BACKGROUND DOCUMENT

for the

THREAT ABATEMENT PLAN

for competition and land degradation by rabbits

2008

Department of the Environment, Water, Heritage
and the Arts

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Content

1 Introduction

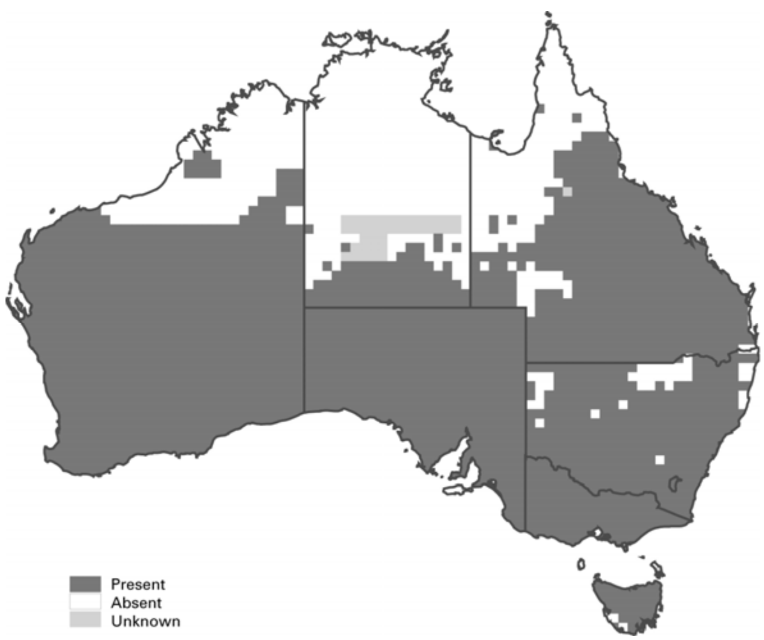
This is the background document to the *Threat abatement plan for competition and land degradation by rabbits* (DEWHA 2008). It provides information on rabbit characteristics, biology and distribution; impacts on environmental, economic, social and cultural values; and current management practices and measures.

The threat abatement plan (TAP) establishes a national framework to guide and coordinate Australia's response to the effects of competition and land degradation by rabbits on biodiversity. It identifies the research, management and other actions needed to ensure the long-term survival of native species and ecological communities affected by rabbits. It replaces the *Threat abatement plan for competition and land degradation by feral rabbits* published in 1999 (EA 1999) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.1 Rabbit distribution and abundance

The European rabbit (*Oryctolagus cuniculus*) is widely distributed across the Australian mainland, Tasmania and many offshore islands. Only the most northerly regions of the mainland are free of this invasive species. Well adapted to climatic conditions in much of Australia, rabbits currently occur in all states and territories and are Australia's most abundant small mammal (with the possible exception of the introduced house mouse). They are most abundant on deep, sandy soils (Myers et al. 1994), which are ideal for digging warrens. However, rabbits also readily live above ground in areas that provide protection. Figure 1.1 shows the distribution of rabbits in Australia.

Figure 1.1: Occurrence of rabbits, *Oryctolagus cuniculus*



Source: IA CRC and NLWRA (2007)

Rabbits were in plague proportions leading up to the release of the myxoma virus in 1950, and then dramatically declined, with initial mortality rates of over 99 per cent among those rabbits that caught the disease. As time went on, the myxoma virus evolved into numerous attenuated field strains, rabbits

developed increasing genetic resistance and rabbit numbers began to recover. Today, myxomatosis kills only about 50 per cent of infected rabbits but is still an important biological control agent, keeping rabbit populations to an average of 5 per cent of former numbers in wetter areas, and 25 per cent in arid areas. In 1995, rabbit haemorrhagic disease (RHD, also known as rabbit calicivirus disease) established itself in Australia and further reduced rabbit numbers, especially in arid areas. Nevertheless, in recent years rabbits have become abundant once again in some areas and there is growing evidence that rabbits are also developing genetic resistance to this second disease
(B Cooke, Invasive Animals Cooperative Research Centre, pers comm, 2007).

1.2 Impact of rabbits

Rabbits are among Australia's most serious vertebrate pests because of their widespread impact on native flora and fauna, as well as on agricultural and pastoral industries. For example, the decline and extinction of many of Australia's terrestrial mammals that weigh between 35 and 5500 g (sometimes referred to as critical-weight-range species), particularly in the arid and semiarid zones, have been associated with the appearance of the rabbit (Calaby 1969). Thus, many of the mammals in central Australia have either disappeared altogether or become exceedingly scarce.

As a significant herbivore, rabbits:

- overgraze and inhibit the regeneration of native vegetation (Crisp 1978, Lange and Graham 1983, Cooke 1987), thus modifying natural plant communities and the fauna they support (e.g. in times of drought, rabbits forage on tree foliage and ringbark trees in searching for moisture [Land Protection 2005])
- compete with native fauna for food (Dawson and Ellis 1979), for example with the yellow-footed rock wallaby, and
- cause soil erosion (McManus 1979, Norman 1988).

As prey, rabbits support populations of introduced predators that also prey on native species (Catling 1988); for example, in semiarid Australia, rabbits are the primary prey species of both feral cats and foxes (Read and Bowen 2001, Holden and Mutze 2002). Finally, rabbits compete with native fauna for shelter (Martin and Sobey 1983, Priddel et al. 1995).

Competition and land degradation by rabbits are listed as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and may affect 156 threatened species listed under the Act. These include 13 mammals, 19 birds, 2 reptiles, 121 plant species and 1 insect species (see Appendix A of the current TAP), with the orange-bellied parrot, the golden sun moth, and 7 plant species (the Norfolk Island abutilon, *Achyranthes margaretarum*, native wintercress, ironstone brachyscias, net-veined gyrostemon, Hindmarsh Valley greenhood and shy Susan) being critically endangered.

For each key threatening process under the EPBC Act, the Minister must decide if a TAP is to be prepared. The Act prescribes the content of a TAP and the mechanisms by which it is to be prepared, approved and published. The relevant sections of the Act are reproduced in Appendix A.

1.3 Rabbit biology

The success of the rabbit in Australia can be attributed to a number of factors, including small body size, which allows the animals to select high-quality feed under favourable conditions, and the use of warrens, which help to protect them from predators and climatic extremes. Rabbits are extremely fecund and can colonise a wide range of habitats.

Although they have well-defined home ranges, rabbits will forage outside these when food is scarce. The gestation period is 28–30 days, and an average litter size is six (range of four to eight) kittens. As many as nine litters are possible in a good season. Breeding is confined to periods of the year when fresh, growing pasture is available.

2 Controlling rabbits

A systematic response to the spread of rabbits occurred during the second half of the 19th century with the introduction of legislation by all states and territories for compulsory rabbit control. At that time, the main interest in rabbit control was to protect primary production; that situation continued for many years, and it is only in the last 10 to 15 years that the huge impact of rabbits on conservation values has been realised, leading to an increase in the control of these pests.

In reviewing the development of rabbit control practices in Australia, Williams et al. (1995) suggested that early rabbit management efforts failed in Australia because of a number of factors, some of which still apply today:

- over-reliance on legislation
- wastage of valuable resources on bounties and the erection of barrier fences
- efforts by trappers and others with vested interests to prevent effective management of rabbit populations
- lack of understanding of rabbit biology and behaviour
- lack of specific organisational structures to deal with rabbits and their impacts
- control efforts concentrating on agricultural land and ignoring natural vegetation
- use of techniques that were not tested scientifically or standardised, and
- failure to recognise that local schemes (e.g. Landcare) provide an avenue for government to work with landholders (although it is now recognised that few of these groups operate on a sufficiently large or coordinated scale to effectively control these widespread pests).

Successful rabbit control will be more likely where integrated approaches target local or regional circumstances, and use the most appropriate suite of options to reduce and control population numbers and their impacts. Careful attention is needed in the selection and implementation of control methods to minimise any non-target impacts resulting from the management regime.

Control of rabbits on Commonwealth land is a small part of the effort involved in conserving species affected by rabbits. State and territory agencies responsible for agricultural pest control have a long history of practical on-ground rabbit control. These agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and other institutions, have researched rabbit ecology and biology, and biological control methods such as myxomatosis and RHD. This research led to advances in managing the impacts of rabbits on both primary production and the natural environment, and today provides a sound basis for rabbit control. The challenge is to ensure that the validated and standardised techniques available are applied at the scale needed.

