate broadscale negative impacts (see Key recommendation 8). There was significant damage to infrastructure on pastoral leases in this zone in January–March 2007 (Edwards et al. 2008). There is a need for broadscale management across this zone to reduce population densities and thereby the negative impacts of feral camels, and all management methods are either suitable or marginally suitable. There will be constraints on management methods due to landholder perceptions: non-commercial management methods are not acceptable across some Aboriginal land, and commercial management methods are less preferred on vacant Crown land and conservation/other lands. Exclusion fencing is considered only marginally suitable over most of the zone but could be used to mitigate camel impact at important local sites if warranted (e.g. individual waterholes or cultural sites).

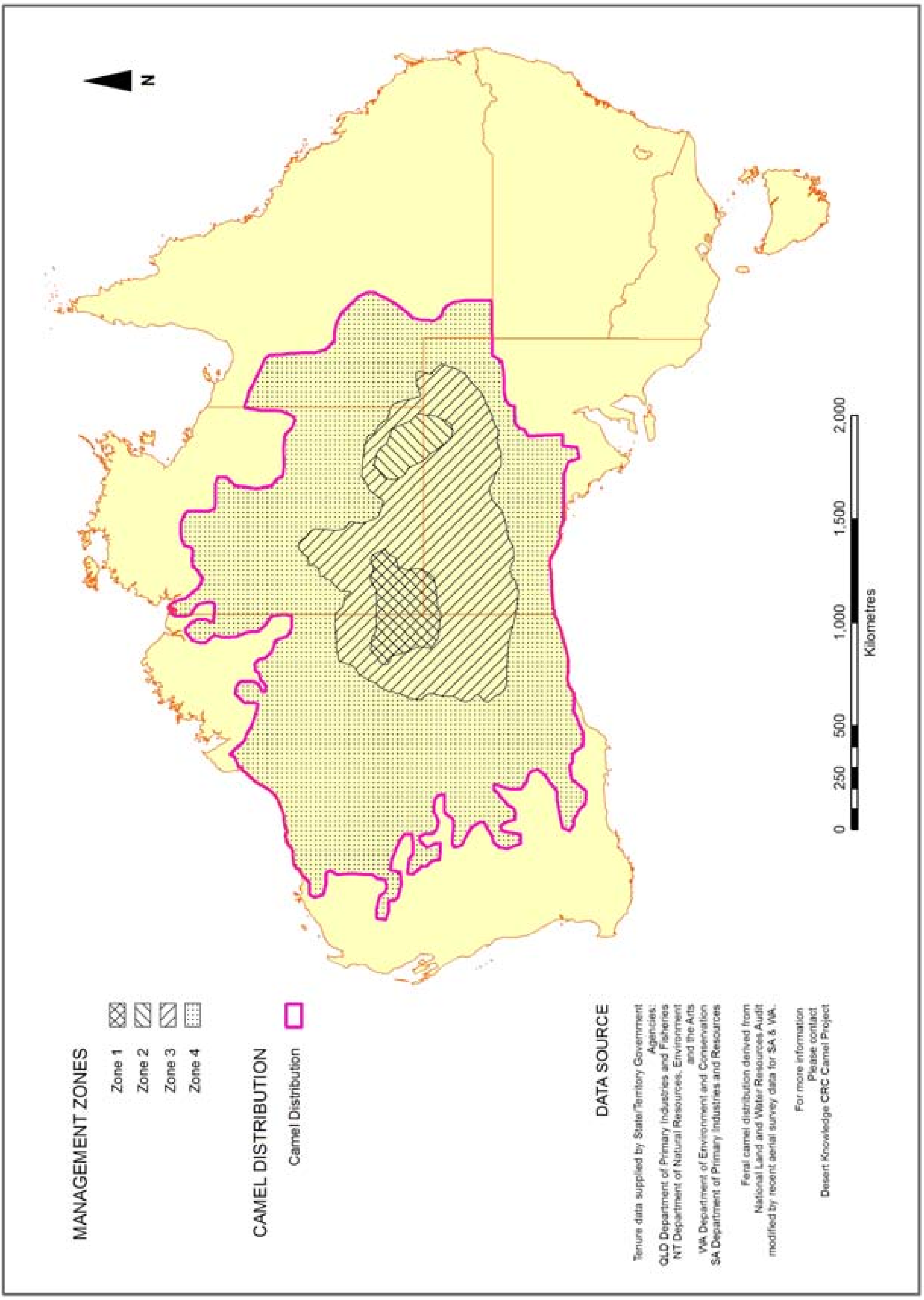


Figure 12.3: Map showing the distribution of feral camels and the proposed management zones

