Queensland **the Smart State**

Rabbit control in Queensland

A guide for land managers

Queensland Government
Department of Primary Industries and Fisheries

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Preface

This manual has been prepared as a straightforward but comprehensive guide to rabbit control for land managers in all areas of Queensland. The statistics and costings that have been included are the most recent available at the time of publication.

A short glossary of technical terms with which readers may be unfamiliar has been included at the back of this guide.

References

The Department of Primary Industries and Fisheries (DPI&F) acknowledges the authors of all the reference sources used to help compile this guide—a list of the most significant of those resources appears at the back of this book. While this publication should serve as a complete guide in itself, the reference list would also serve as a useful starting point for readers who might want further or more detailed information.

Credits

Photographs appearing in this guide come from DPI&F stock images, or have been provided by the following people and organisations: Michael Brennan, Grant Beutel, John Conroy, John Cross, Peter Elsworth, Craig Hunter, David Parker, Steve Parker, Mark Ridge and the Robert Wicks Pest Animal Research Centre.

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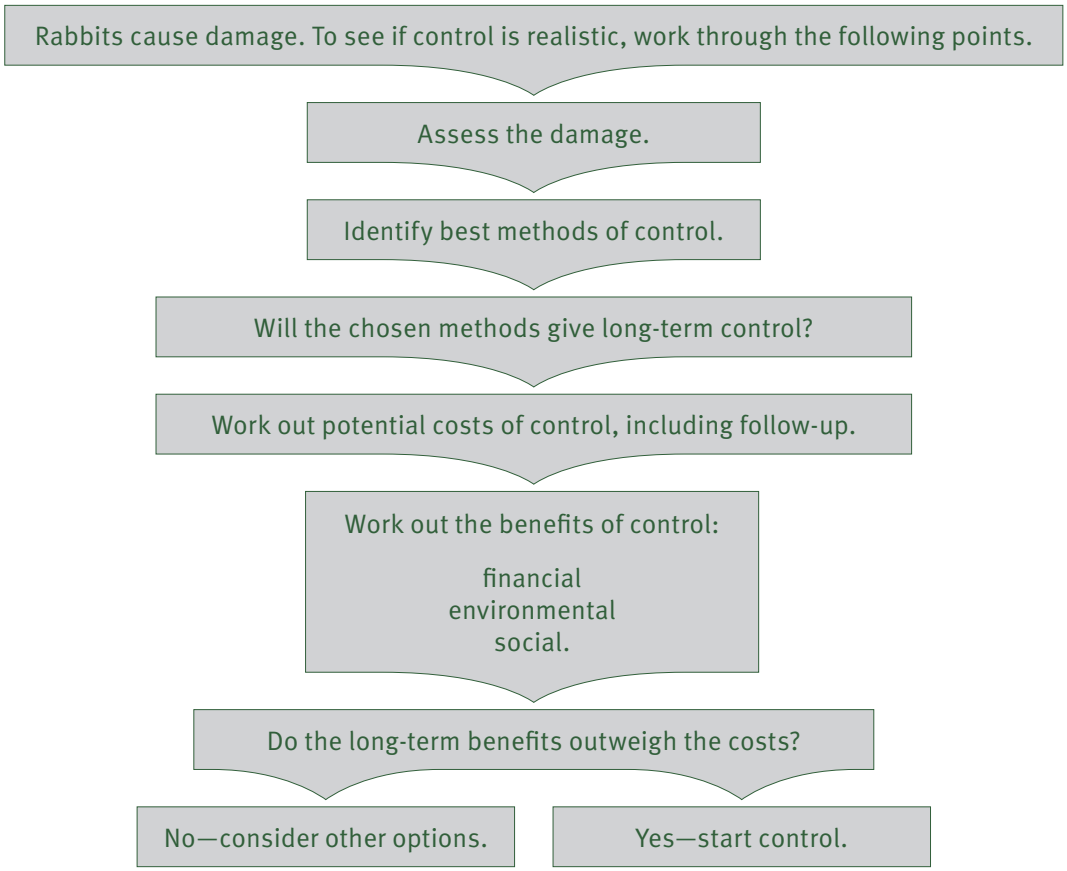
Is rabbit control worthwhile?