The eradication of rabbits from mainland Australia is well beyond the capacity of available techniques and resources because the species is well established across a vast area. However, long-term suppression of rabbit populations is feasible. The Darling Downs–Moreton Rabbit Board, which covers an area of about 28 000 square kilometres in southeast Queensland, is an example of a success story, with rabbits held at low numbers over large areas. This suppression has been achieved using continuous patrols by rabbit inspectors who apply rabbit control measures such as poisoning, fumigation and clearance of cover, as necessary (B Cooke, Invasive Animals Cooperative Research Centre, pers comm, January 2007).

Eradication of rabbits from small islands is possible; they have been eradicated from several islands in Western Australia (Morris 1985). However, on larger islands, rabbit management is focused on control rather than eradication (Brothers et al. 1982). On Macquarie Island, rabbits were previously controlled; however, since the elimination of feral cats on the island, rabbits are again a major problem and an eradication program for rabbits has now been initiated.

2.1 Integrated control

Effective rabbit control requires integration of different methods; any single technique used in isolation is less effective than two or more techniques carefully combined (Cooke 1993). When reliance is placed on only one technique and follow-up control is not implemented, initial gains are lost as rabbits will readily recolonise in the absence of further control (Parer and Milkovits 1994, Williams and Moore 1995).

The value of following up an effective myxomatosis epidemic with warren destruction has been known for many years (Cooke 1993).
A property in South Australia where warrens were ripped following a large decline in rabbit numbers remained almost rabbit free for many years. In contrast, a nearby property, where warrens had not been ripped, experienced high rabbit numbers again soon afterwards, even though myxomatosis reoccurred at both sites in the following year. Similar results were obtained from a study in central Australia that assessed the impacts of ripping warrens on rabbit persistence (Dobbie 1997).

In the past, many land managers relied on the myxoma virus as the only form of rabbit control (Williams et al. 1995). Similarly, since the escape of RHD virus (RHDV), discussed in Section 2.4, land managers have had unrealistic expectations about its effectiveness and many have relaxed their rabbit control efforts. The most effective strategy is to use conventional control techniques after epizootics have reduced populations to more manageable levels (Cooke 1993). Ideally, these diseases should be viewed as part of an integrated rabbit control program for sustained control.

Many of the state and territory government programs set up to encourage land managers to integrate RHD into traditional rabbit control programs are no longer operating. Nevertheless, if RHD reduces rabbit populations in the long term, its role in rabbit control can be similar to that of myxomatosis. RHD outbreaks will result in smaller and more manageable rabbit populations. Outbreaks should be followed up with conventional control to achieve more lasting reductions in rabbit numbers.

Sustained control is clearly the most cost-effective and efficient way to control rabbits under most circumstances (Williams et al. 1995). The relationship between pest density and impacts on environmental values is important information, but such data are not readily available. In addition, rabbit numbers can increase steeply within the course of a breeding season. Therefore, wherever possible, the pest population should be reduced to a manageable level using intensive control techniques and then maintained at that level with regular follow-up control. Ongoing monitoring of the effectiveness of rabbit control in ameliorating their impact is necessary to determine the level of ongoing control necessary.

Williams et al. (1995) reviewed past and present management of rabbits at the state and territory levels; the findings of the review are still relevant today. The authors concluded that effective rabbit management requires an organisational strategy that includes:

- management for the promotion of ecological sustainability and the maintenance of the resource base in both primary production and land conservation
- control practices based on research findings
- integration of research, extension and regulatory activities within a single system at state or territory, regional and district levels
- coordination of rabbit management across states and territories
- adequate training for operational field staff and extension officers
- assessment of rabbit problems and the success of control programs
- legislation that aims for long-term suppression of rabbit damage and binds governments to manage

rabbits on their lands, and

- regulatory enforcement only as a last resort.

Integrating control involves coordinated use of various rabbit control techniques with other land management activities. For example, the control of rabbits should be integrated with the control of other pest species (e.g. foxes and feral cats) and weed management programs.

It is also important that action taken to control a rabbit population has a clearly identified objective, such as the recovery of a threatened species or of an entire ecological community. Essentially, integrated control involves planning control programs in such a way as to take advantage of environmental conditions and other activities. In this way, control effectiveness is maximised and costs are minimised.

Current techniques available for controlling rabbits, discussed below, can be categorised broadly as chemical, mechanical and biological.

2.2 Chemical control

This section discusses the use of fumigants to poison rabbits in warrens and the use of poisons to kill rabbits above ground.

2.2.1 Fumigants

Pressure fumigation or diffusion fumigation may be used to kill rabbits while they are in their warrens (Cooke 1981, Williams and Moore 1995). Toxins used for fumigation include chloropicrin, carbon monoxide, carbon dioxide, calcium cyanide and phosphine (Hayward and Lisson 1978).

Pressure fumigation requires the use of a fan to generate pressure and force the fumigant throughout the warren. The fumigant usually comprises a mixture of thick smoke, carbon monoxide and chloropicrin (Parer and Milkovits 1994). During fumigation, all warren entrances are sealed, with the smoke revealing entrances hidden in rocks or vegetation.

The process of pressure fumigation is slow and cumbersome and only suitable for small areas (Williams et al. 1995). In addition, the use of chloropicrin in pressure fumigation is dangerous to operators and perceived to be inhumane because it causes intense respiratory irritation and profuse watering of the eyes. Animals suffer over a long period, and rabbits that have been exposed to sublethal but acute doses can take weeks to die (Sharp and Saunders 2004a). The identification and use of more humane fumigants is recommended by the TAP and is currently being investigated by the Bureau of Rural Sciences and the Invasive Animals Cooperative Research Centre.

Unlike pressure fumigation, diffusion fumigation requires little equipment, and allows alternative toxins to be used, such as chloropicrin liquid or aluminium-phosphide pellets, which give off phosphine gas (Korn and Hosie 1988). Pellets are placed in absorbent paper towel or newspaper, moistened with water and placed as far into the burrow as possible before the entrance is sealed. This toxin is thought to be more humane than chloropicrin because it causes less intense suffering, and rabbits that are exposed to sublethal concentrations may experience transient illness rather than permanent debilitation (Sharp and Saunders 2004a). Diffusion fumigation is important in following up large-scale programs of baiting and warren ripping (Korn and Hosie 1988, Williams and Moore 1995).

Carbon monoxide, a gas that binds to haemoglobin in place of oxygen, causes unconsciousness and rapid death without pain or discomfort. Fumigation with carbon monoxide may provide a humane alternative to chloropicrin and phosphine. Car exhaust fumes have been used in attempts to generate carbon monoxide poisoning, but this method is unacceptable because it is difficult to achieve adequate concentrations of carbon monoxide, and because exhaust fumes contain irritants and are too hot (Sharp and Saunders 2004a).

Carbon dioxide should not be used for rabbit warren fumigation because rabbits have a high tolerance to the gas and it does not disperse well (Sharp and Saunders 2004a).

2.2.2 Toxins

Various toxins have been used on baits for control of rabbits. The main toxin used for a range of vertebrate pest species, including rabbits, in Australia is sodium fluoroacetate (1080). Benefits of this toxin are that it:

- is effective (with mortality rates of up to 90 per cent [McIlroy and Gifford 1991]) and relatively inexpensive (Martin et al. 1994)
- is considered more humane than the anticoagulant pindone, the other most commonly used poison for rabbit control (Sharp and Saunders 2004a)
- degrades rapidly under field conditions and does not accumulate in animals that ingest a sublethal dose (see Twigg et al. 2003), and
- is tolerated by some native species, particularly in Western Australia, where native fauna have a higher resistance to the naturally occurring 1080 found in native plants.

Symptoms of 1080 poisoning in rabbits include lethargy, laboured respiration, increased sensitivity to noise or disturbance, convulsions and death. Time to death is usually about three to four hours. In contrast, symptoms of pindone poisoning in rabbits include lethargy, haemorrhage, laboured breathing, weakness, bleeding and swollen joints. Time to death is usually about 10–14 days. Pindone is considered inhumane in rabbits, and only justified in situations where 1080 cannot be used (Sharp and Saunders 2004a).

