

DESERT KNOWLEDGE CRC

Overview of the project
'Cross-jurisdictional
management of feral camels
to protect NRM
and cultural values'

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

Report
54

2008



Australian Government



Overview of the project
'Cross-jurisdictional management of
feral camels to protect NRM
and cultural values'

GP Edwards

M McGregor

B Zeng

WK Saalfeld

P Vaarzon-Morel

M Duffy

2008



Australian Government



**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

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.

Desert Knowledge CRC Report Number 54

Information contained in this publication may be copied or reproduced for study, research, information or educational purposes, subject to inclusion of an acknowledgement of the source.

ISBN: 1 74158 101 X (Print copy)

ISBN: 1 74158 102 8 (Online copy)

ISSN: 1832 6684

Citation

Edwards GP, McGregor M, Zeng B, Saalfeld WK, Vaarzon-Morel P and Duffy M. 2008. *Overview of the project Cross-jurisdictional management of feral camels to protect NRM and cultural values*, DKCRC Report 54. Desert Knowledge Cooperative Research Centre, Alice Springs.

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

© Desert Knowledge CRC 2008

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

Contents

1. Summary	1
2. Current status	3
2.1 Feral camel distribution	3
2.2 Modelling population dynamics	4
2.3 The science of vertebrate pest control	5
2.4 Negative impacts of feral camels	5
2.5 Positive impacts of feral camels	7
2.6 Density/damage relationship.....	7
2.7 Net economic cost of the impacts of feral camels	7
3. Current management issues	8
3.1 Current approaches to managing the negative impacts of feral camels.....	8
3.2 Legislation issues that cause inefficiencies in the management of feral camel impacts.....	8
3.3 Commercial use of feral camels.....	9
3.4 Non-commercial approaches	11
4. Guiding principles in managing the impacts of feral camels – a new way to do business	12
4.1 Focus on impacts	12
4.2 One size does not fit all.....	12
4.3 Collaboration: A cross-jurisdictional, cross-tenure, cross-boundary, and cross-sectoral approach	12
4.4 Stakeholder engagement	15
4.5 Communication.....	15
4.6 Address multiple threats.....	16
4.7 Livelihood development	16
4.8 Sustained investment model	16
5. Framework for the cross-jurisdictional management of the impacts of feral camels	17
5.1 Management Zones.....	17
5.2 Recommended strategy.....	20
6. Future research needs.....	21
7. References.....	23
8. Summary of key recommendations	25

Tables

Table 1: The annualised monetary value of the economic impacts of feral camels	7
Table 2: Estimated feral camel population abundance and density for each of the major tenure classifications within the Australian camel distribution.....	13
Table 3: Values within the management zones that are under threat as a result of feral camels.....	18

Figures and graphs

Figure 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	3
Figure 2: Tenure types within the Australian feral camel distribution with feral camel density contours overlain	14
Figure 3: Map showing the distribution of feral camels and the proposed management zones	19

List of shortened forms

APY	Anangu Pitjantjatjara Yankunytjatjara
GIS	Geographic Information System
MBI	Market Based Instrument
NRM	Natural Resource Management

Acknowledgements

This report provides an overview of 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 report.

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.

1. Summary

This report provides an overview of the project ‘Cross-jurisdictional management of feral camels to protect NRM and cultural values’. The final report for this project (Edwards, Zeng, Saalfeld et al. 2008) provides a much higher level of detail in relation to the work undertaken for the project, including additional recommendations pertaining to individual research components.

Feral camels are well adapted to the conditions found in desert Australia and have now occupied 3.3 million km². 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, Zeng, and Saalfeld 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, Zeng, and Saalfeld 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.

