ACT Government
Environment and Planning

Best Practice Management Guide for Rabbits in the ACT

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Telephone: 02 6207 1923 Website: www.environment.act.gov.au

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Dr Don Fletcher, Senior Ecologist, Conservation Planning and Research, Environment and Planning Directorate provided the data and interpretation for the Tidbinbilla Nature Reserve and Googong Foreshores examples of best practice rabbit management described in Section 8.

Cover photo

A rabbit at the Percival Hill Reserve, Canberra Nature Park.

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Contents

1. Overview 1

2. What damage is caused by rabbits? 2

3. Model Code of Practice (CoP) for the Humane Control of Rabbits (Sharp and Saunders 2012) 5

4. Potential impacts of rabbit control techniques on humans, non-target species (e.g. stock, pets, native animals, other pest animals) and the environment. 6

5. Best practice management for rabbits 26

6. Monitoring and assessment for rabbit management programs (Williams *et al.* 1995, Mitchell and Balogh 2007, ACT Government 2012). 28

- 6.1 Spotlight counts along transects 28
- 6.2 Warren counts 29
- 6.3 Active entrance counts 30
- 6.4 Warren mapping 30
- 6.5 Monitoring rabbit damage and adverse impacts of control techniques 31

7. Common barriers to the delivery of rabbit management programs 32

- 7.1 Social 32
- 7.2 Legislation, government and government funding 33
- 7.3 Other financial 33
- 7.4 Technical 33

8. Examples of the successful application of best practice rabbit management in the ACT 35

9. Current rabbit management aims, practices, gaps and constraints in the ACT (O. Orgill) 37

10. References 38

1. Overview

This best practice management guide for rabbits has been developed as an information resource to support ACT Government officers and non-government land managers with responsibility for rabbit control in the ACT.

Rabbits cause significant damage to conservation, rural and urban lands (Section 2) and control of rabbit populations is frequently required to protect high-value sites and assets.

ACT Government rabbit control operations are carried out in accordance with a nationally-agreed Model Code of Practice (CoP) for the Humane Control of Rabbits and suite of associated Standard Operating Procedures (SOPs) (Section 3). The ACT Government encourages all land managers to undertake rabbit control operations according to the CoP and SOPs. It will be mandatory for ACT Government-funded projects that include a rabbit control component to be conducted in accordance with the CoP and SOPs.

The acceptable and conditionally acceptable rabbit control techniques specified in the CoP and SOPs have the potential to impact on humans, non-target species (e.g. stock, pets, native animals and other pest animals) and the environment (Section 4). Table 2 in Section 4 lists the risks associated with each control technique and suggests mitigation measures to ameliorate each risk.

Ten key recommendations for best practice management (Section 5), incorporating details from Sections 3 and 4, are provided to underpin the development of government and non-government rabbit control programs in the ACT.

Operational and performance monitoring of rabbit control programs is essential to ensure they have been carried out as efficiently as possible to get the best return on investment and that rabbit population density or damage reduction targets have been met (Section 6).

Irrespective of the care taken in planning rabbit control programs, some are unsuccessful in reducing rabbit populations and/or damage to acceptable levels. Failure of rabbit control programs can be due to a range of social, legislative, government, financial and technical barriers that can be taken into account to improve control program outcomes (Section 7).

Successful rabbit control programs reduce rabbit populations to low numbers (e.g. less than one rabbit per hectare or six rabbits per spotlight kilometre) that prevent unacceptable damage to sites and assets, and can be maintained in the long term with minimal resources. Examples of where ACT Government rabbit control operations have had ongoing success include the Tidbinbilla Nature Reserve and Googong Foreshores (Section 8).

A brief overview of current rabbit management aims, practices, gaps and constraints in the ACT is also provided (Section 9).

2. What damage is caused by rabbits?

Rabbits cause damage in conservation, primary production and urban landscapes across Australia, with adverse environmental, social and economic consequences (Table 1; Williams *et al*. 1995, Croft and Connellan 1999, NRE 2000, O'Keeffe and Walton 2001, QDNRM 2002, Lowe and Twigg 2014a, Kirkpatrick *et al*. 2008, QDPI&F 2008, Williams 2011, Cooke 2012).

In the ACT, environmental damage in national parks and other nature reserves is a key driver for ACT Government-coordinated rabbit control programs (ACT PCS 2011a), with rabbit control accounting for approximately two thirds of annual vertebrate pest management operational budgets (e.g. ACT PCS 2011b). The Glossy Black Cockatoo, Hooded Robin, Brown Treecreeper, White-winged Triller, Superb Parrot, Striped Legless Lizard and Spotted-tailed Quoll (all listed as vulnerable in the ACT), and the Brush-tailed Rock-wallaby, Grassland Earless Dragon and Golden Sun Moth (all listed as endangered in the ACT)[1] have been recognised to be, or have the potential to be, adversely affected by rabbits (Reddiex and Forsyth 2004, DEWHA 2008, TAMS 2010). Other native species and communities that occur locally and are potentially susceptible to rabbits include the Canberra Spider Orchid, Brindabella Midge Orchid and Leek Orchid, and the Natural Temperate Grasslands of the Southern Tablelands of NSW and the ACT (endangered) (Kirkpatrick *et al*. 2008). Rabbits have been recognised as a prime cause of environmental degradation in the Canberra Nature Park (Williams 2011).

The impacts of rabbits on primary production in the ACT have not been estimated. However, rabbits are thought to cost Australian agriculture $206 million annually in production losses alone (Brown 2012). Rabbits also cause damage in ACT urban areas including sports fields and building foundations, and in urban and suburban open space and gardens.

1 www.legislation.act.gov.au/di/2012-11/current/pdf/2012-11.pdf

Table 1: Damage caused by rabbits and the consequences for natural, primary production and urban ecosystems.

	Damage	Consequences
Natural ecosystems	Degradation of native vegetation and impacts on native plant and animal species	• Reduction in plant biomass and cover. • Reduced seedling recruitment and replacement rates for old trees, delayed growth of seedlings and prevention of regeneration in some cases. • Reversal in the direction of succession. • Densities of 0.5 rabbits per hectare or less can inhibit regeneration in arid areas. • Ringbarking and foliage stripping of palatable trees and shrubs (and less palatable species in drought). • Loss of *Acacia, Maireana, Callitris, Myoporum, Allocasuarina, Eucalyptus pauciflora, Bursaria spinosa, Brachychiton populneus*, palatable herbs, forbs and grasses, and other species. • Reduced seed set from grazing of flowers and seedheads. • Shifts from perennial to annual plant species. • Increased abundance of exotic weeds of Mediterranean origin that evolved with rabbits, particularly in the vicinity of warrens. • Other weed invasion and spreading of weed seeds, including through droppings (however, rabbits may also act as a vector for native seeds). • Grazing of revegetation plantings, and of roadside and wildlife corridor regeneration. • Distribution range contraction (e.g. in wombats, possums) and contribution to extinctions (particularly of mammals and rodents in the 0.05 – 5 kg weight range).

	Damage	Consequences
		• Altered native plant and animal species composition (including permanent changes in grass and herb composition with seed bank loss). • Removal of habitat and/or change in habitat composition disadvantages some species and benefits others. • Direct grazing competition with native animals, particularly for green pick during drought and after fire. • Rabbit populations support predators (foxes, cats) and their diseases, and predation of native animals can be high, particularly after rabbit populations crash, e.g. in drought or after rabbit control. • Warrens provide shelter for predators such as cats (however, warrens may also provide shelter for mammals, reptiles and insects). • Direct aggression towards native animals (e.g. bettongs). • Eviction of native mammals from their burrows. • Destruction of nesting habitat for birds. • Senescence of mature trees containing nest hollows, with mature tree replacement prevented by rabbits. • Interaction of above rabbit impacts with threatening processes such as drought, grazing and fire.
Primary production systems	Grazing of forage (including pasture and palatable shrubs, trees and perennial grasses)	• Reduced palatable species in pasture composition (however, rabbits can aid in the suppression of unpalatable native woody species in rangeland production systems). • Shift from perennial to annual pasture and weed species. • Depletion of drought forage reserves. • Cost of re-establishing pasture and decreased property value.
	Grazing competition with stock	• Stock death from starvation (e.g. during and after drought). • Reduced maximum stocking rates. • Increased need to agist stock. • Rabbits may induce stock to graze on native species by removing more palatable grasses and herbs. • Reduced availability of green feed causing reduced livestock nutrition.
	Other stock impacts	• Fibre and meat production losses (e.g. lower lamb marking rates, bodyweight, wool clip and wool quality). • Greater lambing losses through predation by fox populations that are supported by rabbit populations. • Reduced sheep fleece quality through exposure to soil from bare ground. • Livestock leg injury or breakage in rabbit burrows. • Rabbits provide an alternative host for some parasites and diseases. They may carry dog tape worms and sheep liver fluke. Rabbits may transmit Johne's disease (*Mycobacterium avium paratuberculosis*) to cattle and act as a vector of infective *Escherichia coli* in humans.
	Crop damage	• Reduced crop yields, particularly on crop peripheries. • Known to damage cereals (e.g. wheat, barley, rye), vegetables, fruit/ orchards and forestry operations. • Damage to wine grape crops through consumption of buds.

	Damage	Consequences
Urban landscapes	Grazing	• Damage to ornamental trees and shrubs, lawns, flowers, fruit and vegetables in suburban and public gardens.
	Warren entrances and scrapes in public use areas	• Loss of amenity and landscape values. • Damage to golf courses, sportsgrounds and parkland reserves, structural damage to buildings, garages and sheds, and burrowing beneath gravesites.
Soils (all land uses)	Reduced vegetation cover through grazing and increased soil disturbance through warrens and scrapes	• Soil surface erosion. • Loss of surface mulch and soil fertility, organic matter and water holding capacity. • Higher soil alkalinity and electrical conductivity, and loss of surface cryptogams (mosses, lichen etc.) and native perennials on rabbit mounds. • Deposition of nutrient-poor soils on rabbit mounds during warren construction. • Siltation of dams (with high population numbers). • Weed invasion of bare ground. • Soil disturbance and nutrient enrichment around warrens promotes germination of some weed species. • Sediment, salt and nutrient impacts on groundwater recharge and water quality. • Damage is caused particularly on sandy and granitic soils which rabbits prefer. • Loss of arable land.
Pest management programs	Public costs	• Rabbit control on public lands. • Forestry and tree plantation losses. • Research, development and extension programs. • Reduced tax revenue from primary producers.
	Private costs	• Rabbit control programs on private land. • Greater stock transport, fodder and agistment costs, and forced sale at low prices during drought. • Private forestry, tree plantation and revegetation losses. • Control board levies (not in ACT) and rabbit-proof fencing (limited in ACT).
	Non-target impacts of control techniques	• See Table 2.