In some states, pindone is used in close proximity to urban areas where the potential risks of 1080 poisoning of children and livestock, and the secondary poisoning of cats and dogs, are perceived to be greatest. In Western Australia, pindone is carefully controlled, with specific prescriptions on use in the presence of certain native species, especially large macropods. Experience has shown that some marsupials, bandicoots and birds are very sensitive to this toxin. There are also considerable differences in the susceptibility of individual animals and species to pindone, which requires further investigation (Martin et al. 1991, Martin et al. 1994).

Other poisons include the anticoagulant brodifacoum (Crosbie et al. 1986) and the rodenticides 1,3-difluoro-2-propanol (DFP) (Mead et al. 1991) and cholecalciferol (Eason 1993, Eason et al. 2000, Morgan 2004).

Anticoagulants have a readily available antidote, and are slow-acting and cumulative, meaning that individuals are more likely to ingest a lethal dose before developing an aversion to the bait (Crosbie et al. 1986). However, animals may ingest several lethal doses of poison before they succumb, thereby increasing the hazard to non-target species. Due to persistence and bioaccumulation, some anticoagulants used in broadscale baiting can be highly hazardous to non-target species (Eason and Spurr 1995), to a greater extent than acute, non-cumulative poisons (Bird 1995). Brodifacoum causes some concern because of its longer persistence and accumulation in tissue; for example, the use of brodifacoum for rat control in sugarcane is implicated in the decline of raptors in north Queensland (Young and De Lai 1997).

Like other such rodenticides, cholecalciferol is highly toxic to rabbits. In addition, it is less toxic to birds than other rodenticides (Haydock and Eason 1997), and has a lower potential risk of secondary poisoning than 1080 and brodifacoum. However, cholecalciferol is very expensive in comparison to 1080 and pindone (Eason 1993), and is highly toxic to possums (Jolly et al. 1995, Eason et al. 2000). It was voluntarily withdrawn as a rodenticide in Australia many years ago because of unexpected primary poisoning of domestic dogs (L Twigg, Vertebrate Pest Research Service, Western Australian Department of Agriculture and Food, pers comm, 2007).

Baits commonly used for rabbits include chopped carrot, oat grains or pellets manufactured from bran or pollard. In the past, these were either laid in furrows or broadcast across the area from the ground or air (Korn and Hosie 1988). This type of baiting is not commonly used today as rabbit infested areas are much better targeted using trail baiting. However, there is still interest in some states (e.g. Victoria), where this form of application is being considered for steep hillsides with thick tussock vegetation.

Problems that can arise with baiting include:

- potential poisoning of non-target species, including native fauna, livestock and domestic animals
- avoidance of baits due to neophobia or bait aversion in rabbits that have previously consumed a sublethal dose (this can be caused by frequent and ineffective baiting, it reduces the effectiveness of baiting, and changing poisons does not overcome this problem [Williams et al. 1995])
- lack of an antidote for some poisons, and
- water-soluble toxins leaking from baits laid in damp environments or during wet weather (although leaching of 1080 from baits may sometimes be advantageous because it is rapidly broken down by soil microorganisms [Wong et al. 1992], reducing the time that non-target species are at potential risk).

These perceived disadvantages can be minimised if baiting programs are well managed and directions for use are followed.

Effective methods for using toxins have been developed, and control programs that are well designed and carefully implemented will minimise any potential non-target effects (e.g. Sharp and Saunders 2004a). Research into effective baiting methods has shown that rabbits need to be 'trained' by free-feeding to quickly eat a lethal dose of bait to reduce development of bait aversion, and that baiting should occur in late summer or autumn when there are few young rabbits and few alternative foods, and the likelihood of toxin being leached from baits is low (see Williams et al. 1995 for a discussion of baiting methods). The approach to baiting varies between states and territories, and most states and territories have published protocols for the use of poisons in rabbit control.

The 'tarbaby' technique was seen as a possible alternative to baiting, but it is only suitable for small areas or holdings. It involves mixing a toxin with grease and placing it down the entrance of a burrow. Rabbits that pass through the grease will attempt to groom themselves by licking the grease from their fur and thereby ingest the toxin. However, the technique has not passed beyond the research stage, for a number of reasons:

- the high concentration of 1080 required precludes its use, although alternative toxins (e.g. anticoagulants) may be suitable (Williams et al. 1995), and
- the technique is not suitable on light, sandy soils, such as those found in Western Australia.

2.3 Mechanical control

Destruction of warrens and above-ground harbours is the most widely used mechanical method for rabbit control. This section also covers other mechanical methods that are used less widely, such as fencing, shooting and trapping. These methods are more applicable to areas where there are issues with destroying the surrounding habitat (e.g. presence of rare flora or flora of high value).

2.3.1 Destruction of warrens and above-ground harbours

Rabbits living in semiarid and arid zones depend on warrens for protection from climatic extremes (Hall and Myers 1978, Parer and Libke 1985). The destruction of warrens by ripping can be a cost-effective and efficient method for suppressing rabbit numbers and inhibiting reinvasion of the treated area, as it deprives rabbits of a safe place for breeding (Williams and Moore 1995).

The success of ripping depends on the efficient destruction of the entire burrow system, adequate follow-up control (Williams and Moore 1995) and the implementation of appropriate control measures on adjacent land

(Parer and Parker 1986, Parer and Milkovits 1994). Before ripping, dogs may be used to force rabbits to take refuge in warrens so that fewer will survive. Warrens in relatively inaccessible places such as between trees and in narrow gullies can be ripped using a drag-arm ripper mounted on a hydraulic arm to allow more flexibility in its placement (Williams et al. 1995).

Warren ripping causes the warren to collapse, destroying this safe haven for nesting and breeding, and crushing or suffocating the rabbits present in the warren at the time. It needs to be well planned and completed thoroughly to avoid the need to repeat the process. The most effective method is to use powerful machinery on loose soil with deep ripping; this minimises the possibility of rabbits becoming trapped in partially destroyed tunnels (Sharp and Saunders 2004a). Ripping is best carried out after poisoning, in summer, when the soil is dry (and therefore looser) and when rabbits are most likely to have been affected by myxomatosis and RHD.

Explosives can also be used to destroy warrens in rocky areas, along rivers and in steep sandbanks where ripping is not possible. If used correctly, explosives will completely destroy the tunnel system (Barnes 1983) and have minimal impact on native vegetation (Bruce 2001). However, the use of explosives is expensive and requires qualified personnel with a thorough knowledge of their use for safe and effective control.

Rabbits in some parts of Australia commonly use surface refugia, even when warrens are present (Wheeler et al. 1981, Williams et al. 1995). Whereas destruction of obvious rabbit warrens is straightforward, the destruction of surface refugia is more complex. This might require the removal of the shrub layer, logs and exotic weeds such as blackberry. The removal of native vegetation may be undesirable because such refugia also provide important habitat for species of amphibians, reptiles, small mammals and ground-dwelling or ground-feeding birds. Thus, the relative benefits of this action for enhancing the recovery of affected species must be carefully assessed against potential risks, particularly if it is to be done in conservation areas. Rabbit control will normally be part of a larger plan to reinstate habitat or protect native species, and the relative benefits and drawbacks of destroying surface refugia should be assessed in the context of the larger plan.

2.3.2 Fencing

Fencing does not eradicate rabbits, but can exclude them and may be useful in preventing recolonisation of rabbit-free areas. Rabbit-proof fencing has been recommended for the protection of small areas of native vegetation with high conservation value (Lowe et al. 2003). Fencing as a method for excluding rabbits is discussed in detail in a review by Long and Robley (2004). The review found that few fences are constructed simply to exclude rabbits; rather, they are designed to exclude foxes, cats and rabbits, and more than 90 per cent incorporated electrification, as this is cheaper than traditional fencing. Rabbit-proof fencing is expensive to construct and maintain (about $3700–$4000 per kilometre, although a combined fence can cost as much as $11 400 per kilometre).

Simple electric fences are generally only effective in excluding rabbits for short periods of time, as rabbits soon negotiate them, and are capable of jumping over fences that are 0.5 metres high (McKillop and Wilson 1999).