The ineffective (short term) rabbit control cycle

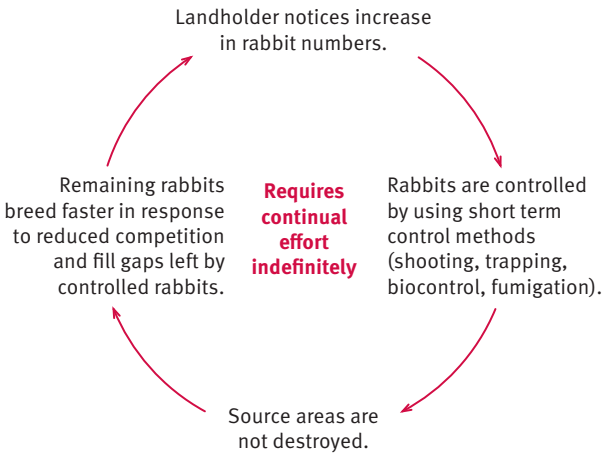


Figure 1: Ineffective (short term) rabbit control cycle.

Effective (long term) rabbit control flow

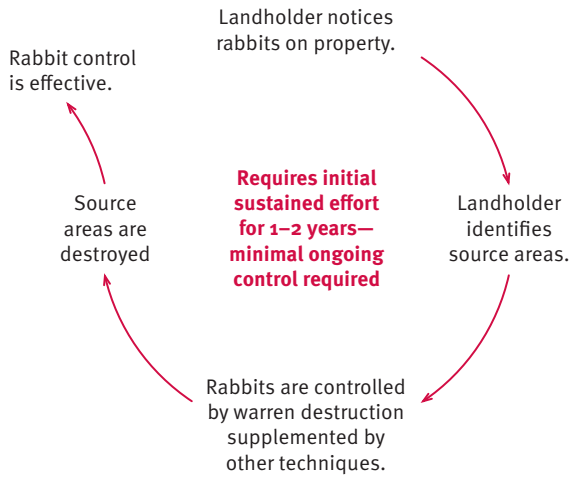


Figure 2: Effective (long term) rabbit control flow.

Introduction

How can this manual help you?

This manual can help you choose the best and most cost-effective way to reduce the impact of rabbits on your property. It includes an easy-to-use guide to work out how much rabbits are really costing you and explains different ways to tailor control techniques to your local environment.

Why control rabbits?

The long-term benefits of effectively controlling rabbits are significant. There should be no ongoing damage and, provided you allow recovery time and don't overstock, you should see major improvements in pasture quality and productivity.

This can mean land is able to better carry stock throughout periods of drought and the need to agist stock will be reduced.

Aim for effective rabbit control

The complete eradication of rabbits from Australia is not a realistic short-term goal but there are effective ways to reduce and minimise their impact on agricultural production and the environment.

Although eradication may be possible in some fenced areas, the rabbit's well-developed ability to disperse and recolonise means that even the best control programs may see rabbits returning at some stage. Persistence and perseverance are required but, if the job is done correctly in the first place, there should be long-lasting effective control with minimal ongoing effort required.

Effective control of rabbits will mean:

- more money in your pocket
- more feed available for other animals (cattle, sheep and wildlife)
- more nutritious pastures with fewer weedy species
- reduced need for stock agistment
- less erosion
- a richer seed-bank in the soil
- recovery of trees and shrubs, which stabilise the country.

Different control methods will be effective for different periods of time. Warren/refuge destruction and fencing off will give long-term (10–30 years, possibly permanent) rabbit control. Shooting, poisoning, bio-controls and fumigation will give short-term (a few months to a year) rabbit control. All control methods are discussed in detail in this guide.

Rabbits in Australia

The European rabbit (*Oryctolagus cuniculus*) was introduced to mainland Australia near Geelong, Victoria, in 1859. Twenty-four rabbits were brought from England primarily for hunting. The rabbits spread across the country at an average rate of 70 km per year. It was the fastest rate of any colonising mammal anywhere in the world.

Rabbits in Queensland

Rabbits were first reported in 1887 in south-western Queensland, 30 miles south of Eulo. Rabbit-proof fences were soon established across southern Queensland but the rabbits spread beyond these barriers—sometimes aided by people transporting them but also due to low predation rates, the availability of the ready-made burrows of native animals, little competition from cattle and no serious diseases.

The Darling Downs–Moreton Rabbit Board fence, located in south-eastern Queensland is the only remaining rabbit fence in the state.

