Australian Government
Bureau of Rural Sciences

SCIENCE *for* DECISION MAKERS

FEBRUARY 2006

REVISED EDITION

Australia's Pest Animals:

NEW APPROACHES TO OLD PROBLEMS

Quentin Hart and Mary Bomford

Q.Hart

Science for Decision Makers is a series published by the Bureau of Rural Sciences. It describes the latest developments in scientific advice, assessments or tools relating to agricultural, fisheries and forestry industries, including their supporting communities.

Its purpose is to make rural science more accessible to those needing to quickly understand the benefits and implications of the most recent research as a basis for decision-making.

For information on how to subscribe to this series, please see the back of this paper.

Key Points

1. At least 80 introduced animal species have established wild populations on mainland Australia. Some of these species — such as rabbits, foxes, feral pigs and feral cats — have become major pests of agriculture and the environment. In some situations, native species may be considered pests of agriculture or the environment, particularly where they have been introduced outside their natural range, or where their historical range and density has been enhanced by European settlement.

2. Despite many decades of intensive effort, no widespread introduced pest animal species has ever been eradicated from mainland Australia, and in the foreseeable future, these species are here to stay. The direct cost of the main introduced pest species has been conservatively estimated at more than $400 million per year, which excludes environmental and social costs, and long-term effects such as general ecosystem degradation.

3. Effort should be focused on effectively managing pests where they are causing significant damage in their existing range; limiting the spread of existing pests; and preventing the introduction of new pests into Australia.

4. There is an ongoing need to develop improved control techniques that address efficacy, specificity, safety and humaneness requirements. This needs to be supported by education that informs the general public about the need for pest control and encourages pest managers to implement control according to public expectations.

5. The increasing focus on risk assessment, early detection and incursion management for invasive species is vital to avoid adding to Australia's significant pest burden. Preventing the introduction of new pests and the further spread of existing pests is generally much more cost-effective than ongoing management of widespread pests.

The Evolution of Australia's Pest Animal Problems

Over the past 200 years, many exotic animals have been deliberately imported — both legally and illegally — into Australia for transport, food, wool, leather, sport, pets, pest control, or by 'acclimatisation societies', who wanted to see familiar animals from their home countries. Other species, such as black rats and house mice, have been accidentally imported.

Disturbance of environments, particularly land clearing and habitat fragmentation, has helped many introduced species to become established, and to spread.

Following importation, some species (e.g. rabbit, fox and trout) were legally released into the wild. Others (e.g. feral goat, feral pig and carp) escaped domestication, and some (e.g. Indian mynah) were released illegally. Exotic vertebrate species that have successfully established wild populations on mainland Australia include 25 mammals, 20 birds, 4 reptiles, 1 amphibian and at least 31 freshwater fish species. Those that have become widespread are listed in Table 1.

Exotic animals that have become established in Australia typically possess some or all of the following attributes:

- a good climate match between their overseas geographic range and Australia
- a history of establishing exotic populations elsewhere
- a high reproductive rate
- a generalist diet
- an ability to live in modified landscapes.

Disturbance of environments — particularly land clearing, habitat fragmentation and provision of permanent water — has facilitated the establishment and spread of many introduced species.

TABLE 1 Introduced (non-native) vertebrate species that have established widespread populations on mainland Australia and their pest status.