3. Model Code of Practice (CoP) for the Humane Control of Rabbits (Sharp and Saunders 2012)

A model CoP for the humane control of rabbits has been endorsed by the former national Vertebrate Pests Committee (now the Invasive Plants and Animals Committee) and the National Biosecurity Committee.

The model CoP provides information and guidance on the humaneness, efficacy, cost-effectiveness and target specificity of rabbit control techniques and on their general suitability for application. Acceptable or conditionally acceptable rabbit control techniques contained in the CoP that are readily available include:

- exclusion fencing
- lethal baiting using 1080 (sodium fluoroacetate; ground and aerial baiting) or Pindone (only acceptable in certain circumstances)
- warren destruction by ripping and blasting
- diffusion fumigation of warrens using phosphine (supplied as aluminium phosphide)
- padded-jaw and cage traps
- ground shooting
- the release of Rabbit Haemorrhagic Disease Virus (RHDV).

Fertility control and the use of myxomatosis as a biological control agent are considered conditionally acceptable control techniques but are not currently available to most land managers. Myxomatosis is not being actively deployed due to resistance of rabbits to the control strain of the virus and there is no prospect of a replacement strain in the foreseeable future. However, natural outbreaks of myxomatosis still occur and may reduce rabbit populations to a point which is advantageous for the application of other control techniques.

Pressure fumigation of warrens with carbon monoxide is being investigated as a humane alternative to diffusion fumigation using phosphine[2], with the new technology currently undergoing trials prior to a registration package being submitted to the Australian Pesticides and Veterinary Medicines Authority (APVMA). It is expected this technology will become available from 2016.

Warren fumigation using chloropicrin, car exhaust fumes or carbon dioxide, and the use of toothed, steel-jaw traps (which is prohibited under the *ACT Animal Welfare Act 1992*), are considered to be unacceptably inhumane and/or ineffective and uneconomical techniques, and are not considered further in this document. Treatment of rabbit warrens using liquefied propane gas technology (e.g. Rid-a-Rabbit, Rodenator), which causes an explosion and concussion in rabbits, has not been assessed for acceptability but is thought to be inhumane; testing is being undertaken by the NSW Government.

Other management approaches such as pasture reestablishment and choosing alternative crops (Croft and Connellan 1999, QPI&F 2008) are not considered in the CoPs or this document.

The model CoP, and a suite of Standard Operating Procedures (SOPs) that support it, are available at http://www.feral.org.au/animal-welfare/humane-codes.

2 www.invasiveanimals.com/research/phase1/goals/goal-7/10u14c

4. Potential impacts of rabbit control techniques on humans, non-target species (e.g. stock, pets, native animals, other pest animals) and the environment.

Some of the techniques specified for rabbit control in the model CoP and SOPs have unacceptable risks for rabbit welfare, or reduced efficacy of control if applied incorrectly, and other risks for non-target species, including humans, and the environment. These have been summarised in Table 2, along with potential mitigation measures for these risks.

Table 2: Potential risks and mitigation measures associated with acceptable rabbit control techniques.

Potential risks	Potential mitigation
Technique: *1080 baiting* *Major use*: To quickly reduce large rabbit populations during the primary phase of a rabbit control program. *Properties:* 1080 is highly toxic to humans and some native fauna, causing cardiac failure in herbivores, central nervous system disturbance and convulsions and respiratory failure in carnivores, and a combination of these symptoms in omnivores. Sub-lethal doses can damage heart, lungs, liver, kidneys, testes and foetuses, and can cause skeletal damage. 1080 is not mutagenic and is not an endocrine disrupting chemical. 1080 may be able to be administered with analgesics to improve animal welfare outcomes. (McIlroy 1992, Sharp and Saunders no date a,b, APVMA 2008a,b, Eason *et al*. 2011, Brown 2012)	
Humans 1080 is a Schedule 7 poison which is highly toxic to humans and has no antidote.	• Follow OHS procedures in accordance with approved label and APVMA permit requirements. Concentrated products are restricted to use by authorised ACT Government officers with appropriate training. Baits can only be obtained from authorised ACT Government officers. Not for use in urban or other residential or built-up areas.
Baiting success Rabbits avoid bait because alternative feed is available.	• Bait when alternative feed is low e.g. during drought, in late summer or early autumn.
Rabbits avoid bait because they are not used to it.	• Pre-feed with non-poisoned bait to accustom rabbits to bait type and to determine the quantity of bait required for poisoning. Pre-feed 2–3 times at 2–3 day intervals then lay one lot of poisoned bait two or more days after the last pre-feed. Carrot bait loading is typically 140–200 mg 1080/kg bait (use minimum effective concentration to ensure a lethal dose). Lay around 30% less poisoned bait than used for the heaviest pre-feed as 1080-affected rabbits consume less. Carrot bait pieces should be a standard 5 grams or about 2 cm x 2 cm – can be broadcast or laid in furrows.
Rabbit kittens and juveniles with a limited range are less likely to access bait and may survive and contribute to population recovery. Dependent young of poisoned adults die a slow death from starvation.	• Avoid baiting during the breeding season (typically spring to early summer). If baiting is necessary, locate and humanely destroy dependent young.

Potential risks	Potential mitigation
1080 concentrations are reduced to sub-lethal amounts in bait by water.	• Avoid laying baits on moist ground or when rain is expected within 48 hours of laying baits.
1080 baiting does not reduce the rabbit population to sufficiently low levels.	• Perform spotlight and warren counts to estimate change in density and activity, and identify the rabbit population range. Place bait trails where rabbit activity is highest, e.g. near warrens, harbour, and scratching and feeding areas.
Non-target animals Non-target native fauna potentially affected by 1080 include herbivorous macropods (e.g. Swamp Wallaby, Tasmanian Bettong, Tammar Wallaby, kangaroos), wombats, Brush-tailed Possums, some dasyurids (e.g. Brown Antechinus, possibly Eastern Quoll), bandicoots, some rodents (e.g. Bush Rat), and some birds (e.g. Crimson Rosella, Red-browed Firetail, White-winged Chough, magpies, crows and galahs). Insectivorous birds may be at risk, either from direct feeding on bait or eating invertebrates that have fed on bait which can contain high concentrations of 1080. Ducks, raptors and doves are relatively tolerant of 1080. Frogs and reptiles are tolerant of 1080 and are unlikely to be affected by either primary or secondary poisoning. Secondary poisoning risks are generally restricted to dogs (most susceptible), cats and foxes based on concentrations of 1080 found in fresh rabbit carcasses (0.8 mg 1080/kg rabbit). Risk of secondary poisoning may be higher if the stomach contents of dead rabbits are consumed.	• Note that risks from poisoning need to be offset against potential benefits from the removal of predators and competitors. • Use the pre-feeding phase with non-poisoned bait to identify native fauna taking the bait – can use sand pads near bait trails. • Avoid baiting where there is a high risk of poisoning to non-target fauna (e.g. in or next to bushland). • During bait preparation, remove (by sieving) small fragments of poisoned carrot bait likely to contain higher than required concentrations of 1080. • Dyeing baits blue or green <u>may</u> make them unattractive or less obvious to some bird species (more evidence is required for this method). • Lay baits late in the day so most bait is consumed overnight and there is reduced risks to birds. • Bury all poisoned bait remaining in furrows after four days to a depth of 100 mm, or collect and incinerate, or bury unused baits at a depth of 500 mm. Avoid broadcasting bait (except in rocky, scrubby or erosion-prone areas) as collecting and burying unused bait is more difficult. • Consider use of bait stations, fencing/exclosures, soft-jawed leghold traps, shooting, non-poisonous bait stations and detection dogs (Munro 2012) to reduce impacts on high-value, non-target species or assets (note that bait stations may deter rabbit feeding). • Collect all observed rabbit carcasses daily for at least 14 days after poisoning to avoid secondary poisoning, and destroy by incineration or bury as above. Rodents contain higher 1080 residues than rabbits so removal of dead non-target rodents is also advisable.

Potential risks	Potential mitigation
Threatened native animals listed under the EPBC Act and/or NC Act that are susceptible to 1080 occur in the proposed baiting area.	• Use alternative methods or bait in accordance with Territory legislation and/or make a referral under the EPBC Act for approval to use 1080. Threatened populations are less resilient to the loss of some individuals than common species so baiting programs have a potentially greater impact. Studies in New Zealand have failed to detect a threat to threatened bird populations during carrot and cereal aerial baiting programs, but further work with better baiting methods and monitoring is required.
1080 is highly toxic to domestic pets (particularly dogs) and stock, and there is no antidote. There is a loss of grazing opportunity in paddocks where primary control is undertaken using 1080.	• Do not use in areas such as urban and peri-urban areas and stocked paddocks where there is an unacceptably high risk of poisoning (consider Pindone as an alternative poison). • Adjoining landholders must be notified and informed of risks three days before baiting. • Baiting must be completed within 7–14 days of the advertised starting date and signs retained for a minimum of four weeks after baiting commences. • Pet and working dogs should be muzzled and restrained for at least the length of the baiting program and pet cats controlled. • Do not place baits within 5 m of boundary fences, 500 m of habitation, 100 m of domestic water supplies or 10 m of the waterline of large water storage facilities. • Dogs may be at risk for >75 days in dry weather from secondary poisoning if rabbit carcasses are not collected.
Environment 1080 poison causes no significant contamination of air, soil or water as it is readily degraded in biologically active systems i.e. non-arid areas. There is minimal risk to aquatic organisms or terrestrial organisms drinking contaminated water because of low bait application rates and rapid dilution. Aerial baiting programs do not cause significant contamination of surface waters in water supply catchments. There have been no demonstrated impacts of 1080 on populations of invertebrates.	• See distance restrictions for water supplies above. No other mitigation measures required.
Laying bait trails up and down slopes causes erosion on susceptible soils.	• Lay bait trails across slope.

Potential risks	**Potential mitigation**
Technique: ***Pindone baiting***	
Major use: Reduce rabbit populations in areas where use of 1080 is unsuitable such as urban/residential and peri-urban areas (e.g. hobby farms, golf courses and horticultural areas).	
Properties: An anticoagulant which interferes with the synthesis of vitamin K-dependent clotting factors. Is most effective when administered as a series of doses over 4-12 days. Symptoms include physical weakness and lethargy, coughing and respiratory distress, pallor, anorexia and ventral haematomas (bruising around the abdomen). Death in rabbits occurs after 10–14 days from anaemia, internal haemorrhaging and blood and fluid loss. Vitamin K is an effective antidote to accidental poisoning. Pindone is considered to be less humane than 1080.	
(NRA 2002, Robinson *et al*. 2005, Animal Control Technologies 2013, Sharp and Saunders no date c)	
Humans Pindone is a Schedule 6 poison that can cause serious damage to health by prolonged exposure if swallowed. It can also be inhaled as dust and be absorbed through the skin.	• Follow OHS procedures in accordance with approved label and material safety data sheet requirements. Pindone concentrate label states 'This product is only to be used to treat grain or carrots for the preparation of baits for the control of rabbits and in accordance with the directions of the appropriate state or territory government department. Restricted chemical product – only to be supplied or used by an authorised person'. • Concentrated Pindone products can only be handled by authorised ACT Government officers with appropriate training. Carrot baits treated with Pindone can be obtained from authorised ACT Government officers. • There are detailed instructions that go with the label on the methods for rabbit baiting and its use in integrated control programs. • Do not place baits where children have access. • Seek treatment with vitamin K if poisoning occurs.
Baiting success Rabbits avoid bait because alternative feed is available.	• Bait when alternative feed is low e.g. during drought, in late summer or early autumn. Note: rabbits do not become bait shy with Pindone (cf. 1080) because of the extended period between ingestion and death.