Burrowing is often the greatest challenge faced when trying to exclude rabbits from an area, particularly where soils are light (Williams et al. 1995). Mesh aprons secured to the ground or buried are used to deter rabbits from digging under fences, but there has been little research into optimal sizes and configurations for such aprons (Long and Robley 2004).

Long-term exclusion requires the use of wire-netting fences (McKillop and Wilson 1987), and electrified wire-netting fences can be very effective if properly maintained as rabbits are unlikely to burrow under an electrified fence (Long and Robley 2004). Where a rabbit's normal food source is some distance from its warren, temporary electric fencing can be used to prevent access to the food and increase the effectiveness of baiting near warrens.

Regular maintenance and patrolling are required for such fences to be effective. Breaches of a fence resulting from burrowing animals, tree falls or climbing will compromise its effectiveness (Williams et al. 1995).

'Barrier' (rather than full exclosure) fences can be constructed to aid local control objectives and reduce immigration from the most likely direction. Although they do not offer complete exclusion, barrier fences are cheaper and can therefore be used to cover larger areas. The Darling Downs–Moreton Rabbit Board rabbit fence in Queensland is an example of a barrier fence that allows near-zero densities of rabbits to be maintained.

Before erecting any fences, consideration should be given to likely impacts on other species. Fences, particularly those that are barriers to rabbits, can alter the movement and foraging of non-target fauna, can cause entanglement and electrocution, and are a significant hazard in the event of bushfire (Sharp and Saunders 2004a).

2.3.3 Shooting

Shooting can be a humane way of destroying rabbits. It is not an effective means of reducing rabbit populations, but can be used to remove survivors as part of an integrated rabbit control program. However, rabbits present a small target and are difficult to shoot; wounded animals must be located and killed as soon as possible (Sharp and Saunders 2004a).

The commercial rabbit industry depends largely on the supply of field-shot rabbits to processing works, and plays no significant role in reducing rabbit populations (Ramsay 1994).

2.3.4 Trapping

For large-scale rabbit control, trapping is labour intensive and inefficient. Trapping does not reduce rabbit populations significantly or maintain them at low levels. All traps have the potential to cause significant injuries, suffering and distress, and should only be used when there is no suitable alternative (Sharp and Saunders 2004b).

Leg-hold traps have traditionally been used to catch rabbits for many years; however, the use of steel-jawed leg-hold traps is now illegal in most states because they are considered to cause unnecessary pain and suffering and do not discriminate between rabbits and other species. Where trapping of rabbits is considered appropriate, such as with small isolated populations, barrel or soft-catch traps should be used (Korn and Hosie 1988).

Traps should be set in areas where they are likely to catch rabbits and are protected from weather extremes; they should be inspected at least once a day. Trapped rabbits should be killed as soon as possible to minimise stress. Native animals that are caught should be released at the trap site if they are not injured, or given veterinary treatment or killed humanely if they are injured (Sharp and Saunders 2004a).

2.4 Biological control

Biological agents, such as myxoma virus, RHDV and immunocontraceptives, work to control pests by increasing their mortality or decreasing their fertility.

Due to the large scale of the rabbit problem, and the expense and limited number of personnel available to manage conventional control programs, there will always be a need for biocontrols to reduce rabbit numbers. Potential new biocontrol agents could result from the following activities (B Cooke, Invasive Animals Cooperative Research Centre, pers comm, 2007):

- revising the current situation in Australia and assessing organisms already here (e.g. rabbit trypanosomes)

- considering organisms introduced into wild rabbits in Europe via the north American cottontail rabbits (*Sylvilagus* spp.), and
- considering potential biocontrol agents appearing in domestic rabbits in north America (presumably originating from *Sylvilagus* spp. or other north American lagomorphs).

2.4.1 Myxomatosis

The myxoma virus was imported into Australia in August 1936 to evaluate its potential as a biological control agent for rabbits (Bull and Mules 1943). Since its release into the wild near Corowa in 1950 (Rendel 1971), myxomatosis has become endemic in Australian rabbit populations (Williams et al. 1990). The effects of myxomatosis immediately following the 1950 release were not well documented (Williams et al. 1995), but at Corowa, 99 per cent of rabbits were thought to have died (Myers et al. 1954). Rabbits and the virus have coevolved, with rabbits developing genetic resistance and the virus attenuating (weakening), so that today only about 50 per cent of rabbits infected with myxomatosis succumb to the disease. The coevolution of virus and host is described in Fenner and Fantini (1999).

Mortality and morbidity rates from myxomatosis vary considerably (Williams and Parer 1972) and may depend on:

- genetic resistance (Williams et al. 1990)
- non-genetic resistance (Sobey and Conolly 1986, Williams and Moore 1991, Parer et al. 1995)
- age at infection (Cooke 1983), and
- weather (Dunsmore and Price 1972, Parer and Korn 1989).

Despite a decrease in the effectiveness of the myxoma virus since its initial release in the 1950s, it continues to have an important role in rabbit control. Parer et al. (1985) demonstrated that when a less virulent immunising strain of myxoma virus was experimentally spread through rabbit populations, the rabbit population increased 8 to 12-fold over two years, comared with a lower rate of increase when the normal virus is present.

A drawback to the use of myxoma virus as a biological control is that considerable suffering occurs. The symptoms (anorexia, swelling, temporary swelling of the eyelids) are severe, and there may be two to four weeks between infection and death (Sharp and Saunders 2004a).

2.4.2 Rabbit haemorrhagic disease

RHD has had a major impact on the rabbit population in Australia. This acute and fatal infectious disease of rabbits was first identified in China in 1984 (Liu et al. 1984, cited in Xu and Chen 1989). Clinical disease resulting from RHD has since been reported in many countries in Asia, Europe, the Russian Federation, the Middle East and parts of Africa, Cuba, Mexico, the United States, India and Reunion Island (Cooke and Fenner 2002).

Cooke and Fenner (2002) describe the history of RHD in Australia. In 1991, the virus (RHDV) was imported into the Australian Animal Health Laboratory at Geelong, under quarantine. Four years later, studies into the impact of the virus, seasonal transmission and disease persistence began. Despite measures to keep it under control, the disease spread. Once it was clear that RHDV was unlikely to affect human health, the release of the virus was approved and it was first officially released in Wagga Wagga, New South Wales, in 1996.

RHDV is now accepted as a biological control agent in all states and territories. The virus was registered as a product for rabbit control in August 2005 and may be used in bait form to initiate new outbreaks.

Little information has been published on morbidity and mortality rates in rabbits (with some exceptions, e.g. Bruce et al. [2004], Bruce and Twigg [2005ab]), although RHDV epizootics have been reported for wild populations in England, Germany, Italy and Spain (Cancellotti and Renzi 1991, Loliger and Eskens 1991, Villafuerte et al. 1994, Trout 1996). Susceptible rabbits challenged with RHDV develop clinical signs following an incubation period of one to three days (Marcato et al. 1991). Death usually occurs as a result of acute respiratory and heart failure from several hours to two days after the onset of clinical signs (Rodak et al. 1991). In Australia, the impact of this agent is greatest in drier regions. Mortality rates in excess of 90 per cent have been observed in some South Australian populations (Mutze et al. 1998a) where naturally recurring outbreaks have kept the population at an average level of 17 per cent of the long-term pre-RHD average (Mutze et al. 1998b). Where conditions are more humid, the disease appears to be much less effective (RCD MS Program 1997), and other factors, such as rabbit age and presence or absence of vectors, also play a part.

Direct contact between infected and susceptible rabbits is one mode of transmission for RHDV. The virus is also passed to susceptible individuals who have contact with the secretions or excretions of infective rabbits, or items such as food and water that have been contaminated (Xu and Chen 1989). Rabbits that survive an RHDV epizootic may persist as carriers for up to a month (Gregg et al. 1991). The virus may also be transmitted via people or implements that have had contact with carrier rabbits (Xu and Chen 1989). An outbreak in Mexico was linked with the importation of frozen rabbit meat contaminated with RHDV (Mason 1989). The rapid spread of the virus in Australia, at more than 400 kilometres per month (Kovaliski 1998), suggests that windborne insect vectors may play an important role in the transmission of RHD in Australian rabbit populations (Cooke 1996).