	Serious pest	Moderate pest	Minor or non-pest
Mammals	European rabbit (*Oryctolagus cuniculus*) Feral goat (*Capra hircus*) Feral pig (*Sus scrofa*) European red fox (*Vulpes vulpes*) Dingo/wild dog (*Canis familiaris*) Feral cat (*Felis catus*) House mouse (*Mus domesticus*)	Feral horse (*Equus caballus*) Feral donkey (*Equus asinus*) Feral buffalo (*Bubalus bubalis*) Feral camel (*Camelus dromedaries*) Feral cow (*Bos taurus*) Black rat (*Rattus rattus*)	European brown hare (*Lepus capensis*) Brown rat (*Rattus norvegicus*)
Birds	European starling (*Sturnus vulgaris*) Indian myna (*Acridotheres tristis*)	Mallard (*Anas platyrhynchos*) Rock dove (feral pigeon) (*Columba livia*) Spotted turtledove (*Streptopelia chinensis*) Blackbird (*Turdus merula*) House sparrow (*Passer domesticus*) European goldfinch (*Carduelis carduelis*) Senegal turtledove (*Streptopelia senegalensis*)	Cattle egret (*Ardeola ibis*) Skylark (*Alauda arvensis*) Tree sparrow (*Passer montanus*) Nutmeg mannikin (*Lonchura punctulata*) Greenfinch (*Carduelis chloris*)
Amphibian	Cane toad (*Bufo marinus*)	—	—
Freshwater fish	European carp (*Cyprinus carpio*) Mosquitofish (*Gambusia holbrooki*) Mozambique tilapia (*Oreochromis mossambicus*)	Weather loach (*Misgurnus anguillicaudatus*) Tench (*Tinca tinca*) Redfin perch (*Perca fluviatilis*) Rainbow trout (*Oncorhynchus mykiss*) Brown trout (*Salmo trutta*)	Goldfish (*Carassius auratus*) Guppy (*Poecilia reticulata*)

Note: Other introduced species have only established localised populations on the mainland or have only become established on offshore islands.

The Impacts of Pest Animals on Valued Resources

Many of the exotic species that have established widespread wild populations are now considered major pests of agriculture and the environment.

Grazing Impacts

Pest animals, such as rabbits and feral goats, compete with livestock for pasture, although the extent of this depends largely on seasonal conditions. During good seasons in the rangelands, for example, pasture production is abundant and there may be little competition between herbivores. However, under drought conditions there is clearly potential for overgrazing, resulting in long-term damage, such as soil erosion and changes in plant composition to less palatable perennials and less stable annuals. Domestic herbivores, such as cattle, can be provided with supplementary feed or moved to prevent this damage. Wild herbivores that are not managed and whose movements are not restricted by fences, will continue to cause damage until they are controlled.

Around half of the world's mammal extinctions in the past 200 years have occurred in Australia

Crop Impacts

Rodents (mice and rats) can form plagues and damage a wide range of crops — particularly cereal and oilseed crops and many horticultural crops. Feral pigs can reduce the yields of grain, sugarcane, and fruit and vegetable crops. Pest birds are becoming an increasing problem as the area of horticultural and wine grape production increases. One of the factors complicating the management of crop impacts is that damage is often sporadic, with growers experiencing little damage in most years, but occasional high levels of damage. Currently, there is considerable research being done to improve our ability to predict mouse plagues and bird impacts, so that growers can focus on preventive rather than reactive management.

Predator Impacts

The threat of livestock predation by wild dogs is a major influence on the distribution of sheep and cattle in Australia. Consequently, sheep are not run in many areas that would be suitable for them if there were no wild dogs. Foxes are a significant threat to lamb production. Being omnivorous, feral pigs may also kill lambs in some situations.

Infrastructure Damage

Rodents can damage electrical and other equipment on farms and in houses. Larger pests, such as camels, feral donkeys, feral horses and feral pigs, can damage fences and waterpoints. The costs of infrastructure damage can run into many thousands of dollars and may be much more significant than grazing or crop impacts on some properties.

Environmental Impacts

Around half of the world's mammal extinctions in the past 200 years have occurred in Australia, and many of these extinctions are linked to introduced predators. Feral cats and foxes consume large numbers of native animals each year. Although some native species are able to maintain viable populations in the presence of feral cats and foxes, the survival of other native species — particularly those already at risk from habitat fragmentation — is considered to be threatened by these predators. Of particular concern is the recent introduction of foxes to Tasmania. If the mainland experience is any indication, the establishment of this pest on the island will have a devastating impact on many native species.