Potential risks	Potential mitigation
Pindone baits are not properly prepared or deployed and are sub-lethal to rabbits.	• Pindone concentrations on manufactured bait are 0.23–0.5 g Pindone/kg bait and should be 0.5 g Pindone/kg on fresh bait. Higher concentrations are needed for oats than carrots as rabbits consume fewer oats than carrots. LD50 for rabbits consuming baits is 0.52 mg Pindone/kg bodyweight/day over seven days. However, an inactive rabbit may survive ingestion of 16 mg Pindone/kg bodyweight/day. The acid and sodium salt forms of the concentrate are essentially equivalent in their toxicity to target and non-target animals. Use of liquid concentrate avoids dust exposure, and clumping of powder and carrot shards in corners of mixer. Use two bait trails at 30+ m and a further 40 m from where rabbits are living. Place bait trails in furrows (10 cm wide and 2 cm deep) or broadcast (in rocky areas, near fallen timber, in crops or in erosion-prone areas). • Disturbed soil in furrows is attractive to rabbits and will result in higher bait consumption. Do not bait if rain is expected within 24 hours.
Rabbit kittens and juveniles with a limited range are less likely to access bait and may survive and contribute to population recovery. Dependent young of poisoned adults die a slow death from starvation.	• Avoid baiting during the breeding season (typically spring to early summer). If baiting is necessary, locate and humanely destroy orphaned, dependent young.
Pindone baiting does not reduce the rabbit population to low levels.	• Perform spotlight and warren counts to estimate change in density and activity, and identify the rabbit population range (including neighbouring properties). • Place bait trails where rabbit activity is highest, i.e. near warrens, harbour, and scratching and feeding areas.

Potential risks	Potential mitigation
Non-target animals Pindone is moderately toxic to a range of species. Granivorous birds (e.g. Crested Pigeon, Bronzewing Pigeon, Port Lincoln Parrot), bandicoots (e.g. Southern Brown Bandicoot), native rodents and macropods (e.g. Western Grey Kangaroo, Swamp Wallaby) are vulnerable to primary poisoning. Possums are relatively resistant to Pindone but it is used to control them in New Zealand. Magpies are at low to moderate risk because of their low sensitivity, omnivorous diet and possibly the capacity for adults to dehusk oats. Black Ducks may be affected if oat baits constitute more than 20% of their diet. Owls may be susceptible based on studies with related compounds. Dasyurids (e.g. antechinus, quolls), foxes, dingoes and raptors may be susceptible to secondary poisoning from poisoned rabbits, particularly raptors with high sensitivity and for which rabbits are a significant dietary component (e.g. Wedge-tailed Eagles, Brown Goshawks). Raptors vary in sensitivity to Pindone (e.g. Nankeen Kestrels are less susceptible). There have been field reports of apparent secondary poisoning in juvenile Brahminy Kites. Rabbits can accumulate Pindone during baiting because they do not become bait-shy. Poisoned rabbits can be lethargic and easier to catch, increasing the risk of secondary poisoning. No published data on Pindone concentrations in poisoned rabbits or carcasses were found, but these could be 10–50 mg Pindone/kg rabbit, which could pose a medium to high secondary poisoning risk particularly to dogs with repeated consumption. Unpublished New Zealand work has found tissue Pindone values in this range.	• Use a pre-feeding phase with non-poisoned bait to identify native fauna taking the bait and estimate poison bait requirements. Can use sand pads near bait trails or motion-triggered cameras. Use 2–3 pre-feeds two days apart followed by 2–3 poisoned bait feeds 3–5 days apart (ensures full dose for entire rabbit population as rabbits missing one of two doses would be likely to survive). The rate of application, pre-feeding rates/patterns and poison-feeding rates/patterns are described for powder concentrates, pre-mixed ready to use baits and liquid concentrates (NRA 2002). Multiple doses at lower concentrations reduces the risk of non-target poisoning (cf. a high concentration single 'one-shot' dose with no pre-feeding where enough bait is laid for rabbits to eat over five consecutive days with bait trails left in place over 14 days). • Manufactured oat baits (***Rabbait*** and *BUNNYBAIT*) can be obtained from most rural supply stores that sell agricultural and veterinary chemicals. Off-the-shelf availability and/or increased product sales <u>may</u> increase risk of non-target poisoning but this risk is unconfirmed. • Vacuum impregnated oats (Western Australia) and pellets (Victoria) aren't available in ACT. • Avoid baiting where there is a high risk of poisoning to non-target native fauna (e.g. in or next to bushland or refuge areas for vulnerable species). As for 1080, risks from poisoning need to be offset against potential benefits from the removal of predators and competitors. • Bait using quantities and Pindone concentrations to ensure all rabbits are poisoned but there is no excessive poison concentration or bait left for non-target consumption (see above). For carrot bait size, see 1080 section above. • Lay baits at dusk at slightly lower rate than pre-feeds to ensure most baits taken by rabbits overnight rather than birds. This may miss less dominant rabbits that can't compete for their share – consider the trade-off between efficacy and non-target poisoning risks. • Consider using mesh bait stations or fencing/exclosures to reduce impacts on high-value, non-target species (birds, macropods) or assets (note that bait stations may deter rabbit feeding).

Potential risks	Potential mitigation
	• Dyeing baits black, red, blue or green may make them unattractive or less obvious to some bird species (more evidence is required for this method – Long-billed Corellas adapt to green-dyed grain). • Avoid using oat baits where granivorous birds that do not de-husk coated grain are at risk of non-target poisoning (observed deaths in crested and bronzewing pigeons may be due to this). • Collect and incinerate or bury unused baits and rabbit carcasses as described for 1080, except that rabbit carcasses should be collected for a minimum of 12 days (not 14).
Dogs, cats, cattle, goats and chickens are susceptible to Pindone. Sheep and horses are relatively resistant but sheep may still be affected, including bleeding and death at shearing, an increase in stillborn and non-viable lambs, and reduced sperm motility.	• Seek veterinary help for poisoned animals to administer vitamin K for at least one week and give whole blood or plasma to replace clotting factors and red blood cells where bleeding is severe. • Do not bait in urban areas or residential blocks less than 1000 m^2 in size (e.g. areas less than 32 x 32 m) or in areas or near feedstuffs accessible to livestock and domestic animals. • Muzzle dogs and restrain domestic cats. • Don't expose sheep to Pindone before shearing as cuts may bleed more. • Notification of neighbours is recommended but not mandatory. • Warning signs must be erected at property entrances and adjacent to public thoroughfares advising bait laying date, toxin and target pest, and must remain in place for at least four weeks.
Environment Pindone can be released from unused bait and carcasses into the environment. There is no apparent significant or persistent contamination of the environment from use of Pindone baits but there are only limited data to support this conclusion. Minimal risk to aquatic organisms. Low dose rates per unit area mean low risk of residues. Pindone has not been detected in soil but is likely to have a half life of around a month based on related products.	• The sodium salt of Pindone is more water soluble than the acid form and may break down in the environment and rabbits more quickly (this is yet to be substantiated). • Do not place baits where streams, waterways and rivers may become contaminated.
Laying bait trails up and down slopes causes erosion on susceptible soils	• Lay bait trails across slope.

Potential risks	Potential mitigation
Technique: *Warren destruction – ripping* *Major use:* To destroy warren structure and prevent reinvasion, not to kill large rabbit populations. *Properties*: Rabbits are crushed or suffocate. The weight of the soil prevents diaphragm movement resulting in asphyxia. Cost-effective technique that provides long-term control. (Croft and Connellan, 1999, Hart 2003, Lowe and Twigg 2014b, Sharp and Saunders no date d,e).	
Humans Serious injury or death caused by falling from, being run over by, or being crushed by ripping machinery.	• Follow machinery operating safety precautions. • Use tractors fitted with a rollover protection structure. • Operate heavy machinery within maximum slope limits. • Generally not suitable for urban rabbit warrens (e.g. under buildings).
Rabbit welfare More rabbits may suffer adverse animal welfare outcomes during warren destruction if population numbers are high.	• Use warren ripping as part of a coordinated management program that includes prior poisoning or fumigation, particularly where rabbit population numbers are high. • Estimate rabbit density using spotlight counts or warren monitoring before ripping (include counts on neighbouring properties where possible). • Destroy warrens when rabbit populations are naturally low, e.g. after drought or RHDV outbreak, and in non-breeding periods.
Rabbits may not be killed quickly because power of machinery is inadequate or ripping conditions are poor. Rabbits suffocate or starve over a long time period, or are directly injured by tines.	• Use machinery adequate to achieve complete destruction for the soil type and location (more powerful machinery is more humane). • Rip to a depth of at least 700–900 mm and 2–3 m beyond the burrows at the edge of the warren, and cross-rip at right angles or used winged tines to completely destroy the warren structure. • Multiple tines on rippers should be no further than 500 mm apart. • Rip sandy soils when dry and clay soils when slightly damp. • Back up to stumps and rip away from them so tines travel along roots. • Fumigate any areas of the warren that can't be ripped more than 72 hours in advance of ripping operations. • Destroy rabbits injured by tines and found above-ground by a shot to the brain or by neck (cervical) dislocation.
Ripping success Rabbits are primarily living above-ground.	• Use loud noises or trained dogs and dog handlers[3] to drive surface rabbits into warrens (dogs are not used to kill rabbits) before ripping (avoids residual population and is more humane as rabbits left on surface are exposed to temperature extremes and predators). • Destroy warrens in the middle of day when temperatures are hottest and rabbits are most likely to be underground. • Focus on other techniques for rabbit control programs. 3 www.feral.org.au/wp-content/uploads/2012/07/gen-002_SOP2005.pdf

Potential risks	Potential mitigation
Warrens incompletely destroyed and quickly recolonised.	• Ensure all warrens in an area are ripped through thorough reconnaissance of the area and logging positions on a GPS or mapping before operations commence (warrens typically have 3–15 entrances). • Follow up with 'mop-up' methods such as fumigation and shooting, re-ripping and an ongoing monitoring and surveillance program. • Remove surface rabbit harbour e.g. blackberries, fallen timber, corrugated iron sheets, waste/equipment dumps etc. prior to ripping (may be unacceptable in conservation reserves, urban areas etc.). • Spray weed harbour regrowth as part of follow-up operations. • Rabbit-proof netting can be used around harbour if it cannot be removed.
Non-target animals Non-target native animals (snakes, mammals) are occupying warrens or adjacent harbour and may be injured or killed during ripping.	• If no rabbits are present, leave warrens and harbour intact. • If rabbits are present, assess potential benefit of rabbit removal against risk to wildlife. • Use sand pads to monitor native animal access. • If a native animal is injured during warren destruction, deliver it to an ACT Government conservation officer or seek veterinary assistance within 48 hours (s. 46 *Nature Conservation Act 1980*).
Environment Warren ripping is impractical for inaccessible areas such as steep slopes, very rocky land, along fences, riverbanks, and in trees/native vegetation. Warren ripping cannot be undertaken because of soil contaminants (e.g. asbestos) or infrastructure (e.g. subterranean cables).	• Use a single tine on the ripping arm of an excavator. • Consider warren destruction using explosives. • Seal or block warren openings manually. • Choose other control techniques.
Soils are prone to erosion.	• Consider a blade plough where sandy soils are at risk of wind erosion. • Rip across slopes (not up and down), and only rip slopes less than 18°. • Smooth/backblade warrens to reduce risk of soil erosion and recolonisation.