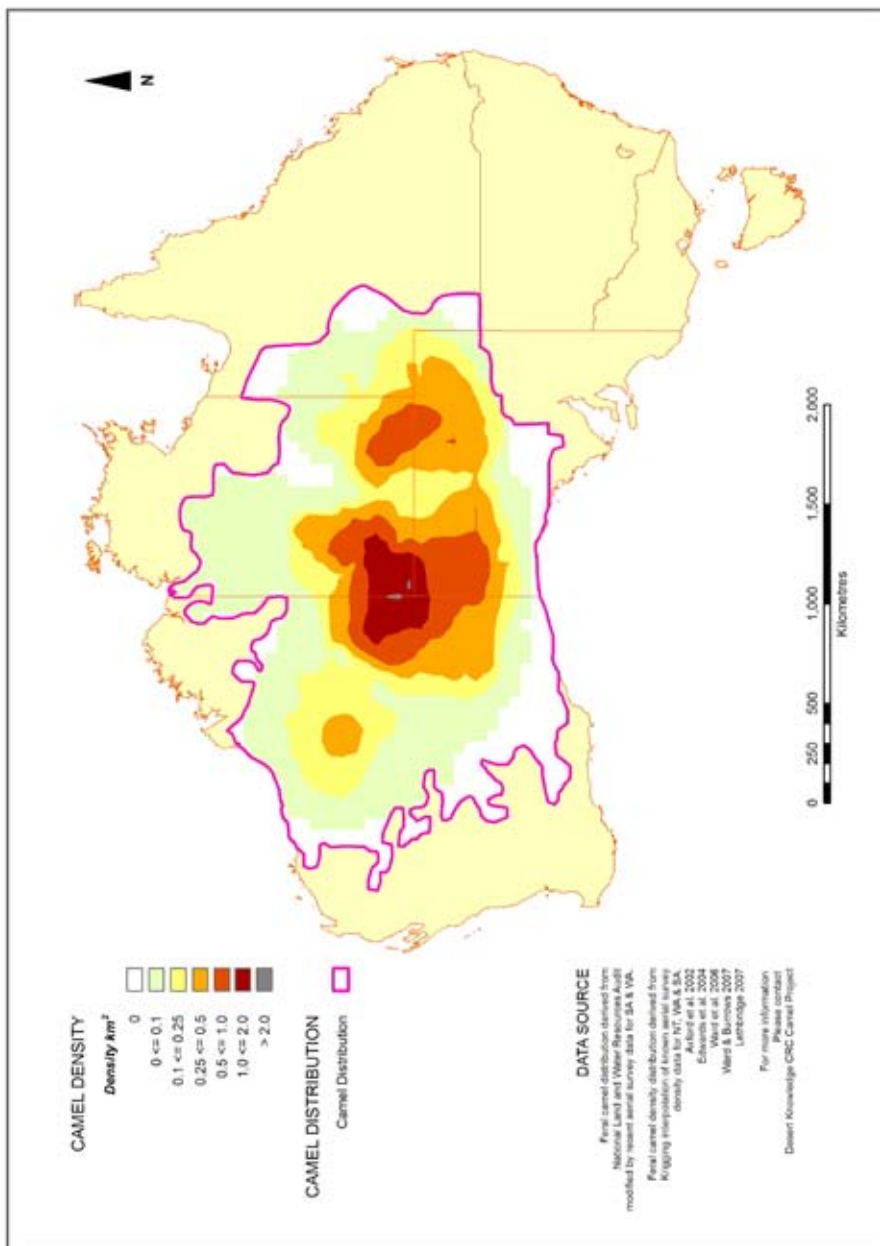
2. Current status

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.



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 km² at an overall density of 0.29 camels/km². 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 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/km² and that on the Simpson Desert in the range 0.5–1.0 animals/km².

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*) (Dörge & 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 \$3.73 million per year, assuming a value of \$15 per ton of CO₂ emitted (see Drucker 2008a).

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°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, Zeng, and Saalfeld 2008). There are real gains to be made in maintaining camel densities on pastoral leases at <0.3 camels/km². The amount of damage tends to flatten out at densities between 0.1–0.2 camels/km², 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/km² 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 1). The net economic impact is -\$14.39 million annually (assessed over the period July 2005 – June 2007 for the most part).

Table 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	-\$3.73 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	-\$14.39 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/km² at property to regional scales (areas in the order of 10 000–100 000 km²) 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 meat 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 km². 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/km²); \$40–100 per animal for densities in the range 0.3–0.1 animals/km²; and a cost per animal >\$100 for densities less than 0.1 animals/km². 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/km² at property to regional scales (areas in the order of 10 000–100 000 km²) 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 1). They are also found across all of the tenure types found in desert Australia (Figure 2), with the highest densities found on Aboriginal-managed lands, followed by vacant Crown land, and areas managed for conservation values (Table 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 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.