Feral goats, rabbits and other pest herbivores compete with native species for food, shelter and water. These herbivores may also cause long-term changes in habitat through selective grazing on certain plant species and general land degradation.

Feral pigs can cause significant damage to sensitive wetlands and rainforests through rooting up soil, and they may also feed on eggs, invertebrates and even vertebrates such as frogs.

Disease Risks

The ability of wild animals to move between properties may pose a threat to the containment and eradication of disease outbreaks. There are several deer species with expanding wild populations that may be involved in the spread of ovine Johne's disease between cattle herds and sheep flocks. Wild dogs are implicated in the spread of hydatids — a risk to human

health and the cause of losses of production associated with hydatidosis in cattle and sheep. Any exotic species with wild populations could have a role in the spread of diseases that affect livestock, native animals and humans, and this issue is a major focus of the recently established Australian Wildlife Health Network.

Social Cost

One aspect of pest animal impacts that is often overlooked is the social cost. This cost is usually an end-product of the economic costs of pest animals, which may reduce the viability of enterprises in some areas. However, there may also be much more direct, emotional consequences of pest animal impacts, such as those associated with mouse plagues and wild dog attacks on livestock. Pest animals may also have a significant impact on the cultural values of indigenous people — for example, predation on totemic native species and damage to cultural sites through trampling and fouling of waterpoints.

The Balance Sheet

In 2002, the Bureau of Rural Sciences (BRS) estimated the direct short-term economic losses caused by Australia's main exotic pest animal species to be at least $420 million per year, mainly in lost agricultural production (Bomford and Hart 2002). In 2004, the Pest Animal Control Cooperative Research Centre (PAC CRC) built on this initial review and attempted to estimate environmental costs for some of the main pest species to produce a total cost of $720 million per year — once again, this figure was considered to be at the lower end of the potential range. The successor to the PAC CRC, the newly formed Invasive Animals CRC, will be working with member agencies, including BRS, to improve the quantification of the economic, environmental and social costs of pest animals.

Direct short-term economic losses caused by Australia's main exotic pest animal species are at least $420 million per year.

Approaches to Reduce Pest Animal Impacts

Reducing pest animal impact seems like a fairly straightforward activity to many people, who believe that it is simply a matter of reducing or even eliminating pest populations. This is not the case for the reasons explained below.

Actual versus Perceived Impact

The mere presence of a pest animal does not mean it is causing sufficiently significant damage to justify its management ahead of other land management priorities. It is important to clarify actual versus perceived impacts — the recently developed PESTPLAN manual (Braysher and Saunders 2003) provides guidance on this. It is also necessary to determine the relationship between pest density and damage, to identify when pests need to be controlled and the level of management resources that are cost-effective.

Other Priorities

Related to the above point, pest animal management needs to be considered in the broader context of farm and environmental management priorities. For example, fox management should not be conducted in isolation from other lamb production considerations, such as stock nutrition, timing of lambing, paddock shelter, etc. Similarly, pest animal management initiatives to protect native animals should first consider whether the area and quality of available habitat is a major limiting factor to the viability of the native species.

Existence of Suitable Control Techniques

For some pest species (e.g. cane toads and feral cats), there is a lack of control techniques that are economically, environmentally (i.e. target-specific and non-residual) and socially (i.e. relatively humane and safe) acceptable.