Potential risks	Potential mitigation
Technique: *Warren destruction - blasting* *Major use*: To destroy warren structure and prevent reinvasion at sites where ripping is not feasible (e.g. rocky, steep, tree-covered sites). *Properties:* Blasting is typically undertaken using ammonium nitrate mixed with fuel oil. Rabbits are killed or injured by disruption of body tissues, burns from explosive gases, fragments of rock, wood etc. propelled by the blast, and injuries and haemorrhaging from air blast. The weight of the soil after blasting causes crushing and suffocation. Provides long-term control but is expensive relative to ripping. (Biosecurity SA 2012a, Sharp and Saunders no date f)	
Note: most of the risks and mitigation measures for warren destruction by ripping are also valid for blasting (see above section).	**Note: most of the risks and mitigation measures for warren destruction by ripping are also valid for blasting (see above section).**
Humans Extremely hazardous – serious injury or death can be caused by inappropriate use of explosives.	• Operators must hold a current shot-firers licence in the ACT (or another jurisdiction), obtain a valid blasting permit from Worksafe ACT and operate in accordance with the *ACT Dangerous Substances Act 2004*. • Follow OHS procedures for storage and handling in accordance with manufacturer's and material safety data sheet recommendations (including recommendations for weight of explosive and length of fuse). • Detonation may occur from heavy impact or excessive heating. • Avoid all contact between explosives and other chemicals. • Use special crimping pliers to crimp detonator to fuse. • Remove all persons, animals and vehicles to beyond 350 metres and do not return to site until toxic blast fumes have dissipated.
Blasting success Warrens/populations incompletely destroyed and quickly recolonised.	• Blasting should lift the subsoil and drop it back into place, compressing the warren in the process (craters should not form) – use 50 mm borehole method to achieve this. • Blasting is more effective when soils are moist and on heavier soils. • Use burrow entrance method for deep burrows and where 50 mm boreholes cannot easily be augured. • Backfill boreholes and/or burrow entrances and compact before blasting to maximise blast effectiveness.
Environment Soils are prone to erosion.	• Blasting using the borehole method can be superior to ripping where soils are prone to erosion.
Blasting may shatter the fine feeding roots of vegetation and cause it to die in the long term.	• Consider using a single ripping tine on an excavator (ripping arm) to destroy the warren rather than using explosives.

Potential risks	Potential mitigation
Technique: *Fumigation with phosphine (aluminium phosphide tablets)* *Major use*: Primarily used as a mop-up technique after poisoning and warren destruction for warren-dwelling rabbit populations. Useful for maintenance control of low density rabbit populations. Also useful where poisoning and ripping are unsuitable, or for small or isolated areas. *Properties:* Phosphine diffuses from tablets after exposure to atmospheric or soil moisture in warrens. Phosphine depresses the central nervous system and respiratory function (through inhibition of cytochrome oxidase). The extent of suffering of rabbits after inhalation of phosphine is unknown but could include nausea, abdominal pain, headache and convulsions followed by coma (as experienced by humans). Highly target-specific (because of placement) but labour-intensive and costly relative to other methods. (Croft and Connellan 1999, Hart 2003, Qld DPI&F 2008, Wiliams 2011, Biosecurity SA 2012b, Sharp and Saunders no date g)	
Human Highly toxic Schedule 7 poison. Note that aluminium phosphide has been nominated for review by the APVMA because of human health concerns.	• Follow product label, material safety data sheet instructions and OHS precautions in SOP for storage and handling. • Fumigate using two trained operators (in case one operator is affected by phosphine). • Fumigate on windy days and work up-wind to avoid gas. • Do not fumigate in confined, sheltered areas like gullies. • Do not fumigate during wet weather (tablets rapidly release phosphine when they become wet before placement in burrow). • Tablets may take up to 72 hours to decompose if warren humidity is low. • Do not use around domestic dwellings.
Rabbit welfare More rabbits may suffer adverse animal welfare outcomes during fumigation if population numbers are high.	• Best deployed shortly before rabbit breeding season (gives longest term effect). • See other mitigation measures under warren ripping.
Time to death may take longer when humidity and soil moisture are low.	• Fumigate when conditions are moist to achieve high phosphine concentrations and rapid death. • Wrap tablets in absorbent paper and add extra water where soils are dry and humidity low. • Treat every entrance. • Note that rabbits exposed to sub-lethal doses of phosphine are unlikely to experience sub-acute or chronic poisoning, or permanent debilitation (based on responses in other animals).
Fumigation is considered to be less humane than 1080.	• Fumigate after poisoning.

Potential risks	Potential mitigation
Fumigation success Phosphine gas leaks into dry sandy or cracked clay soils.	• Fumigate these soil types when moist.
Phosphine gas leaks out of unsealed warren entrances.	• Ensure all active and inactive entrances (including mouse and spider holes) are sealed according to SOPs and product label instructions. • Fumigation is less successful in rocky or scrubby areas where it is difficult to detect all entrances.
Rabbits are primarily living above-ground and these will not be gassed. Burrows are rapidly reopened.	• Only fumigate active, occupied warrens. • See other measures under warren ripping. • Check for success by recording burrow entrances before fumigation and number of re-openings one week after fumigation – treat again as required. • Bait rather than fumigate if active warren entrances are difficult to find in dense scrubby areas. • Block entrances with wire balls and/or destroy with a crowbar after fumigation in rocky areas to prevent recolonisation. • Note that population reductions from fumigation are short term (typically a few months to a year) unless used as part of an integrated program.
Non-target animals Non-target native animals (snakes, mammals) are occupying warrens. Native predatory and scavenger species consume gassed rabbits. Dogs used for driving rabbits underground are exposed to phosphine.	• See mitigation measures under warren ripping. • No significant non-target risk of secondary poisoning. • Ensure dogs are well restrained during and after fumigation.
Environment Soils are prone to erosion.	• Fumigation can be used instead of ripping.

Potential risks	Potential mitigation
Technique: *Shooting* *Major use:* May have application for small, isolated populations, when 'mopping up' after other methods, or around harbour that cannot be removed, but is generally ineffective in significantly reducing population numbers or maintaining them at low levels. *Properties:* Humane and target specific when carried out correctly. Time consuming, labour intensive and generally not cost effective. (Croft and Connellan 1999, Lowe and Twigg 2014b, QDPI&F 2008, Saunders and Sharp no date h).	
Humans Risks to user and other people.	• Store, transport and use firearms and ammunition in accordance with the *ACT Firearms Act 1996* and licence provisions. • Avoid use near human habitation. • Make sure accompanying people stand well behind shooter and out of range of stray bullets or ricochets. • Agree safety procedures with other occupants when shooting from stationary vehicles. • Shooters should familiarise themselves with the terrain and potential hazards in daylight before shooting at night. • Not suitable for use in urban areas.
Rabbit welfare Animals not killed when shot resulting in wounding, and pain and suffering.	• Use experienced/skilled professional or amateur shooters capable of causing immediate insensibility/ painless death. • Shoot only when rabbit is clearly visible and at the closest range practicable. • Use correct firearm, ammunition (see SOP) and placement (deliver a single shot to the head or chest only – see SOP). • Shoot in open rabbit feeding areas with little cover (not in dense cover or inaccessible, rough terrain). • Do not shoot from a moving vehicle. • Ensure each animal is dead before targeting another (despatch wounded rabbits immediately with shot to head). • If lactating rabbits are shot, reasonable efforts should be made to find and dispatch dependent kittens.
Shooting success Ineffective shooting produces gun- and spotlight-shy rabbits.	• Allow several months to elapse before further shooting or spotlighting activities are undertaken.
Rabbit populations are too large for shooting to be an effective method of control.	• Perform spotlight counts before and after shooting to gauge effectiveness of control.
Rabbits not detected during shooting program.	• Rabbits are largely nocturnal - shoot at night with a spotlight rather than during the day. • Dogs may be used to flush rabbits from warrens during daylight shooting programs (see Footnote 3 on p. 13).

Potential risks	Potential mitigation
Non-target animals Non-target native species shot.	• Only shoot target animals once they are positively identified (don't just shoot at movement, colour, shape, sound or eye shine which is pink-red for rabbits). • Do not shoot over the top of hills or ridges where other animals (and people) may be located and outside of spotlight range. • If a native animal is injured during warren destruction, deliver it to an ACT Government conservation officer or seek veterinary assistance within 48 hours (s. 46 *Nature Conservation Act 1980*).
Domestic stock disturbed.	• Avoid shooting near lambing ewes, horses and deer.

Potential risks	Potential mitigation
Technique: *Padded-jaw traps* *Major use*: Should only be used for small, isolated populations when there is no suitable alternative – padded-jaw traps are ineffective and inefficient for both large-scale control and mopping up activities (although they may be used for mopping up in Queensland). *Properties:* Used to restrain rabbits by limbs until euthanased. Traps can cause injuries such as swelling, lacerations, dislocation and fractures. Trapped animals may suffer adverse welfare outcomes. (Lowe and Twigg 2014a, QDPI&F 2008, NSW DPI 2012, Sharp and Saunders no date I)	
Humans Operators risk injury when placing and setting traps.	• Wear appropriate protective clothing (see SOP).
Trapped rabbits and non-target species scratch, bite and release body fluids.	• Wear protective clothing, get immunised against tetanus and practice good personal hygiene with hand washing after handling animals.
Rabbit welfare Trapping can cause swelling, laceration and dislocation of limbs.	• Use soft-jawed traps with no teeth, rubber cushions to reduce impact and prevent the limb sliding out, a spring in the anchor chain and swivel attachments, a gap of 6–8 mm when the trap is closed.
Trapped animals can suffer from exposure, thirst, starvation, shock, capture myopathy and predation.	• Place traps in area protected from weather (but not where they can become tangled in undergrowth, fences etc.) and check traps at least once daily (see SOP for details). • Avoid setting traps in adverse weather. • Ideally, traps should be set late in the day and checked the next morning, then disabled. • If traps are left set during the day, check them again in the afternoon. • Record location of traps in case the trapper is unable to return to check them.
Trapped rabbits are not dispatched quickly and humanely with the minimum of pain and suffering.	• Approach trapped animals carefully and quietly to minimise panic, further stress and risk of injury. • Euthanase trapped rabbits by neck (cervical) dislocation, with or without prior stunning by a sharp blow to the back of the head (see SOP for details), or dispatch by a single shot where permissible. • Humane trapping requires extensive training and experience, particularly for rabbits over one year old for which neck dislocation is more difficult. • If lactating rabbits are trapped, reasonable efforts should be made to find and dispatch dependent kittens.