In several parts of Australia where RHD was initially very effective, rabbits have been on the rise for two to three years, despite poor seasonal conditions. The disease will clearly be unable to keep rabbits below the level (three rabbits per hectare) at which they begin to cause considerable environmental damage and limit biodiversity. Clearly, RHD needs to be supplemented with additional rabbit control methods (poisoning, warren ripping and warren fumigation) in such areas if biodiversity is to be maintained (B Cooke, Invasive Animals Cooperative Research Centre, pers comm, January 2007).

2.4.3 Immunocontraception

Fertility control agents that use viral vectors have been advocated as a means of controlling vertebrate pest populations (Tyndale-Biscoe 1994). The concept of virally vectored immunocontraception is based on the encoding of an antigen specific to elements of an animal's reproductive system and inserting it into a virus (Tyndale-Biscoe 1991). In theory, when an animal is challenged with the virus carrying the antigen it develops antibodies, which reduce fertility. To gain a sustained reduction in rabbit numbers, 60–80 per cent of female rabbits must be prevented from breeding (Williams and Twigg 1996, Twigg et al. 2000, McLeod and Twigg 2006, Williams et al. 2007).

Research into fertility control is supported by animal welfare groups as a desirable and humane way of dealing with vertebrate pest species (Russell and Pope 1993). A central tenet of the development of immunocontraceptive techniques is that they are humane.

Fertility control is an attractive option, but programs to develop immunocontraception in rabbits have not been successful (e.g. Holland and Jackson 1994). Although rabbits can be rendered infertile by a recombinant myxoma virus, the effect is of short duration; most breeding rabbits are immune, having recovered from myxomatosis; and, given the high level of sterility needed to drive populations down (Twigg et al. 2000, McLeod and Twigg 2006, Williams et al. 2007), it is most unlikely that the release of the recombinant virus would be effective.

3 Factors affecting rabbit control

This section discusses factors that can affect the control of rabbits. The issues covered are commercial interests, potential effects on non-target species, animal welfare and cultural issues.

3.1 Commercial interests

Before 1950, there was a substantial wild-harvest rabbit industry trading products in both the domestic and export markets. Exports peaked in 1948–49 when 50 million rabbits were exported, with a value equal to the total of mutton and lamb shipped in the same year (Ramsay 1994). Following the introduction of myxomatosis in the 1950s, rabbit populations collapsed, as did the supply to the commercial trade. Current commercial interest in rabbits in Australia is based on a domestic farmed rabbit industry, which commenced in 1987, and a small wild-harvest industry. Commercial use of wild rabbits takes the form of field-shot animals to supply game meat and pet meat markets, and skins, which are mostly used in the felt hat industry. Ramsay (1994) noted that the wild-harvest industry is based in regions where rabbit population density is high and rainfall low — these areas produce rabbits with lean white meat and white body fat that are preferred by consumers.

The production of large quantities of meat and fur from domestic rabbits, at prices that are very competitive with wild-harvested animals, is due to developments in the husbandry of domestic rabbits. This has led to a steady decline in the commercial harvest of wild rabbits (Ramsay 1994). Further decline has occurred since the release of RHD as a biological control agent. This disease is most effective in the low-rainfall areas, where the wild-harvest industry is based and where myxomatosis is less successful. It is also an offence in most Australian states to harvest rabbits from areas where poison-baiting is being undertaken.

Trade in rabbit fur, skin and meat is discussed in Saunders et al. (2002). The authors note that the export market for all rabbit products is currently less than 5000 kg a year, down from a peak of 1 million kg in 1991–92. Rabbit farming is an emerging industry in Australia and was worth around $1.7 million in 2002 (Saunders et al. 2002). In comparison, rabbit damage is reported to cost Australian agriculture about $113 million, which includes sheep and cattle production loss, cropping industry loss, control costs and research costs (McLeod 2004). If the non-monetary costs of damage to the environment are added to this equation, it becomes clear that the value of the commercial rabbit industry is trivial in comparison with the costs rabbits impose on the environment, agriculture and forestry.

Where an industry based on a wild harvest of a feral animal is compromised by improved control measures, it can result in calls for compensation. In 2005, the Standing Committee on Agriculture, Fisheries and Forestry recommended that people be able to harvest pest animals as a resource, where there is the potential to do so, as part of an overall strategy for controlling pest populations (SCAFF 2005).

3.2 Potential non-target impacts

Rabbit control operations can have both direct and indirect impacts on a range of other species. Direct impacts occur when a control technique kills species other than rabbits. Indirect impacts occur when the reduction of rabbit numbers affects species that rely on rabbits as a source of food or when the decline in grazing pressure leads to the regeneration or return of plants that have been suppressed by rabbits, including some undesirable plants (e.g. weeds). Some of the vegetation changes associated with a reduction in rabbits may be seen as incompatible with other land uses (e.g. regeneration of species that are not palatable to domestic livestock on pastoral properties).

The potential impact of poisoning on native non-target species must be carefully considered, particularly in areas of high conservation value. There is the possibility that non-target species may be exposed to poison following direct ingestion of the bait (Brunner 1983, McIlroy and Gifford 1991) or by scavenging rabbit carcases (McIlroy and Gifford 1992, Twigg et al. 2003). Secondary poisoning may occur when baits of unnecessarily high toxicity are used or if baits are used in excessive quantities. This can be avoided if recognised guidelines are followed. As explained in Section 2, there are effective methods for broadscale rabbit control, and any risk of potential effects on non-target species has to be balanced against the inevitable loss of species if rabbits are not controlled.

The potential impacts on native fauna arising from the release of RHD and other rabbit control programs have been comprehensively reviewed (Newsome et al. 1997). Foxes, dingoes, feral cats, quolls, some large reptiles and several species of diurnal raptors all prey on rabbits (Baker-Gabb 1983, Newsome et al. 1983, Catling 1988, Belcher 1995). The level of dependence on rabbits may vary according to rabbit density and availability relative to other prey (Newsome et al. 1983, Catling 1988). Rabbits are an important component of the diet of 11 out of 24 species of raptors from the order Falconiformes found in Australia (Baker-Gabb and Steele 1996). Anecdotal evidence suggests that following rabbit control through myxomatosis, the clutch sizes of raptors relying on rabbits as a main source of prey declined, while those of species that did not rely on rabbits remained unchanged (Olsen and Marples 1992).

All of these predators are capable of subsisting on other prey when rabbits are scarce or absent. There was speculation that a catastrophic decline in rabbit abundance, such as that following an RHD epizootic, could lead to increased predation on threatened fauna (Williams and Munro 1994) as a result of prey-switching or as a result of predators taking supplementary or opportunistic prey (Newsome et al. 1997). However, there is little evidence that this was the case. Cooke and Fenner (2002) considered this issue and found that at Roxby Downs in South Australia, where RHD caused very high mortality of rabbits, a higher proportion of native fauna was subsequently found in fox stomach contents, but the number of foxes in the area declined substantially so that the net impact on native species was unchanged.

A reduction in rabbit numbers may be sufficient to reduce densities of introduced predators such as the fox and feral cat. There is already evidence that this has occurred in northern South Australia, where numbers of both foxes and cats have been reduced by more than 70 per cent since RHD arrived (RCD MS Program 1998). This could lead to decreased predation on threatened fauna. Clearly, these issues must be carefully considered in planning any rabbit control programs in areas where native or introduced predators rely on rabbits as their main source of food. Robley et al. (2004) reviewed data on the interactions between feral cats, foxes, native carnivores and rabbits in Australia, but further work is needed to determine appropriate combinations of control activities that will minimise encounters between native fauna and introduced predators.

In some regions of Australia, certain tree and shrub species are considered weeds because they are thought to suppress the growth of grasses and herbs (Tatnell and March 1991). Grazing by rabbits prevents the regeneration of trees and shrubs, so there is concern that reduced rabbit numbers could allow the growth and spread of these weeds (BRS 1996). The relationship between rabbits and the occurrence of weeds is not clear (Williams et al. 1995). Nevertheless, it is more prudent for land managers to control the spread of weeds using appropriate techniques, rather than to rely on rabbits for weed control (BRS 1996).