Rabbit numbers in Queensland over time

Rabbit numbers have been variable across Queensland ever since rabbits first appeared in 1887. Disease, seasonal variations, predators and control operations have all had an impact on numbers. The figures in table 1 are an indication of the reduction in rabbit numbers before and after the introduction of myxomatosis (myxo) and rabbit haemorrhagic disease virus (RHDV).

Table 1: Rabbit numbers in Queensland.

Year	Rabbits (millions)
1949 (just prior to Myxo)	150
1995 (just prior to RHDV)	5
1996 (after RHDV)	2

Current rabbit numbers in Queensland have increased from the 1996 figure, and research in 2008 has shown that rabbits may number 14 million.

Distribution of rabbits in Queensland

The largest rabbit populations are found in the Granite Belt, south-western Darling Downs, Maranoa, southern Warrego and the far south-west. Moderate populations are dotted throughout the north-western Darling Downs and north Burnett, and low populations are scattered through much of the remainder of the state. Rabbits do best where they have established warren systems.

Rabbit warrens are most frequently found in deep, well-drained soils. Cracking clay soils are avoided because of waterlogging and the risk of warren collapse. Where warren building isn't possible, rabbits can use above-ground harbour such as hollow logs, or dense undergrowth formed by plants like blackberry or lantana. However, due to strict temperature requirements for successful breeding (refer to section 2.1), they don't thrive in these environments.

A personal history

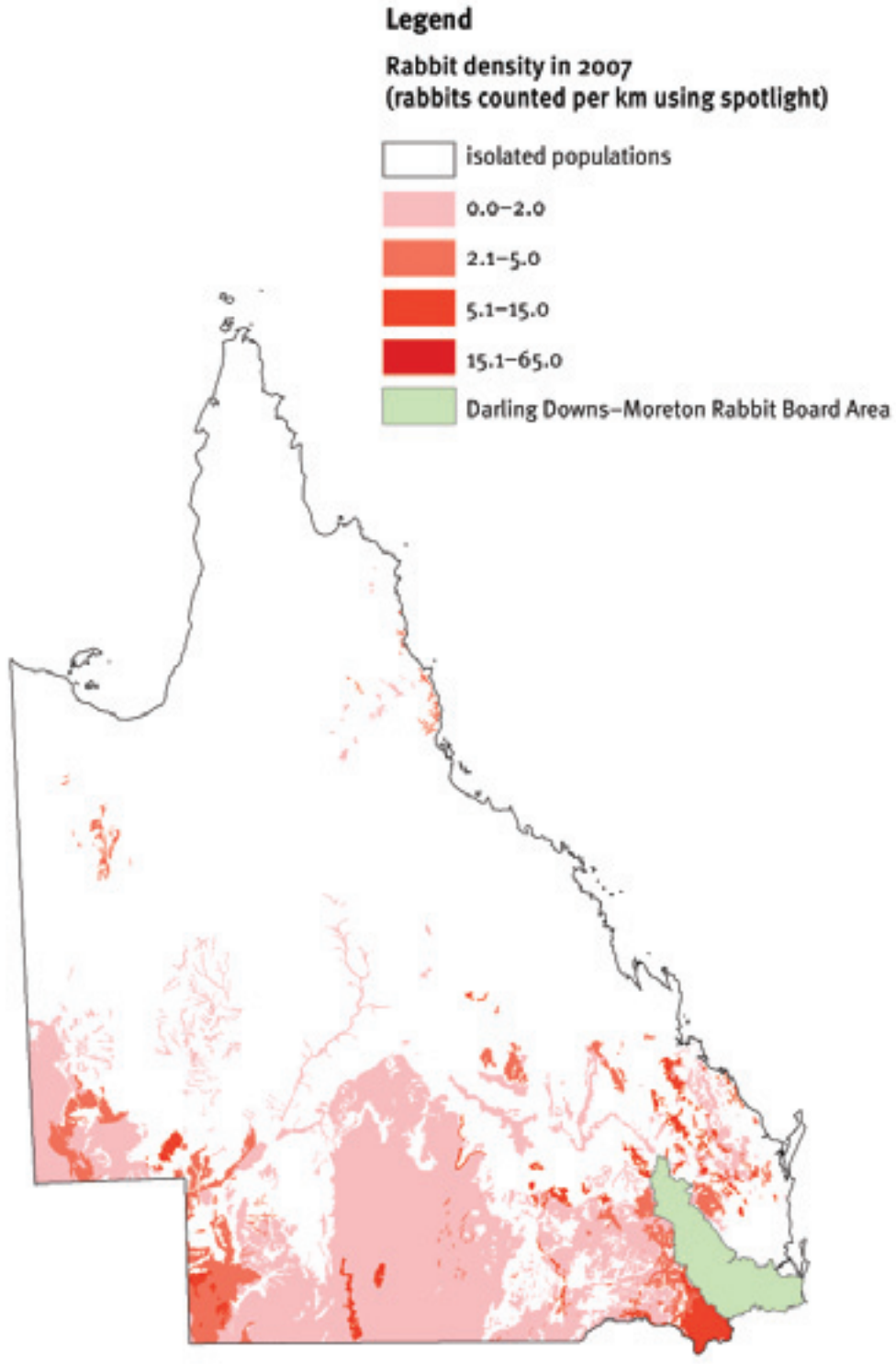
With the introduction of biological controls such as myxomatosis and RHDV, many modern farmers have not experienced the most dire ravages of rabbit infestations. For those who did live through these times, however, the memories of the heartache and devastation caused by rabbits are still fresh. The following true account serves as a warning to land managers of the emotional and social impacts of rabbits. While rabbit numbers are still relatively low at present, the benefits of the biological control may not last into the future and we may yet see again the damage done by large rabbit numbers. This is the story of one family's experiences with rabbits in the 1950s and 1960s. (The family wishes to remain anonymous.)