Potential risks	Potential mitigation
Trapping success Padded jaw traps fail to trap rabbits.	• Check traps are functioning properly before setting them. • Place traps on warren entrance path 20–30 cm out from active entrances or on dung heaps, earth mounds, along rabbit proof fences or near hollow trees or logs (anywhere frequented by rabbits). • Use one trap for each active entrance. • Anchor the trap to a stake or fixed object, or to a small rock or log (drag) that will move when an animal pulls against the trap. • Camouflage trap with leaves and grass, leaving a slightly cleared area (10–15 cm) over the plate. • Ensure shrubs and debris will not interfere with trapping mechanism.
Non-target animals Trapping can catch pets and a wide range of non-target species, including native animals, that experience different levels of stress and risks from injury or predation.	• Don't set traps near waterholes or gully crossings frequented by non-target species. • Set traps so that a depression of 5–6 cm remains – larger animals will step over this depression but rabbits will be attracted to freshly disturbed soil. • Adjust pan tension so the force required limits triggering by non-target species. • Release uninjured, non-target native animals at the trap site. • Euthanase/shoot trapped wild dogs and foxes quickly and humanely. • Seek veterinary assistance or an ACT Government conservation officer for non-target native animals or pets suffering minor injuries. • Destroy severely injured non-target animals quickly and humanely. • Attempt to locate the owner of trapped and/or injured pets through Domestic Animal Services, the RSPCA or a veterinary surgeon.

Potential risks	Potential mitigation
Technique: *Cage traps* *Major use:* Should only be used for controlling low rabbit numbers. Useful in areas frequented by non-target animals/people where padded-jaw traps cannot be used (e.g. urban gardens, vegetable patches, hay sheds, adjacent to or under buildings). *Properties:* Cage traps have bait lures to entice rabbits inside and a mechanism for closing the cage after the rabbit has entered. Animals caught in cage traps are less likely to experience injuries than those caught in padded-jaw traps unless they injure themselves trying to escape. (Lowe and Twigg 2014a, QDPI&F 2008, NSW DPI 2012, Sharp and Saunders 2012)	
Rabbit welfare Trapped animals can suffer from exposure, thirst, starvation, shock, capture myopathy and aggressive behaviour from predators.	• See potential mitigation measures under padded-jaw traps.
Trapped rabbits are not dispatched quickly and humanely with the minimum of pain and suffering.	• See potential mitigation measures under padded-jaw traps.
Trapping success Rabbits do not enter traps.	• Leave traps open with the closing mechanism disabled and free feed using a bait trail leading into the cage for 2–3 nights before trapping, or until all bait is being removed both outside and inside the trap. • Use diced carrot (1 cm cubes), oats or apple as bait. • Use barrel traps (1 m long by 12–15 cm wide made from rabbit netting or light mesh – see NSW DPI 2012) left in burrow entrance.
Non-target animals Non-target animals become trapped in cage.	• Trapped native animals are usually unharmed and should be released at the site of trapping. • Pets can be released unharmed or attempt to locate the owner through Domestic Animal Services, the RSPCA or a veterinary surgeon. • Seek veterinary assistance or an ACT Government conservation officer for non-target native animals or pets suffering minor injuries.

<table>
<tr><th>Potential risks</th><th>Potential mitigation</th></tr>
<tr><td colspan="2">Technique: Exclusion fencing
Major uses: To exclude rabbits from high-value pastures, crops, tree lots or conservation areas, or small areas such as garden beds or areas that provide rabbit harbour but cannot be cleared.
Properties: A humane, non-lethal control method that is limited in its use because of the costs associated with establishment and maintenance. Can reduce/prevent reinvasion of rabbits from adjacent, untreated areas and allow for sequential control programs.
(Williams et al. 1995, Hart 2003, Lowe and Twigg 2014a and 2014b, QDPI&F 2008, Biosecurity SA 2012b, NSW DPI 2012, Sharp and Saunders 2012)</td></tr>
<tr><td>Fencing success
Fence fails to exclude rabbits.</td><td>• Use good quality rabbit-proof wire netting with mesh size ≤ 3 cm to exclude kittens as well as adult rabbits.
• Build fence at least 1 m high.
• Retain an outward-facing 30 cm wire apron at the bottom of the fence or bury wire to a depth of at least 15 cm.
• Reduce the number of rabbits present before, or immediately after, the fence is erected (inside and/or outside the fence) using an appropriate method e.g. poison baits.
• Consider adding a capping or electric wire to prevent rabbits going over the fence.
• Use netting barriers or bed logs to prevent rabbits gaining access around posts and stays and under gates.
• Check fences regularly for holes dug under the wire or other breaches caused by falling trees, large animals etc. that allow rabbit entry.</td></tr>
<tr><td rowspan="2">Non-target animals
Can alter dispersal and foraging patterns of native animals.
Can cause entanglement and electrocution, and be a barrier to animals escaping from bushfire.</td><td>• Consider whether there will be significant disruption to dispersal and foraging patterns of vulnerable species, particularly when fencing high-value conservation areas.</td></tr>
<tr><td>• Weigh up the benefits to be gained by controlling rabbits and their impacts on native flora and fauna against potential injury to and loss of native fauna from these risks.
• Gates can be installed and opened to allow animals to escape during bushfire.</td></tr>
</table>

Potential risks	Potential mitigation
Technique: *RHDV* *Major use:* To quickly reduce large rabbit populations as the initial step in an integrated rabbit control program. Safe technique for controlling rabbits in urban areas. *Properties:* A viral suspension is delivered into rabbit populations via injection of a sample of trapped or caged rabbits or on baits. Symptoms are variably expressed but include fever, anorexia, dullness, prostration, reddened eyes, lethargy, acute liver damage and blood clotting abnormalities causing obstruction of blood supply to vital organs, respiratory and nervous signs, and sudden death within 48–72 hours of infection for 90–95% of susceptible rabbits (5–10% may take up to two weeks to die). Highly target-specific (only affects rabbits), cost-effective and efficient as long as there is little or no background immunity to RHDV in the population. After initial release, natural outbreaks and further reductions in rabbit populations may occur, providing an ideal opportunity to maintain low population numbers using other techniques. (QDPI&F 2008, feral.org.au 2012a and b, NSW DPI 2012, Sharp and Saunders no date j)	
Humans Accidental injection may cause an adverse reaction (but not disease).	• See SOP on prevention of needle stick injuries and seek medical advice if this occurs.
Rabbit bites and scratches, and contact with virus, blood and other body fluids, are sustained during injection of live rabbits.	• Wear protective clothing according to SOP, and ensure operators are immunised against tetanus and routinely wash hands and other skin surfaces that become contaminated.
Rabbit welfare Rabbits become distressed during capture and injection with the virus (this also reduces the effectiveness/likelihood of viral spread through the population after release).	• Use two experienced operators that have been trained by a veterinarian to perform inoculations (see SOP for detailed guidance on appropriate handling techniques). • Humanely destroy injured rabbits as described under padded-jaw traps. • Introduce the virus via diced carrot or oat baits as a more humane alternative.
Inoculation success Virus suspension is affected by heat.	• Store at-70°C and transport frozen on dry ice or use a freeze-dried preparation if available (yet to be approved by the APVMA). • Lay treated baits as soon as possible after preparation.
Rabbit populations have a high level of immunity to RHDV and/or genetic resistance due to prior exposure to the virus or related, benign, naturalised strains.	• Use alternative techniques or wait until a new RHD Boost virus strain is released (post-2016).
Young rabbits less than 12 weeks old that are not susceptible to RHDV or who receive antibodies from lactating does build up immunity within the population.	• Only inoculate non-lactating rabbits outside of the breeding season when juveniles are not present.
Rabbits are unaccustomed to carrot or oat baits.	• Use a free-feeding regime prior to distributing inoculated baits, as described for 1080 and Pindone baiting.

Potential risks	Potential mitigation
Baits are incorrectly prepared or distributed.	• Use bait trails or target warrens (apply a maximum of 5 kg treated carrots or 2 kg treated oats per warren). An authorised ACT Government officer must prepare baits (or they can distribute the suspension with suitable training to commercial pest controllers) according to an APVMA permit and product label instructions.
Spread of virus is limited because of a natural outbreak of RHDV or due to a sparse rabbit population.	• Only release RHDV into dense, healthy, susceptible rabbit populations where there are no or few rabbits less than 900 g in early summer or autumn.
Residual rabbit population recovers and develops genetic resistance to the RHDV inoculant strain.	• Follow up RHDV releases with other 'mop up' techniques to remove the residual population.
Non-target animals Other species are infected by the virus.	• Tests on 29 native and exotic animal species have failed to identify alternative hosts (virus is target-specific for rabbits). • Pet rabbits should be inoculated against RHDV.
Pet rabbits contract the disease and die, either as a result of the RHDV release program or from a natural outbreak of the virus.	• Develop a communication strategy to advise/remind pet rabbit owners and the pet rabbit industry of the need for inoculation prior to new releases of the virus.
Endangered native animals become the target species for predators after reduction in rabbit numbers.	• Arrange for simultaneous control of predators with release of RHDV if required.

5. Best practice management for rabbits

Best practice management for rabbits generally requires an integrated approach with sequential application of more than one of the above techniques as part of a well-planned management program. The key steps for undertaking successful pest animal management programs include (Braysher 1993, Braysher and Saunders 2003, ACT Government 2012, Saunders and Sharp 2012):

- assessing the damage and/or assessing species abundance and/or distribution as a surrogate for damage
- identifying suitable pest management techniques and options for their application within the area to be managed
- determining whether management will be beneficial, feasible and has priority through a risk assessment process (i.e. ensuring that the benefits in damage reduction gained from management will exceed the costs and effort of control)
- developing a pest management plan that includes clear objectives and targets with specific, time-limited outcomes, and engages the key relevant stakeholders
- undertaking operational and performance monitoring and assessment to determine whether the management has been efficient and cost effective, and has reduced population numbers or the risk of damage to an acceptable level.