There is a legal requirement for private landholders to control declared agricultural pests and government conservation agencies have a responsibility to reduce the impacts of exotic pests on native species and habitat. However, despite many decades of intensive effort, no widespread pest animal species has

BOX 1

CRITERIA FOR ERADICATION

There are six requirements for a successful pest animal eradication campaign (Bomford and O'Brien 1995):

1. **Rate of pest removal exceeds rate of increase at all population densities.** This requirement is very difficult to achieve, because pest removal rate reduces as population density reduces, and remaining animals become more difficult and expensive to target and control.
2. **Immigration of pests into the control area is zero.** The distribution of many pest species on mainland Australia is so large that it would not be possible to implement high-level control in all areas simultaneously; therefore immigration would be inevitable.
3. **All animals are 'at risk'.** Even if there was a very wide range of available control techniques for pest animals, it is unlikely that complete control could be achieved over large areas.
4. **Animals can be detected at low densities.** Unless this requirement can be achieved, confirmation of eradication is not possible; the current Tasmanian fox eradication campaign is faced with this problem.
5. **Discounted cost:benefit analysis favours eradication over ongoing control.** The cost of control per pest animal increases exponentially as pest population density declines, to the extent that an attempt to remove the last few animals in an area could cost tens of thousands of dollars per animal.
6. **Suitable socio-political environment.** Control techniques would need to be considered to be specific, safe and relatively humane. There would need to be a guarantee of long-term financial support to avoid wasting any initial investment.

been eradicated from mainland Australia and with current technology, such an objective is unrealistic (see Box 1). Eradication objectives can encourage an 'all or nothing' approach to pest animal management and result in large fluctuations in management effort and pest populations. This commonly occurs with the management of feral pigs and rabbits — both having high reproductive rates. A belief that eradication is achievable may lead to intensive, high-cost control for a year or more, followed by little management as resources and interest wane until pest numbers build up again to high levels. A more cost-effective approach involves budgeting for initial high-level population knockdown, followed by ongoing maintenance control.

Despite many decades of intensive effort, no widespread pest animal species has been eradicated from mainland Australia.

Pest Management Options

Management options for pest animals include:

- **eradication** — a common suggestion; however, see Box 1 for limitations
- **no management** — a default option, although it can be a valid one, provided it is justified by an assessment that the pest animal impact is acceptable; the cost of control would exceed the value of the impacts; or there are no appropriate management techniques available for the particular situation
- **crisis management** — a commonly adopted option that involves waiting until there is a major pest problem, and then implementing hasty management actions, which does not prevent initial damage
- **one-off management** — e.g. construction of a pest-exclusion fence, such as the 5500 km 'Dog Fence' (although ongoing maintenance is still required)
- **sustained management** — e.g. reduce pest population to a low level and keep it there

- **targeted management** — e.g. only prevent pest impact during critical periods, such as fox management during lambing.

Pest animal management has traditionally focused on lethal control techniques including baiting (mainly with '1080'/sodium monofluoroacetate); biological control (myxomatosis and rabbit haemorrhagic disease); shooting (aerial and ground); trapping (yard, cage, jaw, snares and 'sprung' nets); warren and den fumigation or destruction; and mustering (commercial use).

There are a number of non-lethal management options that should be considered instead of, or in conjunction with, traditional pest population control techniques. These options include:

- accepting a certain level of damage and only conducting management above this damage threshold
- exclusion fencing or netting
- habitat manipulation to make an environment less suitable for pest animals (this may be particularly effective for carp management)
- decoy feeding to divert pests away from valued resources
- enterprise diversification or substitution (e.g. farming cattle rather than sheep in areas with wild dogs)
- repellents (e.g. coating forest seedlings to prevent browse damage)
- scare devices (electronic and non-electronic audio and visual approaches)
- fertility control — there are some current techniques (e.g. hormone implants) as well as ongoing research into new approaches (e.g. bait delivery and immunocontraception).

If lethal management is attempted, it is important to take into account the following:

- Many species are pests because they have a high reproductive rate — ad hoc control is unlikely to have a long-term effect because pest populations will recover rapidly in between sporadic control events.
- What level of pest population reduction is required to reduce impacts sufficiently?
- Are there cost-effective, safe, target-specific and relatively humane control techniques available to achieve and maintain the required level of population control indefinitely ('sustained management') or during the required period ('targeted management')?