My parents attempted to run a profitable crop and fruit farm in Victoria in the late 1950s and early 1960s. They owned a small farm on the outskirts of Kyabram, which is in the Goulburn Valley in Victoria. The main farming activities in the district were growing fruit and vegetable crops, and dairy farming.

My parents were dedicated, keen farmers but finally the problem of an overwhelming infestation of rabbits proved to be the last straw for my father. My parents and my two brothers regularly carried out control measures and the release of the myxomatosis virus was a considerable help, but eventually the rabbit numbers recovered to pre-myxomatosis release levels. Totally disheartened by the ever-growing rabbit problem and the uncooperative attitude of the neighbours towards rabbit control, my parents made the tough decision to abandon the family farm when I was nine years old. (I was the youngest of five children.)

Consequently, we changed from being a farming family, living on the outskirts of town, to being a town-dwelling family, living on ¼ of an acre. My father found himself in the position of having to learn new skills at the age of 41. To complete his qualifications in his new trade, he had to leave the family temporarily and travel to Melbourne to complete his motor mechanic apprenticeship. This all led to a lot of upheaval for the whole family and my two brothers also moved to Melbourne to gain further skills and to seek employment opportunities.

My father is 85 years old now and he can still remember the despair he felt—after shooting and trapping rabbits regularly for years on end—seeing fresh infestations coming from neighbouring properties.



Map 1: Number of rabbits likely to be seen with a spotlight at night. Darker red areas indicate more suitable rabbit habitat.

Section 1: Rabbits cost you

If allowed to get out of control, rabbit damage will cost you dearly—and not just economically. While rabbits can have a profound and obvious impact on your income, the ravages caused to your property can also affect its ecological sustainability and viability, as well as your peace of mind and social wellbeing.

While the economic impacts of rabbits are usually pretty easy to measure, the social, emotional and environmental costs are more difficult to quantify and are frequently overlooked. Nevertheless, all these factors should be considered when making decisions about rabbit control.

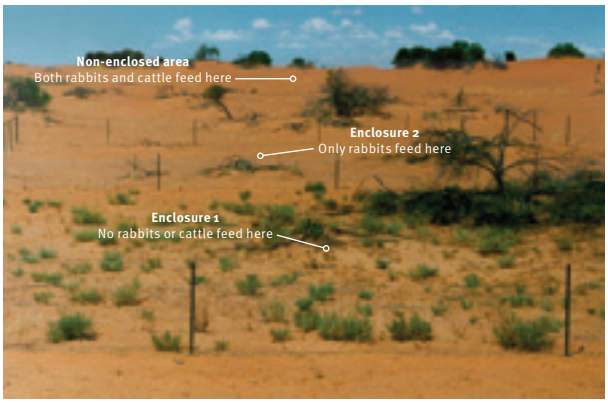
1.1 Production losses

Most rabbit-related production losses are the result of competition with livestock for food, and pasture damage. On average, 10 rabbits are capable of eating as much pasture as one sheep, and 100 rabbits as much as one yearling steer. So the cost of even a small rabbit problem can be significant.