There are comprehensive publications on rabbit management based on the acceptable and conditionally acceptable techniques included in the model CoP that can inform best practice rabbit management for the ACT (Williams and Moore 1995, Williams *et al*. 1995, Croft and Connellan 1999, NRE 2000, Hart 2003, DEWHA 2008, QDPI&F 2008, Williams 2011, Brown 2012, NSW DPI 2012, Sharp and Saunders 2012). Key recommendations from these publications for achieving humane, efficient, cost-effective and enduring rabbit management are summarised below.

Key recommendations for best practice rabbit management

1. Management programs are most effective, efficient, cost effective and humane if they can be implemented when rabbit population numbers are naturally low (e.g. during drought, after a parasite, RHDV or myxomatosis outbreak, before breeding) and efforts can be concentrated in rabbit refuge/source areas (i.e. where rabbit populations survive, even during drought or disease outbreaks).
2. Unless eradication of isolated populations is achieved or low population numbers are maintained (<1 rabbit per hectare or <6 rabbits per spotlight kilometre), managed areas usually recolonise and/or recover to pre-control levels in under a year to up to 2–3 years. The actual time to recovery is influenced by the residual population size (rabbits breed more efficiently at low to medium than at high densities), time of year, seasonal conditions that affect the amount, timing and quality of feed available (≥ 14% protein and high water content promote breeding), temperature (> 27°C in warrens reduces breeding success), size of adjacent rabbit populations, level of competition from other herbivores and level of rabbit predation.
3. Where starting rabbit populations are medium to high (≥ 1–4 rabbits per hectare or ≥ 6–30 rabbits per spotlight kilometre), management programs should include intensive primary and follow-up control phases, with regular and effective monitoring and ongoing maintenance control once acceptably low rabbit population numbers have been attained (e.g. every 6–12 months as part of routine management, including areas not previously colonised). Although initially expensive (first 1–4 years), this approach is the most cost effective and efficient over the long term (e.g. over 10–30 years).
4. Ongoing maintenance of low population numbers is more humane than allowing populations to build up again (i.e. lethal control is kept to a minimum) and protects the initial resources invested during primary control, which should not need to be repeated. If rabbit management plans do not include adequate provision and resourcing for follow-up and ongoing maintenance control, then taking no action may be the most appropriate decision.

5. Primary control should be undertaken using multiple techniques as appropriate for the management area to achieve (ideally) a 95% reduction in population numbers or greater to mitigate against rapid population replacement. Primary control should also seek to reduce rabbit surface harbour and warren structure and, consequently, the rate of population recovery. Control efforts should focus initially on rabbit breeding areas and/or areas where the most unacceptable damage is occurring, and then expand to other areas.
6. Primary control techniques typically include initial removal of surface harbour, then baiting with 1080 or Pindone, or biological control using RHDV, followed by destruction of warrens by ripping or blasting (or crowbarring in steep, rocky areas), and then follow-up control or 'mopping up' of residual populations by techniques such as re-ripping or diffusion fumigation of reopened/active warren entrances, shooting, trapping and spraying of weed harbour regrowth, to a point where populations are sufficiently low that they will not recover rapidly.
7. Warren destruction and the removal of surface harbour, coupled with coordinated management of rabbits on adjacent land tenures over the largest possible area, are the most effective means of minimising the recolonisation and recovery of rabbit populations in managed areas and give the greatest benefit:cost ratio. Sharing labour (including contractors) and equipment and working jointly with neighbours improves both the cost effectiveness and the likelihood that control program targets will be achieved.
8. Techniques such as shooting, baiting, release of RHDV and fumigation that do not disrupt rabbit surface harbour or warrens can improve the percentage of the population removed during primary control and have application for mopping up residual populations. However, used by themselves they generally produce only a short-term reduction in rabbit numbers of a few months to a year.
9. Program success can be influenced by the sequence in which techniques are used (e.g. baiting before ripping results in lower warren reopening rates) and on the time of day (e.g. fumigation is most effective in the middle of a hot day), season (e.g. baiting works best outside of the rabbit breeding season) and/or seasonal conditions (e.g. Pindone is less effective when there is abundant green pick containing the natural antidote Vitamin K1). Factors which influence the efficacy of techniques (summarised in Table 2) should be taken into account when developing rabbit pest management plans for control programs. As a general guide for the ACT, baiting is best performed from November to December (between breeding events) or late summer to autumn, RHDV release is most effective in summer to autumn, and warren fumigation is best undertaken in September to October during the breeding season. Warren destruction by ripping or blasting and removal of residual rabbits by shooting and trapping can be performed at any time when population numbers are low.
10. Operational and performance monitoring before, during and after the management program, including abundance and/or damage assessment and benefit:cost analysis (see Section 6) is essential to determine whether the management program is warranted and, if so, the efficiency and cost effectiveness of the program and whether modification of techniques or their application is required. In grazing systems and conservation areas, the impact of all herbivores (e.g. stock, kangaroos) that affect total grazing pressure should be assessed and managed in conjunction with rabbits, and simultaneous control of predators (particularly foxes and cats) considered. Other factors that may need to be considered include the susceptibility of the land to rabbit infestation, value and susceptibility of the biodiversity, potential impacts on soil, water, production, weed dispersal and revegetation programs, interactions with fire management, and whether there is sufficient land manager and/or community engagement to support ongoing action.

6. Monitoring and assessment for rabbit management programs (Williams *et al*. 1995, Mitchell and Balogh 2007, ACT Government 2012).

Rabbit management programs require monitoring and assessment to determine whether they have reduced the population and/or damage to a targeted level (performance monitoring) and whether they have been efficient and cost effective (operational monitoring).

Before the control techniques described in Table 2 are employed, monitoring should commence to estimate starting rabbit population densities, assess actual or potential damage levels, determine the location, extent and activity of warrens, identify potential impacts on non-target species and the environment (see Table 2), and set the objectives and targets for the management program.

During the primary and follow-up control phases, performance monitoring is used to determine whether program objectives and targets are being met (i.e. that there has been a suitable reduction in rabbit populations and/or damage to low levels) or whether they are not being met and the program needs to be modified to succeed. Operational monitoring of the costs, labour and other resource use associated with control activities occurs in parallel. Ongoing monitoring of the management area as part of routine activities can determine the success of maintenance control and allow for early detection of any resurgence in the rabbit population.

Monitoring techniques used to assess rabbit abundance and damage, and their relative advantages, disadvantages and risks, have been described and compared by Williams *et al*. (1995) and Mitchell and Balogh (2007[4]). Indexes or proxy measures of rabbit abundance used for performance monitoring include night-time spotlight and headlight counts from vehicles or spotlight counts on foot (along fixed transects), daytime counts on foot (may be along transects or focussed on or near warrens), counts of warrens and/or their active and inactive entrances, counts of rabbit sign (dung, diggings, rabbit tracks in sand plots) and live trapping counts. Monitoring for rabbit damage includes operational monitoring of the costs of control (equipment, material and labour costs, operator hours), estimating production costs and losses, damage to infrastructure, changes in plant biomass, cover and composition (for crops, pastures and/or native vegetation), scoring of visual damage to native vegetation, estimates of native animal abundance, fixed photo points and soil erosion monitoring.

The choice of monitoring technique for a particular program depends on many factors such as the:

- ease, flexibility, accuracy, efficiency and cost of the technique
- density of the population to be monitored
- size and topography of the area to be monitored
- height and complexity of pasture or other vegetation
- prevailing weather or seasonal conditions
- number, skill and experience of available operators
- ability to detect rabbit warrens, source areas and recolonisation
- land use objectives and the type of damage caused.

For coordinated rabbit control programs being implemented across multiple land tenures and over an extended period, standardisation of monitoring techniques will allow for comparison within and between sites, and across techniques and years, for the area being managed. Three commonly used and relatively reliable techniques for monitoring rabbit abundance applicable to different land uses are described below. The range of attributes to be considered for mapping warrens is also considered. Inclusion of monitoring techniques for rabbit damage, if used, should be selected to suit the land uses and management objectives within the management area.

6.1 Spotlight counts along transects

Spotlight counting of rabbits from vehicles along transects is a relatively easy technique that can cover large distances and encompass many habitats under similar conditions in a short time (Williams *et al*. 1995, Mitchell and Balogh 2007, NSW DPI 2012). The number of rabbits recorded per spotlight kilometre provides an index of rabbit abundance. Other non-target native and feral animals and stock that are present should be counted at the same time.

4 http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/218531/Monitoring-techniques-for-vertebrate-pests---rabbits.pdf

For a standardised method, it is important to perform counts at a fixed distance (e.g. 50–100 m) to one or both sides of each transect and record the counts at regular intervals. Each transect should follow a fixed route of known length and have year-round accessibility. For each count along the transect, a standard vehicle is driven in the same direction at the same speed (e.g. 10–15 km/hour) using spotlights with the same power and passing through representative areas of all land types (i.e. areas of land with similar soil, vegetation and land use) likely to be inhabited by rabbits.

Accuracy can be improved by using longer transects and by conducting at least one count in each season to account for annual variability in rabbit numbers. Ideally, transect length should be 2–5 km, or the distance that can be covered in 1–1.5 hours, with up to five nights of counting required if numbers on consecutive nights vary by more than 10% (NSW DPI 2012). Counts should also be performed within a week before and after control activities for performance monitoring purposes. Each count should commence just before or after nightfall (which varies seasonally) over at least three consecutive nights with similar weather (no strong wind or heavy rain) and moonlight conditions (NSW DPI 2012). Counts may be less reliable where tall or complex vegetation obscures the line of sight, between sites with variable topography, and where different operators perform the counts (operators of different height or experience may count a different number of rabbits). Counts may also be less reliable when rabbit numbers are low (QDPI&F 2008).

Spotlight transect counts in open country with good visibility may be considered low, medium and high at 5, 6–30 and >30 rabbits per spotlight kilometre, respectively (Williams *et al*. 1995, Sharp and Saunders 2012). However, the threshold population of rabbits that can be considered acceptable will depend on the land use and management objectives, and the damage being caused.

The Namadgi National Park spotlight protocol, as summarised below, has been suggested as the basis for standardised spotlight monitoring for all ACT Government rabbit management programs (D. Fletcher personal communication). Where transect spotlight counts from vehicles are not possible, warren and active entrance counts may provide an alternative index of rabbit abundance.

A. Spotlight monitoring is to be undertaken on three nights on all identified transects.

B. Spotlight monitoring is to be conducted:

   i. at least 60 minutes after official sunset

   ii. within seven days either side of the new moon

   iii. in a vehicle travelling approximately 7–10 km/hour

   iv. with the counter standing on the tray of a four wheel drive utility

   v. over 180 degrees in a forward facing arc.