BOX 2

A RECENT SUCCESS STORY: RABBIT HAEMORRHAGIC DISEASE

Rabbit haemorrhagic disease (RHD) has had a major impact on the rabbit population since its widespread release in 1996, with more than 95% initial population knockdown in some rangeland areas and, even today, rabbit populations remain well below pre-RHD levels in much of their range. In more temperate areas, the effect on the rabbit population has been patchy and rabbits remain in moderate to high numbers in many places. Regardless, there is no doubt that, as with myxomatosis, rabbits will develop some resistance to the virus and even rangeland populations may increase to unacceptable levels. Therefore, it is essential that landholders act now to rip rabbit warrens on their properties to enhance the impact of RHD. However, at a cost of $5–25 per hectare, it is likely to be prohibitively expensive to rip entire rangeland properties; therefore, effort should focus on key refuge areas, such as floodplain country.

BOX 3

THE PROBLEM OF RELYING ON PROSPECTIVE 'SILVER BULLET' SOLUTIONS

A major limitation to effective pest animal control in Australia is the availability of cost-effective control techniques to manage pests across their range — which can be huge in the case of some species, such as rabbits. Biological control offers the prospect of ongoing population management without ongoing cost. Rabbit calicivirus is an example of an organism that has been introduced to Australia with dramatic effect, as outlined in Box 2.

Other approaches, such as 'immunocontraception', involve using gene technology to manipulate organisms. Immunocontraception aims to target the pest's reproductive process, tricking the immune system into attacking the pest's own reproductive cells.

The predecessors of the new Invasive Animals Cooperative Research Centre (IA CRC) invested considerable amounts of time and money into developing this technology for foxes, rabbits and mice. Although there have been some successes along the way, only the mouse immunocontraception program is continuing, and it will still face a number of hurdles, including refining the laboratory technology into a highly effective and reliable form; demonstrating that the level of sterility achieved is sufficient to suppress wild mouse populations; and obtaining approval to release a genetically modified organism into the open environment.

It is important to consider all options in managing the large and widespread pest burden that Australia has to contend with. However, it also important not to raise expectations and invest too heavily in prospective 'silver bullet' solutions at the expense of traditional control techniques. The IA CRC recognises this and the bulk of its lethal control research program focuses on traditional approaches.

- Is there local (and wider) community support to conduct the control program?
- Is there an ongoing budget to support ongoing maintenance control ('sustained management')?
- How will pest population reduction and damage reduction be measured to assess whether lethal control is cost-effective?

Impediments to Effective Pest Animal Management

At present, the management of pest animal damage across much of Australia is sub-optimal for a range of reasons, including:

- the lack of cost-effective, safe, target-specific and relatively humane control techniques for some species
- poor implementation of existing techniques, or poor coordination between land managers for controlling mobile pest species that readily cross property boundaries
- inadequate consideration of the 'population dynamics' of the pest species, resulting in rapid recovery of pest population between control events
- landholders may lack time, money, knowledge, expertise, equipment or interest, or may rely too heavily on 'silver bullet' solutions (e.g. rabbit haemorrhagic disease and immunocontraception — see Boxes 2 and 3)
- the fact that Australia is large and sparsely populated limits resources for pest management, particularly in the rangelands
- the potential conflict between 'commercial use' versus 'control' (see Box 4)
- native animal management can be problematic due to public perceptions about culling native species, regardless of how overabundant their local populations are in some situations (see Box 5).

BOX 4

TURNING A PROBLEM INTO AN OPPORTUNITY

As well as being pests, many introduced vertebrates are valued as a resource. Hunters and fishers value deer and trout as important game species, and in some areas, fees are charged to take them. Feral horses, camels, goats and pigs are mustered or shot for their meat and hides and are an important commercial resource. Many landholders make significant profits from their harvests which can offset other control and damage costs.