Management Zone 4: This zone encompasses the remainder of the Australian camel distribution and covers 2.4 million km^2, slightly greater than 70% of the total distribution. The camel density across the zone was estimated to be relatively low in comparison with the other zones (fewer than 0.25 animals/km^2 over most of the zone but with a small area in north-west WA having a density slightly above 0.25 animals/km^2). However, there was a problem with the Krigging process used to estimate camel densities for this zone, particularly on the margins of the zone, and densities may be marginally higher than the estimates indicate. Despite this problem, camels are not considered to be causing serious broadscale damage to cultural and environmental values over most of the zone, with the possible exception of the area in north-west WA having a density slightly above 0.25 animals/km^2. However, pastoral assets within this zone may need protection. Some cattle properties in the marginal region of the zone did report significant camel impacts during the survey of pastoral properties (Zeng & Edwards 2008a). This highlights the fact that there are camels on the margins of the distribution where Krigging indicated that there were none, and that localised densities may be high enough to be causing a level of impact that warrants management action. All of the broadscale management methods were deemed either marginally suitable or unsuitable for application over most of Zone 4. The exception to this is that small patches of Zone 4 in the east and west were identified as being suitable for both aerial culling and live export. Reported camel impacts on pastoral properties that fringe the camel distribution may best be addressed through a coordinated program of ground shooting, providing that camels can be accessed by road. Fencing is considered unsuitable over most of Management Zone 4 but could be used to mitigate camel impact at important local sites if warranted (e.g. individual waterholes or cultural sites).

5.2 Recommended strategy

There should be an initial management focus (with significant resource investment) on Management Zones 1, 2, and 3. Here management should focus on mitigating the negative impacts of feral camels in as short a time frame as is possible (<5 years) through a combination of broadscale population reduction and exclusion fencing at the local level. Feral camels should be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing (Key recommendation 8). In Management Zone 4, management should be applied in situations where camel impacts are unacceptably high. Over most of Zone 4, camel densities and associated impacts are too low to warrant the application of broadscale management approaches.

Advantage should also be taken of opportunities that arise which may expedite efforts to manage negative impacts through population reduction. An example would be targeting camels concentrated on water resources during dry conditions.

Key recommendation 22: Initiate broadscale management programs targeting Management Zones 1, 2, and 3, and provide appropriate resources to allow these to achieve agreed outcomes in respect of damage mitigation. Apply management in Zone 4 as required to address localised impacts.

Given the large geographic areas involved and the need for cross-jurisdictional, cross-tenure, cross-boundary, and cross-sectoral collaboration there will be a requirement for national coordination in managing the impacts of feral camels. This approach is in alignment with the *Australian Pest Animal Strategy* (2007).

Key recommendation 23: Create and fund the position of National Camel Management Facilitator to facilitate collaborative management actions across jurisdictions to mitigate the negative impacts of feral camels.

The framework outlined above is not intended to address how prescribed management would be rolled out across the four Management Zones. There will be a need to develop detailed activity plans for each zone. Actions to ameliorate camel impacts should build on existing management initiatives, draw on local expertise, and capitalise on local people's willingness to engage in camel management. Appropriate management would need to be applied at the appropriate scale to mitigate impacts. Appropriate management is that which is acceptable to the landholders, is cost-effective, and is humane.

The first step in developing activity plans would be initiation of discussions between state and territory governments and the Commonwealth, and then with agencies with legislative responsibility in the appropriate areas. Appropriate areas would include pest animal management but could also include, for example, health, animal welfare, and employment. Following this would be establishment of a two-way communication process between management authorities and local landowners. This would ensure that local landowners were aware of the full range of issues, including details of the management framework outlined here, their responsibilities, and the range of management options available to them. This would allow landowners to make informed decisions in respect of managing the impacts of feral camels on their land. The communication process would also ensure that management authorities were aware of landholder aspirations and degree of acceptance of various management methods. Once agreement had been reached on desired outcomes and the management methods to be used in particular locations, governments and the private sector would need to work with local communities to maximise local livelihood opportunities and to provide adequate and sustained resourcing to allow agreed outcomes to be met and maintained.