Extremely conservative estimates suggest rabbits currently cost the Queensland cattle and sheep industries at least $1 per rabbit per year. This equates to an estimated $150 million per year prior to the introduction of myxomatosis, $5 million per year after the introduction of myxomatosis and $2 million per year following the introduction of RHDV (formerly known as rabbit calicivirus disease—RCD). These estimates are a bare minimum. The cost to the wool industry alone could be somewhere between $20 million and $70 million per year. It is estimated that rabbits cost Australia between $600 million and $1 billion dollars annually in damage to agricultural industries and the environment.

1.2 Pasture quality

Rabbits are picky eaters and prefer succulent, actively growing grasses that are high in protein and water. They will selectively graze your best grasses down to root level, causing a change in pasture composition where the preferred grasses are eaten out, making way for less palatable grasses and weeds to spread. This can mean reduced production of livestock or huge pasture re-establishment costs in the future.



Pic. 1: Rabbits and cattle are excluded from enclosure 1, and only rabbits can enter enclosure 2. You will notice that the area outside is the same as enclosure 2. Rabbits take all the good feed that cattle eat.

1.3 Crop damage

Rabbits cause problems in horticultural, grain, forage and wine-grape crops throughout Queensland. The amount of damage caused depends on the number of rabbits and the stage of crop they eat. For example, if rabbits eat the buds of wine grapes it will cost the producer 12 months worth of production, whereas in grain crops, they may only damage the outer crop edge. (Crop-edge damage can also be caused by climate and weather conditions and this can make it difficult to determine exactly how much should be attributed to rabbits.)

Stop feeding the rabbits

- **$1 per rabbit per year** can be lost in production on a sheep or cattle property.
- **$50 per rabbit per year** can be lost in production on irrigated pasture (estimated for lucerne hay fetching $15 per bale).
- **$200 per rabbit per year** can be lost in production on a vegetable-growing property (based on 2008 prices of broccoli, cauliflower and capsicum).

Pic. 2: Rabbit-infested country on the left, rabbit-free on the right. (Pasture protected by a rabbit proof fence near Canberra in 1953.)

Pic. 3: Evidence of rabbits gnawing on tree roots.

1.4 Environmental impact

Rabbits are environmental vandals and the damage they do to the balance of your local ecosystem can have a lasting impact. While it may not be something you can actually see, an ecosystem that functions properly is vital to ensure your property can recover from constant agricultural use.

In times of drought, rabbits will climb trees to forage on the foliage and will often even ringbark trees in their search for moisture. Their grazing and burrowing reduces vegetation coverage, prevents native vegetation from regenerating, and can lead to soil erosion. The exposed bare soil is then blown or washed away making areas less productive and causing associated water-quality problems.

Rabbits have contributed to the localised extinction and decline of many native plant and animal species, including other burrowing animals such as the wombat and bilby. The loss of vegetation from rabbit grazing and the destruction of new seedlings threaten the survival of native plants as well as the native birds, mammals and insects that rely on the plants for food and shelter.

1.5 Urban impact

Rabbits also cause problems in urban areas where they damage town gardens and golf courses, and can cause structural damage to buildings by digging under the foundations. They have even been known to cause problems in town cemeteries by burrowing beneath gravesites.

The cost of urban damage is difficult to gauge as it will vary significantly between locations.

1.6 Legislative responsibilities

Because of the threat they pose to primary industries and the environment, rabbits have been designated Class 2 declared pests under the *Land Protection (Pest and Stock Route Management) Act 2002*. As a consequence, all land managers have a legal responsibility to control rabbit numbers on their properties. (Further information on legal responsibilities and possible penalties is available in section 7.3.)

It is worth bearing in mind, however, that the economic incentives for control may outweigh the legal imperatives—the cost of rabbit damage often out-strips control costs. (Further information on control costs is available in section 4.3.)

Pic. 4: Rabbits have destroyed this vegetable garden near Brisbane.

Section 2: Rabbit biology—know your enemy

Effective pest control exploits its target's weaknesses. A good knowledge of the biology and behaviour of rabbits can help determine the best times to apply control treatments and explain possible variations in effectiveness.

2.1 The rabbit

The European rabbit *(Oryctolagus cuniculus)* is a small mammal that belongs to family Leporidae, which also includes hares. The male rabbit is called a buck, the female is called a doe and her young are called kittens.

The coat colour can vary in Queensland but grey always predominates. In western Queensland ginger rabbits occur quite regularly but this is not common in eastern Queensland. Black, white and piebald also occur but are quite rare.