There is a valuable export industry in feral pig and feral goat meat for human consumption. The value of exported goats and goat products is around $20–30 million per year. The feral pig harvesting industry is valued at around $25 million per year. Carp are harvested commercially for human consumption, fish bait, pet and stock food and fertiliser.

In the past, Australia was one of the world's most important exporters of fox and feral cat pelts which generated significant export income. With the decline in world fur trade this no longer occurs. Feral cats and a range of introduced herbivores are also a significant subsistence food source for some Aboriginal groups, providing high-quality fresh food and economic savings to the communities.

However, in many cases, commercial use does not reduce pest animal density to a level at which damage is sufficiently reduced, particularly where landholders do not reduce stocking rates to account for ongoing harvest of wild herbivores. Additionally, the value of maintaining a pest animal population for ongoing commercial use may be insignificant compared with the cost of the damage. In these situations, government agencies must encourage — and, where necessary, regulate — increased levels of pest population reduction.

What is Being Done to Improve our Management of Pest Animals?

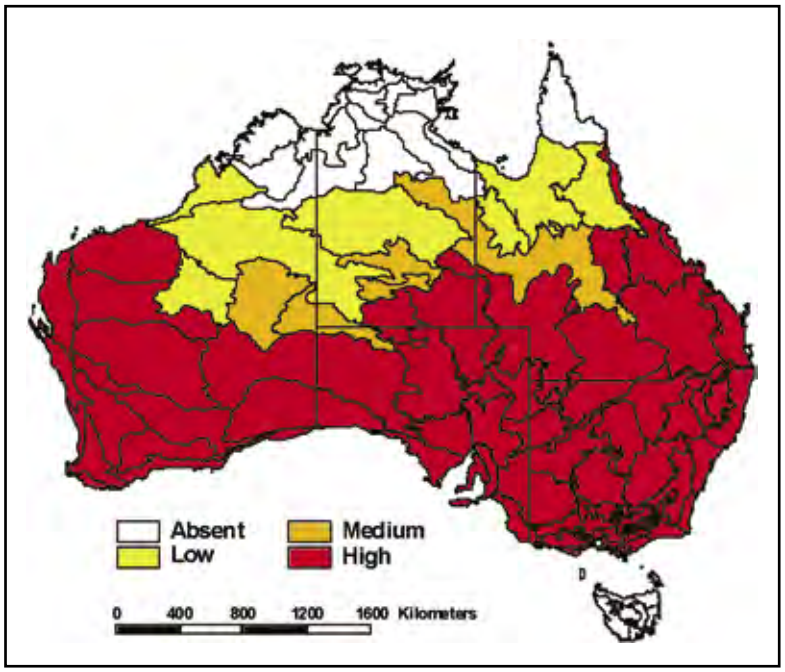
The links between pest animal research, extension and management have improved significantly over the past decade with contemporary research increasingly considering the practical needs of managers, as well as economic considerations. There is good information available for land managers to address most pest animal situations and a greater ability to rapidly update information through the internet.

There is good information available for land managers to address most pest animal situations.

Land managers must work cooperatively to implement 'best practice' pest animal management and researchers have an important role in developing new control techniques and strategies to improve current 'best practice'. Given the limited resources available for both management and research, prioritising activities is essential (i.e. focusing on those situations where particular pests are causing the most evidence-based damage).

The National Feral Animal Control Program (NFACP) is funded under the Natural Heritage Trust and administered by BRS to develop and promote new approaches to monitoring and managing pest animal impacts on agricultural production and the environment. The program has prepared guidelines for the management of rabbits, foxes, feral goats, feral pigs, rodents, carp, wild dogs, pest birds and feral horses. These guidelines identify the deficiencies in legislation, research, extension and management that hinder effective management of the respective species.