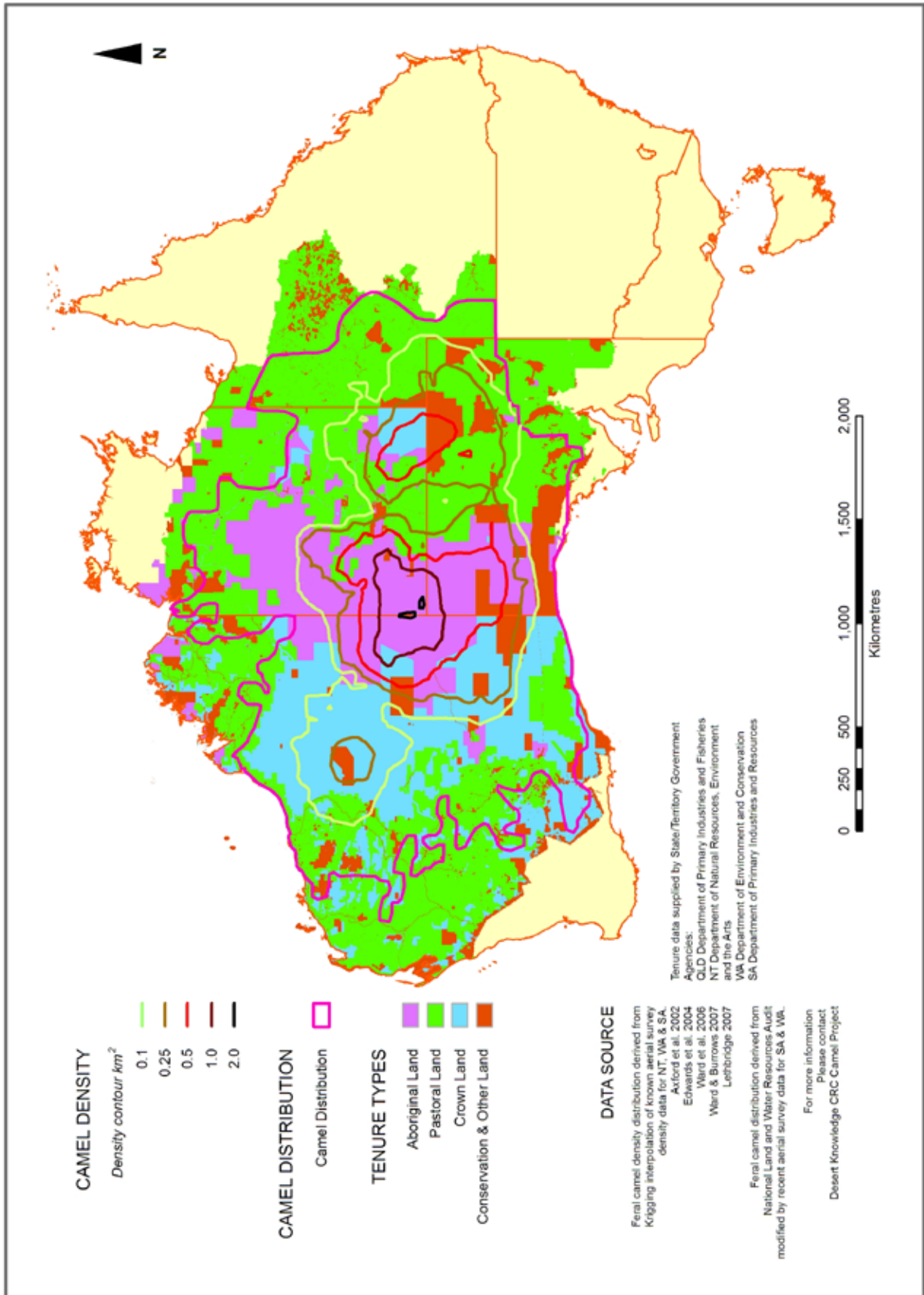


Figure 2: Tenure types within the Australian feral camel distribution with feral camel density contours overlain

Note: Contour intervals are 0.1, 0.25, 0.5, 1.0, and 2.0 camels/ km^2 .

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 meeting, 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 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/km²) and is the zone of greatest broadscale camel impact. It is approximately 116 000 km² 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 Anangu 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 3). There was significant damage to infrastructure on Aboriginal communities in this zone in January–March 2007 (Edwards, Zeng, and Saalfeld 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/km²). Densities are considered sufficiently high to warrant concern about possible broadscale camel impacts (Edwards, Zeng, and Saalfeld 2008) and the zone contains a range of values that are believed to be under threat as a result of feral camels (Table 3). The zone is approximately 61 000 km² 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 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		XXXXXX	X	X
Bush tucker	XXXXX	XXXXXX	XX	X
Native vegetation	XXXXX	XXXXXX	XXX	X
Cultural sites	XXXXXX	XXX	XXX	X
Community infrastructure	XXXXXX		XX	X
Pastoral infrastructure*		XXX	XXX	XX
Conservation reserves	XXXXXX	XXXXXX	XXX	X
Vehicles/people in vehicles	XXXXXX		XX	X
Cattle production**		XX	XX	X
Archaeological sites		XX	XX	X

*See Figure 7.10 (Edwards, Zeng, and Saalfeld 2008)

** Perception-based impact (see Zeng & Edwards 2008a; Edwards, Zeng, and Saalfeld 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 km² 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/km² (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/km² at property to regional scales (areas in the order of 10 000–100 000 km²) 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, Zeng, and Saalfeld 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).