6.2 Warren counts

Simple warren counts provide a rapid index of rabbit abundance, indicate trends in rabbit abundance over time and can be used to estimate the extent of warren ripping and fumigation required for control programs (Williams *et al*. 1995, Mitchell and Balogh 2007). For a standardised approach, permanently marked transects are established across all land types in the area to be managed. The number of transects established and the distance between them depends on the size of the area to be managed and the variability in land types. The number of active and inactive warrens (presence or absence of rabbit activity) is recorded to a fixed distance (e.g. 10 m) either side of each transect within each land type. Density of warrens per unit area for each land type is calculated as the number of warrens counted divided by the area of transect counted. A standard error of up to 15% of the mean is acceptably accurate. The total number of warrens is calculated by multiplying the total land area by the average warren density across all transects and land types.

Accuracy can be improved by ensuring all warrens in the transect area are counted, including where they occur in dense vegetation or dry, sandy soil. Accuracy can also be improved by randomly selecting blocks (e.g. 100 m x 500 m) in each land type, counting all warrens within each block, and using the average warren density from all blocks in a land type to correct the strip transect counts. Note that warren counts are not suitable where there are few warrens and/or most of the rabbits are living above ground (QDPI&F 2008).

6.3 Active entrance counts

Counts of active burrow entrances can give a better index of rabbit activity than scoring the presence or absence of activity as assessed in simple warren counts. For a standard approach, select a number of 1–5 hectare sites (ideally five sites associated with a spotlight transect) that are representative of the different land types present, with each site containing more than five warrens, and each warren comprised of more than three entrances (Williams *et al*. 1995, Mitchell and Balogh 2007). Place a permanent marker in the middle of each warren in each site, locate by GPS and estimate the area that each warren occupies. Record the number of active entrances (as indicated by smooth floors, recent soil disturbance, footprints and claw marks, fresh urine/pellets and/or hair) and inactive entrances (which often contain leaves, grass heads, weeds, wind-blown and rain-washed soil, old pellets and spider webs). Accuracy is improved by waiting for about four days after significant rain events to perform counts, and by using the same observer on each counting occasion. If the management area is small then count all warrens present or aim to count 10–20 warrens for larger areas (QDPI&F 2008).

There have been attempts to relate the number of active entrances to estimates of rabbit population abundance, with the conversion factor of rabbits to active entrances varying from 1.36 to 3.3 based on differences in soil type, the presence of young rabbits during the breeding season and whether the population estimate was taken over the entire year. These factors are considered to be site and time specific. As a guide, use a conversion factor of 1.6 in the non-breeding season and 3 in the breeding season to calculate the number of rabbits per warren (divide the total number of active entrances in the warren by the conversion factor).

6.4 Warren mapping

Warren mapping is useful for recording areas of highest rabbit abundance and activity, and for facilitating warren and active entrance counting, and planning and prioritisation for warren ripping and fumigation (Williams *et al*. 1995, Croft and Connellan 1999, Mitchell and Balogh 2007, QDPI&F 2008, NSW DPI 2012). Useful attributes for inclusion on the map include:

- key topographic, vegetation, soil type, land use and road/boundary/infrastructure features
- the limits of rabbit distribution in the management area
- source areas where rabbits survive under adverse conditions and subsequently breed
- the largest warrens with the most feeding and/or breeding activity
- small warren complexes
- warren boundaries
- feeding grounds
- indexes of rabbit abundance
- the ratio of active to inactive warren entrances
- areas where the highest damage is occurring
- inactive but intact warrens
- areas with soil types and conditions that are prone to rabbit infestation
- the presence of above-ground harbour
- proximity of active warrens to those being treated
- areas that are intractable for rabbit control
- planning for and recording of bait trail and spotlight transect routes.

A series of maps over time can indicate changes in rabbit activity and abundance in relation to control efforts and other changes in land use and management practices.

6.5 Monitoring rabbit damage and adverse impacts of control techniques

Coordinated rabbit management programs conducted over multiple land tenures are likely to include a range of land uses. Techniques for monitoring and quantifying rabbit damage are often specific to the land use (e.g. crop or stock production measures) and can be difficult, costly and laborious, and require scientific expertise to carry out (Williams *et al*. 1995).

Techniques for monitoring damage that have application over more than one land use include (Cooke *et al*. no date, Williams *et al*. 1995, Mitchell and Balogh 2007):

- assessment of rabbit and total grazing pressure usually expressed as dry sheep equivalents (may include assessment of stock, feral animals and native herbivores)
- use of grazing enclosures and exclosures to show rabbit (and other herbivore) impacts on plant biomass and production, ground cover, species composition and regeneration for pasture or native vegetation
- scoring of visual damage to native vegetation
- estimates of the presence and abundance of native animals, (including monitoring for non-target impacts e.g. using non-toxic bait stations)
- use of photo points for visual monitoring of damage over time
- soil erosion monitoring.

The inclusion of techniques for monitoring damage in coordinated rabbit control programs needs to be decided on a program-specific basis with reference to land uses and the availability of resources.

In areas where threatened (vulnerable or endangered) native animals occur, they may be impacted by rabbit control techniques or become an increased target for predators after reduction in rabbit numbers. A thorough risk assessment should be conducted in all areas with known populations of threatened species to mitigate adverse impacts.

7. Common barriers to the delivery of rabbit management programs

Ideal rabbit management programs based on the recommendations for best practice management and monitoring above are not always achievable. Key social, legislative, government (including funding), other financial and broader technical barriers to achieving rabbit management goals (Williams *et al*. 1995, NRE 2000, QNDRM 2002, DEWHA 2008, QDPI&F 2008, Williams 2011, Cooke 2012, Munro 2012) are described below. These potential barriers should be taken into consideration when designing rabbit control programs.

7.1 Social

- Scarcity or intermittent/seasonal unavailability of landowners, land managers, contractors or volunteers to undertake any or all phases of a rabbit control program including planning, undertaking primary, follow-up and ongoing maintenance control activities, and operational and performance monitoring. This is partly due to reductions in rural and government workforces, and the changing viability of rural industries.
- Tolerance of low rabbit numbers, sometimes coupled with the belief that rabbit populations will be kept in check by cats and foxes (which does not occur unless rabbit population numbers are extremely low), mean that control is not attempted. Historically, there has also been an overreliance by landholders on biological control agents to keep numbers low. Landholders or managers may not recognise that rabbit control is required. Hobby farmers, part-time farmers and absentee land owners can be less aware of rabbit damage and have less interest in or capacity to control rabbits.
- Unwillingness by adjacent landholders or managers to engage in coordinated rabbit control programs. Neighbouring properties do not control their rabbits through apathy or viewing rabbits as the government's or their neighbour's problem. There may be real or perceived differences in the relative amounts of control being undertaken by neighbours, particularly between private landholders and government land managers.
- Competing landholder or manager commitments and values mean rabbit control programs are given low priority, goals cannot be agreed on, assessment and control activities are not undertaken in a timely manner, or there is no control at all. Reaching agreement on goals for rabbit management plans in coordinated programs is likely to be most difficult where there are multiple landholders and land uses in the area to be managed.
- Community concerns about target and non-target animal welfare and the use of pesticides in the environment lead to limited support for, or opposition to, rabbit control programs, particularly where native animals, pets and livestock are (or are perceived to be) at risk. For native animals, there may be a failure to recognise that the benefits of rabbit control can outweigh the non-target impacts of poisons and other control techniques in terms of habitat improvement, increased survival and the maintenance of viable native animal populations.
- Coordinated control programs by landholders may be successful in reducing rabbit populations to low numbers during the primary control phase, but are particularly prone to failure in the follow-up and ongoing maintenance phases without strong program coordination and incentives to persist. Participants in coordinated control programs may lack the skills, commitment, practical experience or credibility to coordinate a successful reduction in rabbit numbers to low levels and ensure ongoing maintenance control.
- Participants involved in rabbit management programs lack the technical knowledge and training in rabbit biology and behaviour, the types of damage caused by rabbits, and monitoring, control and assessment techniques to develop an effective management plan. Program participants may be unaware of the national CoP and SOPs, available guidelines on best practice management, and which approaches and techniques are most suited to their local conditions.

- Unskilled labour and community group volunteers lack appropriate chemical and safety training and are unable to assist in coordinated rabbit management programs to their full capacity.
- Appropriate training courses are unavailable or are not accessible by landholders or managers with responsibility for rabbit control, or by others participating in rabbit control programs. Courses in pest animal management and natural resource management have insufficient rabbit-specific content to inform the development of an effective rabbit management plan.

7.2 Legislation, government and government funding

- Governments may be overly dependent on legislation to drive rabbit control, which may be coupled with a failure to enforce the legislation as a last resort when landholders or managers are non-compliant and uncooperative.
- The legislation requires eradication (which is usually unachievable) rather than effective, long-term suppression of rabbits.
- The government land management agency fails to undertake adequate rabbit control.
- Government responsibilities relating to rabbit control, including legislation and regulation, policy development, research, extension, coordination and control activities, are not integrated across government or with regional, neighbouring state/territory or Commonwealth governments.
- Government action to initiate, manage and advise on coordinated rabbit control programs, which is often critical to program success, is lacking or inadequate. Government fails to provide and promote appropriate support measures or support the networks that achieve broad-scale control of rabbits across land tenures, including across jurisdictional boundaries. Government incentives for landholders to participate, such as the provision of prohibitively expensive equipment (e.g. ripping machinery), are absent.
- Governments have variable and unpredictable funding for rabbit control that is dictated by annual budget cycles and is often reduced by competing government priorities. An assured budget is critical for the delivery of long-term best practice rabbit management, particularly the capacity to undertake ongoing maintenance control and protect prior investment. There may be insufficient amounts in annual budgets to undertake expensive primary control activities, and no flexibility to initiate opportunistic control when rabbit population numbers are naturally low.
- Governments have insufficient resources to monitor the extent and severity of rabbit damage comprehensively to identify and direct resources towards priority areas where the public benefit is highest. The source of available funding may influence where rabbit control occurs.

7.3 Other financial

- The cost to individual landholders of materials and equipment for rabbit control can be prohibitive.
- Inadequate finance is available to individual landholders at optimal times for rabbit control.
- There is insufficient knowledge of the costs associated with different control techniques, either alone or in combination and in relation to the area being managed, to inform the development of a cost-efficient management approach.
- Financial uncertainty discourages potential rabbit contractors from undertaking appropriate training and establishing viable businesses, and the availability of contractors becomes a limiting factor to undertaking control.

7.4 Technical

Technical barriers to the success of individual rabbit control techniques have been summarised in Table 2. Some broader technical barriers to the success of implementing rabbit control programs are considered below.

- There is a limited understanding of the relationship between rabbit numbers and the damage they cause in temperate conservation areas (most of the research on this relationship has been conducted in the arid zone). Locally relevant research is required, for example through local exclusion studies and accounting for the impacts of all herbivores, to identify damage and population-related thresholds above which control is beneficial.