MBIs may enter into negotiations at this early stage. They could play a key role in kick-starting management programs and in providing valuable work experience and training. However, as stated above, their use should be limited to situations where the commercial extraction of feral camels is a strategic component of a wider cross-jurisdictional feral camel impact management plan and not as a subsidy for the establishment of a new industry. That said, MBIs are particularly well suited to Zone 1 and Zone 3. The multi-threat approach to management would enhance the development of sustainable employment opportunities.

Monitoring of outcomes is a key element of any NRM program. In managing camel impacts, outcomes that should be monitored include damage mitigation, legislative change conducive to effective management of camel impacts, stakeholder attitudes to camel impact management, job creation, and camel industry development. Monitoring of damage mitigation is a task that could be completed by local landowners, thereby enhancing the development of sustainable employment opportunities.

The Decision Support Tool developed for this project (Saalfeld et al. 2008, Lamb & Saalfeld 2008) is capable of addressing regional or even local-scale management issues with spatial input data of the appropriate scale. Data presented in Appendices 11.10–11.12 in Saalfeld et al. (2008) and like spatial data pertaining to the spatial distribution of important environmental assets can be used to set priorities within Management Zones to mitigate the impacts of camels on biodiversity values.

Key recommendation 24: That the GIS-based Multiple Criteria Decision Support Tool developed here be further enhanced and used for feral camel management planning when new finer-scale spatial data become available.

6. Future research needs

Waiting for further research and development results is not a justifiable reason to stop immediate action for the management of feral camel impacts. There is enough information available now to show that feral camels are a serious problem and to provide a pathway forward in terms of damage mitigation. There are, however, some areas of research identified that would enhance the control strategy outlined above. These are:

- Better quantify the density/damage relationship for feral camels across a range of environments and for various response variables (including environmental variables), with particular emphasis on identifying the threshold density below which impacts are negligible.

- Develop appropriate monitoring and evaluation systems (localised and broadscale) for the range of response variables (e.g. camel density, impact mitigation, change in perceptions, legislative change).
- Develop appropriate communication tools that are focused on specific target groups.
- Describe new pathways and systems for creating sustainable employment in remote communities. The DKCRC is currently involved in relevant research that would be applicable here.
- Investigation of pesticide and fertility control agents as prescribed in Lapidge et al. (2008).
- Describe/develop systems to facilitate investment, including consideration of custodianship models, biodiversity offsets, and carbon economy.
- If a commercial meat industry is to be developed for human consumption, market research and market development work is required.
- Resolve survey bias issues.
- Develop a suitable approach for assigning an economic value to the negative impacts of feral camels on environmental and social/cultural values.
- Achieve a better understanding of the factors influencing the movement patterns and population distribution of feral camels at the local to regional scale.
- Develop a dynamic model of feral camel density distribution.

7. References

Australian Pest Animal Strategy: a national strategy for the management of vertebrate pest animals in Australia. 2007. Natural Resources Ministerial Council, Canberra.

Brown A. 2004. *A review of camel diseases in central Australia*, Technical Bulletin 314. Northern Territory Department of Primary Industry, Fisheries and Mines, Alice Springs.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H and Williams G. 2008. *Review of legislation and regulations relating to feral camel management*, DKCRC Research Report 50. Desert Knowledge CRC, Alice Springs.

Carey R, O'Donnell M, Ainsworth G, Garnett S, Haritos H, Williams G, Edwards GP, McGregor M and Zeng B. 2008. Review of legislation and regulations relating to feral camel management (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 125–132. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

CSIRO. 2007. *Climate change in Australia*, Technical Report. Commonwealth Scientific and Industrial Research Organisation. Available at: http://www.climatechangeinaustralia.gov.au/resources.php

DKCRC. 2008. Media Release: *Living 'on country' pays off*. DKCRC, Alice Springs. 10 August 2008.

Dörges B and Heucke J. 2003. *Demonstration of ecologically sustainable management of camels on Aboriginal and pastoral land*, Final report on project number 200046, Natural Heritage Trust (Online). Available at: http://www.camelsaust.com.au/NHTreport2003.doc

Drucker AG. 2008a. *Economics of camel control in the central region of the Northern Territory,* DKCRC Research Report 52. Desert Knowledge CRC, Alice Springs.

Drucker AG. 2008b. Economics of feral camel control in the central region of the Northern Territory (summary). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 283–286. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Edwards GP, Eldridge SR, Wurst D, Berman DM and Garbin V. 2001. Movement patterns of female feral camels in central and northern Australia. *Wildlife Research,* vol. 28, 283–289.