Poisoning and destruction of surface harbour are the only effective techniques for control of surface-dwelling rabbits (Williams et al. 1995). The removal of surface harbour is likely to affect native species adversely but, with due caution, poisons can be used with minimal potential risk.

3.2.1 Interaction with other herbivores

The presence of too many herbivores in an area can lead to overgrazing and land degradation. Domestic livestock numbers can be actively controlled by land managers, but a range of other herbivores, including rabbits and feral goats, may be significant contributors to total grazing pressure and not as easy to control.

These species may not normally be considered in determining total stocking rates on an area, but their numbers, combined with domestic livestock numbers, may exceed safe stocking rates. The impacts of feral species will be most pronounced during drought, when animals compete for declining food and water resources. Studies in the Broken Hill district by Tatnell and March (1991) showed that rabbits were responsible for 5–50 per cent of the total grazing pressure. Mutze (1991) estimated that the grazing pressure due to rabbits was seven times the average stocking rate for his study site in South Australia.

Herbivores are also known to selectively feed upon species that are highly palatable to them. Studies by Cooke (1981), Auld (1990), Lowe et al. (2003) and Martin et al. (2007) indicate that rabbits alone are capable of preventing the regeneration of a range of native trees and shrubs. Where conservation of a particular native species is the objective of management, it is necessary to determine the importance of each herbivore so that appropriate action can be taken.

3.2.2 Foxes and cats

Given that rabbits are an important source of prey for cats and foxes, control activities identified in the TAP for rabbits must be integrated wherever possible with those detailed in the feral cat and fox TAPs. Reduction in rabbit numbers can have a flow-on effect on numbers of cats and foxes, as has been seen in the Flinders Ranges in South Australia since the spread of RHD, which initially reduced rabbit numbers by 85 per cent (Holden and Mutze 2002). Within 6–10 months, this led to a substantial decrease in the number of both cats and foxes. The diet of cats did not change markedly with the drop in rabbit numbers, but their physical condition deteriorated. In contrast, foxes ate a greater amount of invertebrates and carrion in response to the decrease in rabbit numbers, and maintained their physical condition. In the case of islands, coordination of control efforts is particularly important; for example, rabbit numbers have increased dramatically on some islands following eradication of cats.

3.3 Animal welfare concerns

There is a community expectation that all animals, including pests, are to be treated humanely (Braysher 1993). Therefore, animal welfare issues must be an important consideration when planning rabbit control operations.

In general, the National Consultative Committee on Animal Welfare (NCCAW) (1992) has advocated the use of techniques that result in high-level and sustained control, which reduces the need to frequently apply controls. The techniques used must be as humane as possible. Techniques that are generally considered inhumane are steel-jaw traps and fumigation using chloropicrin (Williams et al. 1995), and their use is not recommended.

Section 2.2 discusses the different toxins used to poison rabbits. There is still some debate as to the humaneness of 1080 poisoning, but 1080 is generally considered to be the most humane option of the toxins currently available. Williams et al. (1995) conclude that there is no evidence to suggest that rabbits suffer severe or prolonged pain. Gregory (1991) outlined the case that 1080 poisoning is humane. If used in the recommended way, 1080 should remove more than 90 per cent of rabbits; when combined with warren fumigation and ripping, it can result in long-lasting control. In South Australia, landholders requesting baits containing 1080 are required to indicate that they will follow up with additional control methods to remove residual rabbits.

The anticoagulant pindone appears to be less humane than 1080 because bleeding into joints can result in severe pain. Of the fumigants, phosphine is more humane than chloropicrin, but the length of suffering of animals depends on the structure of the warren and environmental conditions (Williams et al. 1995).

The humaneness of ripping depends on the depth of warrens and population density. Where warrens are deeper than the tines of the ripper, rabbits will be trapped in tunnels where they suffocate or starve slowly.

This type of death is less acceptable than rapid asphyxiation that kills rabbits in tunnels that are collapsed by the tines. The humaneness of this technique could be improved by conducting a poisoning campaign using 1080 before ripping, reducing the number of rabbits that will suffer a slow death. In addition, the NCCAW (1992) considered this more humane because it achieves longer lasting control.

Lenghaus (1993) observed that rabbits inoculated with RHDV died quietly within approximately 36 hours. In this acute form, the virus appears to be a very humane form of control that compares favourably with myxomatosis and other rabbit control techniques.

Regardless of the technique used, any significant rabbit control program should be evaluated to ensure it meets appropriate animal welfare standards. Consultation with animal welfare agencies, such as the RSPCA, has been facilitated through recent developments, such as the discussion paper *A national approach towards humane vertebrate pest control* (HVPC Working Group 2004).

The Department of the Environment and Heritage (now the Department of the Environment, Water, Heritage and the Arts) commissioned the development of codes of practice and standard operating procedures (SOPs) for the humane capture, handling and destruction of feral animals. The *Model code of practice for the humane control of rabbits* (Sharp and Saunders 2004a) provides information and recommendations to vertebrate pest managers responsible for the control of rabbits, including advice on how to choose the most humane, target-specific, cost-effective and efficacious control techniques.

The SOPs for rabbits include information about trapping using padded-jaw traps (Sharp and Saunders 2004b), inoculation of rabbits with RHDV (Sharp and Saunders 2004c), ground baiting with 1080 (Sharp and Saunders 2004d) and pindone (Sharp and Saunders 2004e), aerial baiting with 1080 (Sharp and Saunders 2004f), diffusion fumigation of warrens (Sharp and Saunders 2004g), warren destruction by ripping (Sharp and Saunders 2004h) and explosives (Sharp and Saunders 2004i), and ground shooting (Sharp and Saunders 2004j). Each SOP provides information about the appropriate application of the method, animal welfare considerations, health and safety considerations, equipment required and procedures to guide managers.

3.4 Cultural issues

Many Indigenous people regard exotic species such as the rabbit as having just as much right to inhabit the land as indigenous fauna, and are generally opposed to control programs that do not make use of the animals destroyed (Rose 1995). The decline and extinction of many of Australia’s small mammal species, particularly in the arid and semiarid zones, was associated with the appearance of the rabbit, but the effects were confounded by the spread of foxes shortly afterwards (Calaby 1969). It is arguable that rabbits support higher predator populations than would be sustained by native game alone (Pech and Hood 1998). Many of the mammal species used by Indigenous communities in central Australia for sustenance either disappeared altogether or became exceedingly scarce. The rabbit, in contrast, is easily obtained by hunting or purchase from local shooters and is a common food item in many central Australian Aboriginal communities (Burbidge et al. 1988, Reid et al. 1993). Rabbits are also commercially harvested by some of these communities, providing economic and employment benefits (Williams et al. 1995).

Indigenous Australians have a unique role to play in the management of natural and cultural areas, particularly in areas where traditional skills and knowledge are strong. Indigenous people can interpret the landscape and give insights into the natural history of certain species. They can fulfil a range of other roles in feral animal control; for example, by being contracted to remove, monitor and manage rabbits. As the legal owners and managers of large areas of Australia, Indigenous communities are very important groups in the management of Australia’s feral animals.

Rabbit hunting for sport and game meat is a relatively important pastime for some Australians, although many hunters perceive rabbits to have little sporting merit. Rabbits will not be eradicated in the foreseeable future, so hunting opportunities for rabbits remain available. Nevertheless, effective rabbit control campaigns will reduce the available opportunities.

In order to minimise potential conflict and misunderstanding, all groups with an interest in the planning and implementation of rabbit control programs should be involved wherever possible. Consideration of the differing cultural values attached to rabbits must be an important component of any control program.

4 Developing a national approach to rabbit management

This section looks at the different aspects involved in developing a national approach to rabbit management in Australia. It covers planning, strategies for allocating resources and identifying priority areas for action.

4.1 Planning for nationally coordinated action

Cost estimates of expenditure on rabbit control activities in Australia are shown in Table 4.1. Landholders and land managers are legally required by the states and territories to control rabbits on their land and are financially responsible for that control. Bomford and Hart (2002) estimated that private expenditure on rabbit control was approximately $10 million per year, although this figure is likely to be extremely conservative.