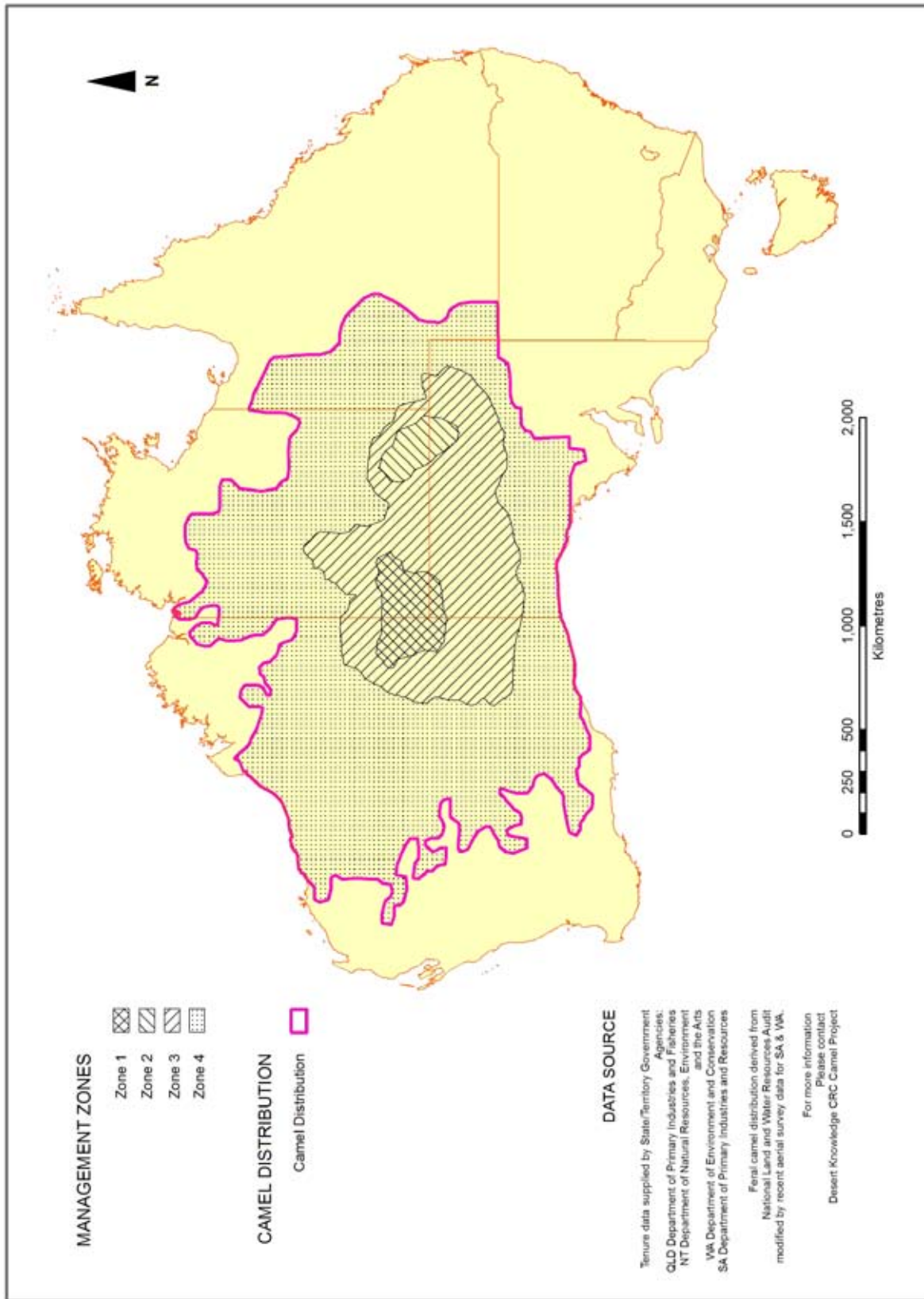


Figure 3: Map showing the distribution of feral camels and the proposed management zones

Management Zone 4: This zone encompasses the remainder of the Australian camel distribution and covers 2.4 million km², 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/km² over most of the zone but with a small area in north-west WA having a density slightly above 0.25 animals/km²). 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/km². 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/km² at property to regional scales (areas in the order of 10 000–100 000 km²) 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.
- Dörge 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>
- 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>
- 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 Humphreys 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/km² at property to regional scales (areas in the order of 10 000–100 000 km²) 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