- Failure to standardise (or use standardised) protocols for spotlight monitoring of rabbits, or to establish standardised alternative techniques such as active warren counts for areas where spotlighting cannot be undertaken, may be due to resourcing constraints or communication barriers between different areas in government and in coordinated management programs.
- Methods for monitoring impacts of rabbits on native flora and fauna are either absent, poorly developed or labour and resource intensive.
- None of the techniques for rabbit control developed to date reliably provide complete mortality, so the use of multiple techniques and follow-up and ongoing maintenance control remains necessary, with its associated risks to success.
- There is no available poison that specifically targets rabbits.
- The development of resistance in rabbits to RHDV is widespread.
- There is little uptake of rabbit management research outcomes and new or improved control techniques due to poor communication and inadequate extension of knowledge.
- Landholders and managers fail to integrate rabbit control with other land management activities and achieve potential operational efficiencies (note that integration of activities can risk a loss of focus on rabbit control goals).
- High rainfall years favour rabbit population recovery despite concerted management efforts and interfere with primary, follow-up or ongoing maintenance control activities.

8. Examples of the successful application of best practice rabbit management in the ACT

Long-term rabbit control has been undertaken in the Tidbinbilla Nature Reserve using a variety of techniques over time. Monitoring of rabbits using spotlight counts indicates the population responses (in number of rabbits per spotlight kilometre) to the different control techniques. (Figure 1; data and interpretation provided by D. Fletcher).

Prior to the mid-1970s, shooting was used as the primary control technique for rabbits in Tidbinbilla Nature Reserve but was largely ineffective, with the number of rabbits per spotlight kilometre typically high (data not shown). In 1977, the tarbaby technique was used, in which grease containing 1080 poison is introduced into rabbit warrens, causing the rabbits to die through ingestion of the poison after grooming grease from fur and paws. Although the tarbaby technique caused a short-term reduction in rabbits, the resurgence in numbers was rapid because warrens were left intact. From the late 1980s to the mid-1990s, numbers were maintained below eleven rabbits per spotlight kilometre (the blue line in Figure 1) through repeated baiting with 1080 on carrots complemented by an ongoing warren destruction program.

A brief resurgence in numbers in the late 1990s may be related to an extended period without baiting and/or the commencement of a fox baiting program that effectively reduced predation on rabbits during this period. Very low rabbit numbers observed from 1999 to 2005 (below four rabbits per spotlight kilometre; brown line in Figure 1) are attributable to the deliberate introduction of RHDV into the reserve. More recently, rabbit numbers have risen, which may be partly due to the development of resistance in rabbits to RHDV.

These data demonstrate that an ongoing rabbit management program, which has warren destruction as a key component, can be effective in maintaining low rabbit populations. Application of a suite of rabbit control techniques, including annual control with 1080 baiting and warren destruction, and the introduction of RHDV in 1996, has also maintained low numbers (generally less than two rabbits per spotlight kilometre) at Googong (Figure 2; data and interpretation provided by D. Fletcher). Note that, compared to Tidbinbilla (Figure 1), fox baiting at Googong (Figure 2) did not result in a resurgence in rabbit numbers, presumably due to ongoing control programs.

Figure 1: Rabbit spotlight counts at Tidbinbilla Nature Reserve.

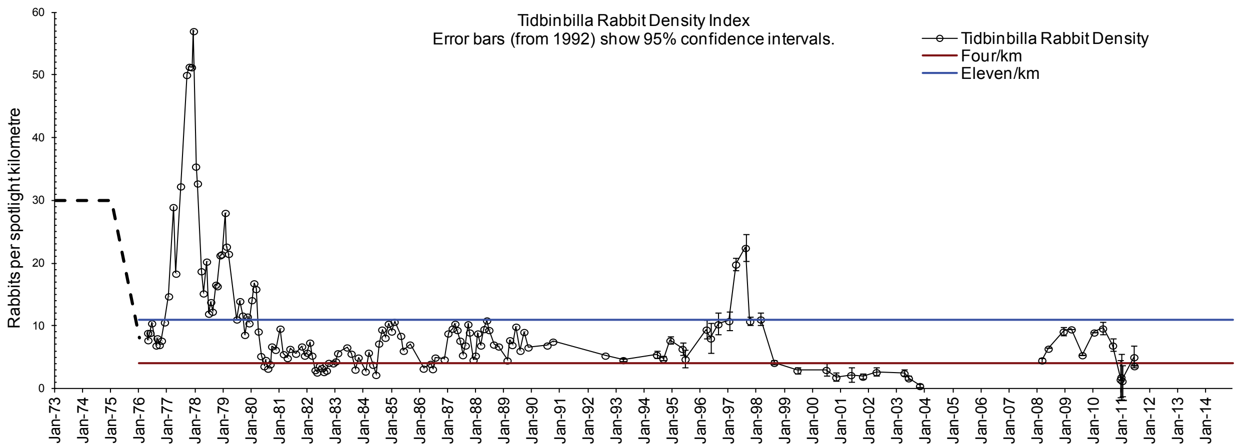
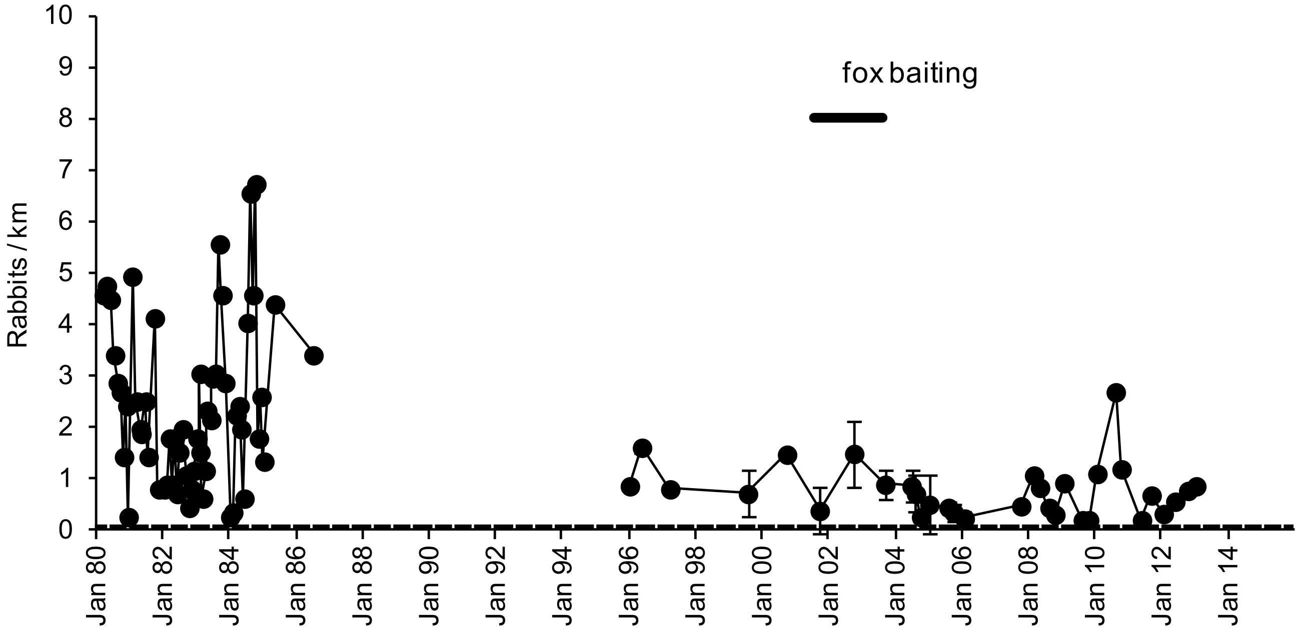


Figure 2: Rabbit spotlight counts at Googong.

Mean rabbit count per kilometre at Googong.
Bars show 95% confidence intervals in one lunar cycle.
(Only one count was done per session before Jan 1996.)
Chart does not show the rabbit control carried out ~ annually since the 1990s.
RHD introduced in 1996.



9. Current rabbit management aims, practices, gaps and constraints in the ACT (O. Orgill)

The main aims of ACT Government rabbit control programs are to:

- manage rabbit populations to minimise negative impacts on natural and cultural heritage values, and on adjacent agricultural and suburban lands
- assist the rural community and other land managers to manage impacts on primary production and assets by encouraging coordinated rabbit control programs across land tenures.

Rabbits impact on natural and rural lands in the ACT causing a loss of vegetation cover which exacerbates erosion and weed colonisation, and threatens the survival of native birds, small mammals and insects that rely on groundcover plants for food and shelter. Rabbit numbers have been increasing in the ACT and in all other Australian jurisdictions over the last five years due to a failure to use conventional techniques for rabbit control to capitalise on low rabbit numbers following introduction of RHDV in 1995.

As with other fast-breeding, mobile pest species like foxes, effective, sustained management of rabbits relies on coordinated management at the landscape scale to prevent recolonisation from neighbouring, untreated areas (Section 5). No control program achieves 100% removal of rabbits so follow-up of primary control is a vital element of ACT Government rabbit control programs that prevents remaining rabbits rapidly breeding up to reach pre-management numbers. After one or two years of intensive follow-up control, including harbour removal, rabbit numbers are kept suppressed through annual surveillance and maintenance control of any rabbits that attempt to re-establish.

Broad scale primary and follow-up programs on public land are often undertaken by contractors under supervision by TAMS staff, while ongoing maintenance control is often carried out directly by TAMS staff. Control programs vary with individual sites but generally involve a combination of warren ripping, fumigation with phosphine gas, and poisoning with Pindone or 1080. Follow-up shooting is used occasionally.

Adjoining land managers are often invited to participate in a cooperative rabbit control program, although uptake of invitations may be low. ParkCare volunteers play a vital role in rabbit control programs by mapping rabbit warrens in many conservation areas.

Long-term monitoring to detect population trends is undertaken at selected sites (e.g. Figures 1 and 2; Section 8), and performance monitoring to assess the effectiveness of control is routine practice for ACT Government rabbit control programs. Rabbit populations are monitored by spotlight counting along transects of known length to give an index of rabbit abundance expressed as rabbits per spotlight kilometre (Section 6).

While spotlight monitoring of populations is regularly undertaken as part of ACT Government rabbit control programs, monitoring of rabbit impacts is rare. In the absence of impact monitoring, the potential for damage is inferred from spotlight abundance indices and the success of control programs is assessed as the relative abundance of rabbit populations before and after control.

The location and abundance of rabbit populations is known across most lands managed for conservation. However, there is a lack of consistent knowledge regarding rabbit populations across rural lands and unleased Territory Land, with no quantifiable data (i.e. warren mapping, spotlight counts, economic impacts etc.) for many populations. Targeting of coordinated rabbit control programs in the ACT would be facilitated by monitoring of rabbit populations across a wider range of land tenures.

Achieving effective rabbit control can be a complex issue, particularly where there are multiple land managers in a small geographic area, for example, in urban areas. Each lessee or custodian is responsible for rabbit management on their own land. Failure to achieve consistent cooperative management across multiple land tenures may result in ineffective control programs.

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