Local government agencies are also actively involved in rabbit control activities, but there are few reliable data on the costs of these efforts. State and territory agencies invest in rabbit control. For example, in New South Wales, funding for operational programs for rabbit control was $84 000 in 2000–01 and $108 000 in 2001–02 (English and Chapple 2002); also, most of the state's Rural Lands Protection Boards have rabbit control advisers or inspectors. The Australian Government funds rabbit control on its own lands and provides funding for a range of cooperative rabbit control initiatives (see Table 4.2), including:

- strategic management of RHD (national, project ceased in 2002)
- the role of baiting in future best-practice rabbit management (national)
- pressure fumigation of rabbit warrens using carbon monoxide (New South Wales)
- development of a rapid field test for measuring the serological status of wild rabbits to RHD (Victoria, project ceased in 2007)
- adaptive fox and rabbit management in agricultural areas (South Australia), and
- crop and pasture protection from rabbits in native bush remnants (Western Australia, project ceased in 2002).

The Australian Government, through the activities of CSIRO, has had a long involvement in a wide range of activities related to rabbit management. The results of the research and management programs funded by the Australian Government have provided a valuable information base from which the rabbit TAP has been developed.

Strategic management of RHD has now been taken up by industry groups Australian Wool Innovation, and Meat & Livestock Australia, who are spending $600 000 on research in an 18-month period from 2005 to 2007.

Table 4.1: Cost estimates for control of rabbits

Method	Cost	Reference
Fencing	\$3700–\$4000(–\$11 400)/km (upper figure for a combined fence)	Long and Robley (2004)
Estimated total labour cost	\$0.8–\$1.4 million/year (1998–2003)	Reddiex and Forsyth (2004)
Total control cost	\$20 million/year	McLeod (2004)
Total economic impact[a]	\$113.1 million/year	McLeod (2004)

a Total economic impact includes sheep and cattle production loss, cropping industry loss, control cost and research cost.
Note: Costs are limited to fencing and labour because the costs of rabbit control measures are often part of other land management, making a more compete assessment unfeasible.

Table 4.2: Australian Government projects related to rabbit management, 2002–06

Project name	Recipient of funding
2002–03	
A project to increase understanding of feral goat, feral cat, feral rabbit, fox and feral pig control required to minimise threats to native species and ecological communities Review of existing red fox, feral cat, feral rabbit, feral pig and feral goat control in Australia. II. Information gaps	Arthur Rylah Institute for Environmental Research
A project to increase understanding of interactions between feral cats, foxes and feral rabbits in Australia	Arthur Rylah Institute for Environmental Research
Cost effective fencing systems to exclude feral animals from areas of high conservation value in Australia	Arthur Rylah Institute for Environmental Research
Development of a model code of practice and standard operating procedures for the humane capture, handling or destruction of feral animals in Australia	NSW Agriculture
A project that improves Australia’s ability to protect its island habitats from feral animals — Western Australia	WA Department of Conservation and Land Management
2003–04	
A project that develops an agreed code of practice and standard operating procedures for the humane care and use of pest animals in Australia for the purposes of scientific research	NSW Agriculture

2004–05	
Introduced animals on New South Wales islands: improving Australia's ability to protect its island habitats from feral animals	NSW Department of Conservation
A report outlining Australia's past performance in invasive species prevention, detection, eradication and management	Agtrans Research
A project that reviews the Commonwealth Government's threat abatement plans for feral goats, feral rabbits, feral cats and the European red fox	Bureau of Rural Sciences
Introduced animals on Tasmanian islands: improving Australia's ability to protect its island habitats from feral animals	Tasmanian Department of Primary Industries, Water and Environment
2005–06	
Development of PAPP (para aminopropiophenone) based toxins as an alternative toxin for vertebrate pest control in Australia	Scientec Research Pty Ltd
Landscape-based optimisation of vertebrate pest management strategies	University of Canberra

Williams et al. (1995) noted that successful rabbit management requires an integrated approach at the state, regional and local levels. Effective action depends on:

- improved training courses integrating rabbit management with other aspects of land management
- enhanced understanding by land managers of the damage caused by rabbits and the implementation of control techniques
- coordinated action by state and territory agencies to develop pest management information systems, and
- an economic framework to assist in assessing the relative values of different control strategies.

Williams et al. (1995) reported that the majority of successful group operations (which should not be confused with, or seen as a substitute for, government organised work on a large scale) have relied on the zeal and motivation of small rural communities, and are characterised by:

- a high degree of local community understanding of the nature and extent of rabbit damage
- group reinforcement through peer pressure and good communication
- clear, identifiable and shared goals
- synchronisation of the control effort
- economies of scale and efficient use of machinery and human resources, and
- strong support from local and state pest management authorities.

4.2 Strategies for allocating resources to rabbit management

Abating the threat posed by rabbits is a long-term process requiring careful planning, research, frequent review, the adoption of new knowledge and an adaptive management framework. Resources will never be sufficient to deal with all rabbit management problems, so this plan must ensure the strategic allocation of resources to give the best outcome for threatened species conservation.

Localised rabbit control in specific areas of high conservation concern, particularly around populations of threatened species, is a high priority. Recovery plans for a number of species identify the rabbit as a threat. It is likely that more species will be identified as being at risk from rabbits as future recovery and management plans are developed.

Local eradication is an option for areas such as small islands, isolated small populations on the mainland or small mainland sites that meet strict criteria (these criteria apply to pest animal control in general, not just to rabbits). Successful local eradication requires that:

- reinvasion risks are manageable
- all animals are accessible and at risk during the control operation, and
- animals are killed at a rate higher than the ability of a population to replace these losses through breeding.

Buffer zones may be a necessary component of managing small areas, to reduce the threat from continual reinvasion from surrounding areas. Development of lower density buffer zones requires active participation of surrounding landholders and a clear identification of the benefits to be obtained by all participants; to this end, collaboration with neighbours is essential.

Where local eradication is not possible, there are two broad strategies for localised management of rabbits: sustained management, where control is implemented on a continuing regular basis, and intermittent management, where control is applied at critical periods of the year when it will have the greatest impact and is most likely to reduce populations to acceptable levels. Removing the threat of rabbits through an integrated control program is more effective than taking temporary seasonal measures at sites where there is a seasonal threat (e.g. to annual crops).

To ensure efficient and effective use of resources, an experimental approach should be used to determine the significance of the impacts of competition and land degradation by rabbits, and to identify the level of control necessary for recovery of affected species. This monitoring needs to include areas with and without rabbit control. By approaching local control on an experimental basis, an accurate measure of the threat to affected species can be identified. If rabbits are a significant threat, then the expansion of rabbit control activities to other sites where the affected species occurs is justified. Alternatively, if rabbit control is shown to be of little relevance to recovery of affected species, efforts can be redirected towards other, more effective activities. Assessments about the effects of rabbits on broader habitat decline should also be made in the context of programs on general rabbit control.

Regional management, which focuses on key areas where maximum benefits can be derived from reducing rabbit numbers, is a central element of the TAP. Regional control programs involving both conservation and farming systems need to be designed to provide protection for more than one affected species and expansion of their available habitat. Broadscale control of rabbits at this level of resolution requires a substantial investment of resources. An adaptive management approach is appropriate on a regional scale as it can accommodate different experimental control techniques within a broadly comparable area. A focus on regional management also provides a mechanism for integrating rabbit control with other biodiversity conservation actions.

High priority must be given to monitoring the outcomes of rabbit control in terms of the conservation benefits derived. High rates of kill may not lead to effective control if rabbits are able to maintain high reproductive rates or where low rabbit numbers can still restrict or prevent plant regeneration (e.g. in arid regions). Unless rabbit numbers and effects on affected species are monitored, control efforts may be wasted.

4.3 Identifying priority areas for action

The identification of native species and habitats that will benefit most from coordinated rabbit control is clearly important in the protection of affected species and conservation of biological diversity. The ability to identify priority areas for control on primary production land, based on measures of rabbit impacts, distribution and density, is also critical to effective and economical management of rabbits in these areas.

Recovery plans for a number of threatened species identify competition and land degradation by rabbits as a threat. They also identify areas of habitat critical for the survival of these species. However, there is little reliable information on the benefits of rabbit control for these species (Reddiex and Forsyth 2004). Local community groups and relevant landowners must be encouraged to coordinate rabbit control activities for their region to increase both primary production and biodiversity benefits.