Edwards GP, Saalfeld K and Clifford B. 2004. Population trend of camels in the Northern Territory, Australia. *Wildlife Research,* vol. 31, 509–511.

Edwards GP, Zeng B and Saalfeld WK. 2008. Evaluation of the impacts of feral camels. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 133–182. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Gee P and Greenfield B. 2007. 'SA Arid Lands Feral Camel Management Plan', DRAFT, South Australia Arid Lands Natural Resource Management Board, South Australia.

Grigg GC, Pople AR and Beard LA. 1995. Movements of feral camels in central Australia determined by satellite telemetry. *Journal of Arid Environments,* vol. 31, 459–469.

Hart Q and Bomford M. 2006. *Australia's pest animals: new approaches to old problems*. Department of Agriculture, Fisheries and Forestry, Canberra.

Hone J. 2007. *Wildlife Damage Control*. CSIRO Publishing, Collingwood.

Lamb D and Saalfeld WK. 2008. *A multiple criteria decision support framework for the management of feral camels*, DKCRC Research Report 53. Desert Knowledge CRC, Alice Springs.

Lapidge SJ, Eason CT and Humphrys ST. 2008. *A review of chemical, biological and fertility control options for the camel in Australia*, DKCRC Research Report 51. Desert Knowledge CRC, Alice Springs.

McLeod SR and Pople AR. 2008. *Modelling management options for management of feral camels in central Australia*, DKCRC Research Report 48. Desert Knowledge CRC, Alice Springs.

Saalfeld WK and Edwards GP. 2008. Ecology of feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 9–34. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK, Edwards GP, Zeng B and Lamb D. 2008. A Multiple Criteria Decision Support Tool for feral camel management. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 287–330. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Saalfeld WK and Zeng B. 2008. Review of non-commercial control methods for feral camels in Australia. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 185–220. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008a. Key stakeholder perceptions of feral camels: Aboriginal community survey (abridged). In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 79–124. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Vaarzon-Morel P. 2008b. *Key stakeholder perceptions of feral camels: Aboriginal community survey,* DKCRC Research Report 49. Desert Knowledge CRC, Alice Springs.

Yu S. 2002. Ngapa kunangkul (Living water): an indigenous view of groundwater, in *Country: visions of land and people in Western Australia*, Eds A Gaynor, M Trinca and A Haebich, Perth, Western Australian Museum and Lotteries Commission of Western Australia.

Zeng B and Edwards GP. 2008a. Key stakeholder perceptions of feral camels: pastoralist survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 35–62. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

Zeng B and Edwards GP. 2008b. Key stakeholder perceptions of feral camels: Conservation manager survey. In: GP Edwards et al. (Eds), *Managing the impacts of feral camels in Australia: a new way of doing business*. DKCRC Report 47. Desert Knowledge Cooperative Research Centre, Alice Springs. pp 63–78. Available at http://www.desertknowledgecrc.com.au/publications/contractresearch.html

8. Summary of key recommendations

The research has resulted in the following key recommendations:

Key recommendation 1: That the broadscale aerial survey database of feral camel distribution and abundance be expanded by implementing aerial survey in areas not previously covered in order to improve estimation of density distribution for feral camels.

Key recommendation 2: That research be undertaken to address the issue of environmental bias associated with current aerial survey estimates of feral camel population distribution and abundance. This could be achieved by conducting a survey in an area, then removing a significant number of the camels in the area, then resurveying the area (i.e. an index-manipulate-index experiment).

Key recommendation 3: That a national database be created incorporating all available aerial survey data related to feral camels from all jurisdictions, with data incorporated at the finest spatial scale available, and that this database be supported by all jurisdictions.

Key recommendation 4: That efforts are made to achieve a better understanding of the factors influencing the movement patterns and population distribution of feral camels at the local to regional scale. This would allow static aerial survey data to be more accurately projected forwards and facilitate the development of a dynamic model of feral camel density distribution.

Key recommendation 5: Investigate different methods of survey that may yield accurate data over large areas at minimal cost.

Key recommendation 6: The management of feral camels should focus on mitigation of negative impacts. As there is a positive relationship between camel density and degree of damage, reducing camel density is an important strategy in achieving damage mitigation.

Key recommendation 7: There is a need to quantify the density/damage relationship for feral camels for response variables (particularly environmental and cultural variables) for which the relationship is not known across a range of environments and with particular emphasis on identifying the threshold density below which impacts are negligible.