NFACP supports projects to overcome impediments identified in the respective species guidelines. For example, the program is currently supporting work to develop a carbon monoxide fumigation technique for rabbit warrens to overcome concerns about the humaneness of the current fumigant, chloropicrin. NFACP is also providing support for the development of a manufactured feral pig



This distribution map for foxes gives an indication of the magnitude of Australia's pest animal problem.

bait — a high-profile project coordinated by the Invasive Animals CRC to reduce the agricultural and environmental impacts of feral pigs.

A major impediment to effective pest management is poor coordination and misinformation between stakeholders. To help overcome this, NFACP invests in education and extension activities ranging from brochures to the feral animal web portal.[1]

BRS is also involved in developing risk assessment models for importing and keeping exotic vertebrates — a critical activity to help prevent new pest animals from becoming established in Australia.

[1] See http:// www.feral.org.au

BOX 5

NATIVE ANIMALS AS PESTS

Native animals may also be considered pests in certain situations. This may occur where changing land use results in overabundant populations of some species or in the concentration of gregarious species in a particular area. Examples of this include:

- increased kangaroo populations in some rangeland areas in response to increased water availability and wild dog control
- large, mobile flocks of some parrot species in response to a mosaic of year-round food from grain and fruit crops.

In other situations (e.g. koalas on Kangaroo Island in South Australia), native animals have been translocated to new areas where they have effectively assumed the role of an exotic species, and — in the absence of natural predators and competitors — they may increase to densities that cause considerable short-term damage and will ultimately result in a significant shift in ecosystem equilibrium to the detriment of other native species.

With changing land use, it is inevitable that new conflicts with native animals will develop. However, the management of native animals is a careful balancing act between conservation objectives, damage mitigation needs and public perception. In many cases, there are few technically or socially acceptable control techniques to reduce native animal damage.

BOX 6

'WANTED — DEAD': THE ROLE OF BOUNTIES

Bounties aim to encourage the culling of pest animals by providing a payment (bounty) on presentation of a nominated body part (usually a scalp or tail). BRS has reviewed the potential of bounties to contribute to pest animal management objectives and concluded that bounties are an inefficient tool that require considerable supervision and are unlikely to deliver long-term reductions in pest animal populations and related damage.

The main shortfalls of bounties are:

- failure to produce a significant decrease in pest animal populations and the need to produce evidence of a kill encourages the use of inefficient control techniques (usually ground-based shooting or trapping) over more effective strategies, such as coordinated broadscale baiting
- susceptibility to fraud (e.g. animals may be taken from areas where they are easiest to obtain rather than from the target area where they are causing the most damage)
- long-term bounties can promote the deliberate spread of pest animals and facilitate pest animal breeding (e.g. releasing female and young animals)
- bounties have to be high to induce adequate participation and have to increase if pest animal density becomes lower and search time increases. This makes them a potentially expensive approach to pest control.

Localised bounty schemes to target individual 'problem' wild dogs or feral pigs may have some benefit, but the National Vertebrate Pest Committee recently restated its position that bounties are not suitable for general pest animal population control given that baiting and other techniques are far more effective and efficient.

CONCLUSIONS

There are a number of technical, economic and social factors hampering better pest animal management in Australia. Although the term 'best practice' implies best use of available techniques, the development of new, simple and more cost-effective monitoring and control techniques will improve current 'best practice' and overcome some of the economic and social barriers to adoption. However, the impetus and resources for developing new techniques is limited by the small market for commercial products. There is a case for government support, recognising the 'public good' aspects of pest control, and this has been demonstrated by recent Australian Government and State support for the Invasive Animals CRC.

Technical difficulties and community attitudes towards genetic modification and viruses will affect the ability of scientists to introduce potentially safer and more humane biological control techniques for pest animals.
If developed, such techniques could enable more cost-effective population control over large areas. This is particularly important for a country such as Australia, where large property sizes often make pest control using conventional techniques uneconomic.