As resources are not sufficient to implement all the control measures identified in recovery plans, priority areas must be ranked on a valid and nationally consistent basis to maximise the conservation benefits. An agreed national methodology for priority ranking should cover the protection of threatened and significantly affected species, facilitate the expansion of populations of these species and prepare areas for translocation if necessary. It is important to prioritise areas according to risk and potential risk reduction, to allocate resources to areas where rabbit management is most needed and most likely to be successful. The Pestplan system developed by Braysher and Saunders (2003) includes a five-step process for prioritising actions to get the most cost-effective return from pest management.

Priorities for investment in rabbit control for biodiversity conservation should be guided by:

- the degree of threat posed to the survival of a species or ecological community
- the potential of the species or ecological community to recover
- the number of threatened species likely to benefit from control in a location
- the cost-efficiency, and
- the likely effectiveness of control.

Appendix A: Threat abatement plans and the EPBC Act

Extracts from the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and EPBC Regulations 2000 relating to the requirements for threat abatement plans.

Section 271 Content of threat abatement plans

(1) A threat abatement plan must provide for the research, management and other actions necessary to reduce the key threatening process concerned to an acceptable level in order to maximise the chances of the long-term survival in nature of native species and ecological communities affected by the process.

(2) In particular, a threat abatement plan must:

(a) state the objectives to be achieved; and

(b) state the criteria against which achievement of the objectives is to be measured; and

(c) specify the actions needed to achieve the objectives; and

(g) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).

(3) In making a threat abatement plan, regard must be had to:

(a) the objects of this Act; and

(b) the most efficient and effective use of resources that are allocated for the conservation of species and ecological communities; and

(c) minimising any significant adverse social and economic impacts consistently with the principles of ecologically sustainable development; and

(d) meeting Australia's obligations under international agreements between Australia and one or more countries relevant to the species or ecological community threatened by the key threatening process that is the subject of the plan; and

(e) the role and interests of indigenous people in the conservation of Australia's biodiversity.

(4) A threat abatement plan may:

(a) state the estimated duration and cost of the threat abatement process; and

(b) identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan; and

(c) specify any major ecological matters (other than the species or communities threatened by the key threatening process that is the subject of the plan) that will be affected by the plan's implementation.

(5) Subsection (4) does not limit the matters that a threat abatement plan may include.

Section 274 Scientific Committee to advise on plans

(1) The Minister must obtain and consider the advice of the Scientific Committee on:

(a) the content of recovery and threat abatement plans; and

(b) the times within which, and the order in which, such plans should be made.

(2) In giving advice about a recovery plan, the Scientific Committee must take into account the following matters:

(a) the degree of threat to the survival in nature of the species or ecological community in question;

(b) the potential for the species or community to recover;

(c) the genetic distinctiveness of the species or community;

(d) the importance of the species or community to the ecosystem;

(e) the value to humanity of the species or community;

(f) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

(3) In giving advice about a threat abatement plan, the Scientific Committee must take into account the following matters:

(a) the degree of threat that the key threatening process in question poses to the survival in nature of species and ecological communities;

(b) the potential of species and ecological communities so threatened to recover;

(c) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

Section 279 Variation of plans by the Minister

(1) The Minister may, at any time, review a recovery plan or threat abatement plan that has been made or adopted under this Subdivision and consider whether a variation of it is necessary.

(2) Each plan must be reviewed by the Minister at intervals not longer than 5 years.

(3) If the Minister considers that a variation of a plan is necessary, the Minister may, subject to subsections (4), (5), (6) and (7), vary the plan.

(4) The Minister must not vary a plan, unless the plan, as so varied, continues to meet the requirements of section 270 or 271, as the case requires.

(5) Before varying a plan, the Minister must obtain and consider advice from the Scientific Committee on the content of the variation.

(6) If the Minister has made a plan jointly with, or adopted a plan that has been made by, a State or self-governing Territory, or an agency of a State or self-governing Territory, the Minister must seek the co-operation of that State or Territory, or that agency, with a view to varying the plan.

(7) Sections 275, 276 and 278 apply to the variation of a plan in the same way that those sections apply to the making of a recovery plan or threat abatement plan.

Environment Protection and Biodiversity Conservation Regulations 2000

REG 7.12 Content of threat abatement plans

For paragraph 271 (2) (g) of the Act, a threat abatement plan must state:

(a) any of the following that may be adversely affected by the key threatening process concerned:

(i) listed threatened species or listed threatened ecological communities;

(ii) areas of habitat listed in the register of critical habitat kept under section 207A of the Act;

(iii) any other native species or ecological community that is likely to become threatened if the process continues; and

(b) in what areas the actions specified in the plan most need to be taken for threat abatement.

Glossary

Arid	The arid and semiarid lands are those remote and sparsely populated areas of inland Australia, defined by the presence of desert vegetation and

	landforms as well as by low rainfall. They are bound by median annual rainfalls of about 250 mm in the south but up to 800 mm in the north and about 500 mm in the east (Beeton et al. 2006).
Bioaccumulation	The accumulation of a substance in various tissues of a living organism.
Biocontrol	Control of pests by disrupting their ecological status through the use of organisms that are natural predators, parasites or pathogens.
Biodiversity	Variability among living organisms from all sources (including terrestrial, marine and other ecosystems and ecological complexes of which they are part), which includes diversity within species and between species and diversity of ecosystems (Beeton et al. 2006).
Biodiversity conservation	The protection, maintenance, management, sustainable use, restoration and enhancement of the natural environment (Beeton et al. 2006).
Buffer zone	An area that keeps two or more areas distant from one another.
Commercial harvesting	The taking of animals from the wild for a commercial purpose.
Critically endangered	Under the EPBC Act, a native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Epizootic	The occurrence or outbreak of a disease in a population or region at a much higher level than normally expected (Williams et al.1995).
Eradication	Application of measures to eliminate an invasive alien species from a defined area.
Exclosure	Area fenced to keep out unwanted animals.
Fecundity	Potential rate at which an organism reproduces.
Feral	An introduced animal, formerly in domestication, with an established, self-supporting population in the wild.
Immunocontraception	The stimulation of the immune responses (antibody production and cell-mediated immunity) in the target animal against its own reproductive hormones, gamete proteins or another protein essential to reproduction, to induce sterility (Saunders and McLeod 2007).
Invasive species	A species occurring as a result of human activities beyond its accepted normal distribution and which threatens valued environmental, agricultural or personal resources by the damage it causes (Beeton et al. 2006).
Key threatening process	Under the EPBC Act, a process that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.
Myxomatosis	A disease caused by the myxoma virus that was introduced to Australia as a biological control agent for rabbits.
Neophobia	The tendency of an animal to avoid or retreat from an unfamiliar object or situation.
Pest animal or species	Any non-human species of animal that causes trouble locally, or over a wide area, to one or more persons, either by being a health hazard or a general

	nuisance, or by causing damage to agriculture, wild ecosystems or natural resources.
Rabbit haemorrhagic disease	An exotic viral disease that causes high death rates in rabbits. Also called rabbit calicivirus disease.
Recovery plan	Under the EPBC Act, a document setting out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities.
Semiarid	Lands where rainfall is so low and unreliable that crops cannot be grown with any reliability (Beeton et al. 2006). *See* Arid zone
Threat abatement plan	Under the EPBC Act, a plan providing for the research, management, and any other actions necessary to reduce the impact of a listed key threatening process and impacted species or ecological communities.
Threatened species	Refers to the Australian Government list of threatened native species divided into the following categories as per the EPBC Act: critically endangered, endangered, vulnerable, conservation dependent.
Translocation	The reintroduction of a species that has suffered localised extinction after the threat to that species has abated.
Vector	An insect or other organism transmitting germs or other agents of disease.
Wild	Not domesticated or cultivated, but including escapees from domestication or cultivation.

Acronyms and abbreviations

CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPBC Act	the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
NCCAW	National Consultative Committee on Animal Welfare
RHD	rabbit haemorrhagic disease
RHDV	rabbit haemorrhagic disease virus
TAP	threat abatement plan
1080	sodium fluoroacetate

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