Key recommendation 8: Feral camels be managed to a long-term target density of 0.1–0.2 camels/km^2 at property to regional scales (areas in the order of 10 000–100 000 km^2) in order to mitigate broadscale negative impacts on infrastructure on pastoral stations and in remote settlements, and on plant species that are highly susceptible to camel browsing.

Key recommendation 9: Legislation be harmonised across all jurisdictions to remove barriers to effective cross-jurisdictional management of the negative impacts of feral camels.

Key recommendation 10: The commercial utilisation of feral camels can, and should, be integrated into a national strategy to manage the negative impacts of the species.

Key recommendation 11: There is a need to develop critical capital infrastructure, particularly export-accredited abattoirs to support the development of commercial activities.

Key recommendation 12: The use of a market-based instrument (MBI) approach should be trialled across tenures and jurisdictional boundaries, but these should only be used to encourage the reduction in feral camel impact and should not be seen as a subsidy for the establishment of a new industry.

Key recommendation 13: Any future commercial operations on Aboriginal land (and other tenures) should be underpinned by business models that foster the involvement of local people. Such models should provide for training, including mentoring in business management, and flexible employment (see also Key recommendation 20).

Key recommendation 14: A national peak body should be established to coordinate the camel industry's development. The role of the peak body would be to speak for the commercial industry; advise government on the needs of the industry in terms of legislation and regulation, capital infrastructure, training, market development, and research based on an industry strategic plan; research potential markets for camel products; facilitate communication, information sharing, and cooperation among the industry participants; and develop a dialogue between the industry, land managers, and government.

Key recommendation 15: Aerial shooting be regarded as the non-commercial control method with the greatest applicability to the broadscale reduction of the negative impacts of feral camels. Ground-based shooting is considered to be of limited applicability in broadscale situations where damage mitigation requires the removal of large numbers of camels or where access is difficult. It is best suited to a long-term management role of maintenance of relatively low density populations in accessible areas in combination with other management activities. Exclusion fencing is not considered to be a broadscale management tool but is suitable for protection of small areas having high cultural or environmental value.

Key recommendation 16: Techniques and opportunities for chemical, biological, and fertility control of feral camels should be investigated as a means of reducing their negative impacts.

Key recommendation 17: Development of collaborative structures is fundamental to the successful mitigation of feral camel impacts and there is a need for collaboration at all levels. This includes cross-jurisdictional, cross-tenure, cross-boundary, and cross-sectoral collaboration.

Key recommendation 18: Ensure that the willingness and capacity of Aboriginal people, pastoralists, and conservation land managers to engage in feral camel impact management and their intimate knowledge about such impacts and camel presence are harnessed when developing and implementing a cross-jurisdictional management approach, by undertaking appropriate consultations and providing necessary support and opportunities for collaborative engagement. Consultations involving people with customary interest in land and involving other community members must be undertaken and coordinated by representative bodies charged with managing Aboriginal land and should focus on the negative impacts that camels are having and how these might be addressed.

Key recommendation 19: Develop a communications strategy aimed at informing all stakeholders, including those not directly impacted, of the magnitude of the feral camel problem, and the options for impact mitigation, including the costs and benefits (quantitative and qualitative) of the management options. The communications strategy must be professionally developed and appropriately targeted at the intended audience.

Key recommendation 20: Both commercial and non-commercial approaches to the management of feral camel impacts provide opportunities for local economic development, employment, capacity building, and empowerment. The overwhelming benefits of employing land managers, especially Aboriginal people and pastoralists in Caring for Country type initiatives, should be recognised as an activity that has national significance and is in need of sustained investment.

Key recommendation 21: Any proposed program to manage the negative impacts of feral camels must be fully resourced (including all monitoring requirements) so that it can produce the desired outcomes.

Key recommendation 22: Initiate broadscale management programs targeting Management Zones 1, 2, and 3, and provide appropriate resources to allow these to achieve agreed outcomes in respect of damage mitigation. Apply management in Zone 4 as required to address localised impacts.

Key recommendation 23: Create and fund the position of National Camel Management Facilitator to facilitate collaborative management actions across jurisdictions to mitigate the negative impacts of feral camels.

Key recommendation 24: That the GIS-based Multiple Criteria Decision Support Tool developed here be further enhanced and used for feral camel management planning when new finer-scale spatial data become available.

DKCRC Partners