There are likely to be significant changes in community and political attitudes to the presence, impact and management of non-indigenous animals in Australia. It is likely that some introduced species (particularly long-term 'residents') will be increasingly accepted in some situations. Regardless, it is crucial not to add to the list of exotic species and we do not have to wait for high-tech solutions to implement effective barrier controls and risk assessment processes.


CSIRO

REFERENCES AND FURTHER READING

Bomford M and Hart Q (2002). Non-indigenous vertebrates in Australia. In: *Biological Invasions – Economic and Environmental Costs of Alien Plant, Animal and Microbe Species,* Pimental D (ed), CRC Press, New York.

Bomford M and O'Brien P (1995). Eradication or control for vertebrate pests? *Wildlife Society Bulletin 23.*

Braysher M and Saunders G (2003). PESTPLAN: *A guide to setting priorities and developing a management plan for pest animals.* Bureau of Rural Sciences, Canberra.

Caughley J, Bomford M, Parker B, Sinclair R, Griffiths J and Kelly D (1998). *Managing Vertebrate Pests: Rodents.* Bureau of Resource Sciences and Grains Research and Development Corporation, Canberra.

Choquenot D, McIlroy J and Korn T (1996). *Managing Vertebrate Pests: Feral Pigs.* Bureau of Resource Sciences. Australian Government Publishing Service, Canberra.

Fleming P, Corbett L, Harden B and Thomson P (2000). *Managing the Impacts of Dingoes and Other Wild Dogs.* Bureau of Rural Sciences, Canberra.

Koehn J, Brumley A and Gehrke P (2000). *Managing the Impacts of Carp.* Bureau of Rural Sciences, Canberra.

Olsen P (1998). *Australia's Pest Animals: New Solutions to Old Problems.* Bureau of Resource Sciences, Canberra and Kangaroo Press, Sydney.

Parkes J, Henzell R and Pickles G (1996). *Managing Vertebrate Pests: Feral Goats.* Bureau Resource Sciences and Australian Nature Conservation Agency. Australian Government Publishing Service, Canberra.

Saunders G, Coman B, Kinnear J and Braysher M (1995). *Managing Vertebrate Pests: Foxes.* Bureau of Resource Sciences and Australian Nature Conservation Agency. Australian Government Publishing Service, Canberra.

Williams K, Parer I, Coman B, Burley J and Braysher M (1995). *Managing Vertebrate Pests: Rabbits.* Bureau of Resource Sciences and CSIRO Division of Wildlife and Ecology. Australian Government Publishing Service, Canberra.

BRS website: http://www.brs.gov.au/feral

Feral animal web portal: http://www.feral.org.au


G Chapman


NSW DPI

Australian Government
Bureau of Rural Sciences

The **BUREAU OF RURAL SCIENCES** is the scientific bureau within the Australian Government Department of Agriculture, Fisheries and Forestry. We provide effective, timely and relevant scientific advice, assessments and tools to support decision-making for profitable, competitive and sustainable Australian industries and their supporting communities.

IN THIS **SERIES**

- Agricultural Sleeper Weeds
- Assessment of Vegetation Condition
- Australia's Pest Animals
- Climate Change
- Coordinated Land Use Mapping for Australia
- Managing Connected Surface Water
- Old Growth Forests in Australia
- Plantations And Water
- Sourcing the Salt
- Sustainability Indicators

Visit our website at www.brs.gov.au to download copies of these papers, or call +61 2 6272 4282 to subscribe.

Contact

For more information contact:
David Cunningham
Programme Leader
Bureau of Rural Sciences

Email david.cunningham@brs.gov.au
Phone +61 2 6272 5160

DISCLAIMER

The Commonwealth of Australia acting through the Bureau of Rural Sciences has exercised due care and skill in the preparation and compilation of the information and data set out in this publication. Notwithstanding, the Bureau of Rural Sciences its employees and advisers disclaim all liability, including liability for negligence, for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying upon any of the information or data set out in this publication to the maximum extent permitted by law.