Pic. 5: Kittens at entrance to burrow.

Pic. 6: Ginger-coloured rabbit.

Rabbit adaptability—negative factors

- Drought—Rabbits retreat to source areas during droughts.
- Shelter—Rabbits need appropriate shelter with temperatures below 27 °C to breed effectively.
- Climate—Rabbits breed best in areas with long cool seasons and high protein grass cover (short green pick) and this is one reason they don't do well in North Queensland.
- Disease (bio-controls)—Rabbits are susceptible to RHDV and myxomatosis.
- Predation—Rabbits are preyed on by carnivores (e.g. dingoes, wedge-tailed eagles, foxes, goannas) and this can restrict rabbit numbers.

Rabbit adaptability—positive factors

- Reproductive ability—Female rabbits can produce 20–30 offspring per year and can increase reproduction to replace individuals lost to short-term (shooting, poisoning, trapping, bio-control) control programs.
- Opportunism—Rabbits take advantage of human structures and man-made waters.
- Warrens—Rabbits excavate their own breeding areas.
- Diet—Rabbits can eat a very wide variety of food.
- Climate—Individuals rabbits can survive extremes of temperature (though they may not be able to breed).
- Distribution—Individuals rabbits can disperse to colonise/recolonise areas.
- Resistance—Individual rabbits can develop resistance to bio-controls.

2.2 Rabbit or hare?

Neither rabbits nor hares are native to Australia—both have been introduced but, unlike rabbits, hares do not have to be controlled according to Queensland's state legislation. Rabbits, however, are declared pests in Queensland, which means that they have to be controlled by land managers.

Hares are a far less serious problem than rabbits for two main reasons. While they can have as many as six litters per year, they do not spread as rapidly as rabbits and are not found in such high

Rabbit facts at a glance

daily feed intake	150–500 g
daily water intake	0–100 ml
gestation period	28–30 days
age at weaning	23–25 days
age at mating	3–4 months
litter size	average 4–6 (up to 10)
adult weight	average 1.6 kg
breeding season	can be all year
age to begin eating solid food	21 days
age eyes open	10 days
sexual cycle	multiple cycles in breeding season (polyoestrus)—females can be fertile again immediately after giving birth
time from giving birth to re-mating	½–2 hours
life span	1.2–2.5 years in the wild

densities. In addition, hares shelter in refuges of grass or other vegetation, or in shallow 'scrapes' (shallow depressions in long vegetation or under fallen timber—also called 'squats') and do not form extensive burrows or warrens as rabbits do. Therefore, there is none of the environmental damage associated with the erosion or undermining of foundations caused by rabbits.

Nevertheless, rabbits and hares do look similar and inaccurate identification can cause problems for land managers.

How to distinguish a hare from a rabbit

Hares:

- are considerably larger than rabbits with a head and body length of 55 cm (40 cm for rabbits)
- are rather more golden-brown in colour (rabbits are greyer)
- have relatively longer ears with distinct black tips
- have relatively larger hind legs and can run faster
- do not lift their tails when disturbed so the black upper-surface is always visible (Rabbits cock tails and show white undersurface as a general alarm signal—often seen when rabbits are scuttling for shelter.)
- tend to lead solitary lives except when breeding (rabbits live in groups).

Pic. 7: Hare (top) and rabbit (bottom).

2.3 Rabbit reproduction

Under good conditions, rabbits can breed all year round but breeding may be limited by two main factors:

- Female rabbits require a diet of at least 14% protein to trigger breeding. (Short fresh green grass and herbage usually has a high protein content.)
- Lactating female rabbits need a warren temperature under 28 °C. (A higher temperature lowers the milk output of the lactating female so the young have less chance of survival.)

Rabbits mostly breed during the cooler months of the year but this depends on seasonal conditions. In a good season, five to six litters are possible; breeding may stop completely in dry conditions.

In areas where warren temperatures are above 27 °C and rain falls predominantly in summer, pasture quality may be poor and heat stress can reduce the milk output of lactating females so their young may have less chance of survival. This may help to explain why rabbits have not spread in large numbers into the northern parts of Queensland.

Rabbits reach sexual maturity at three to four months of age. The gestation period is 28–30 days, and the female is able to mate again within hours of giving birth. Depending on the amount and quality of food available, a female can produce an average of 11 young per year in marginal areas and as many as 25 or more in favourable areas.

Once mature, a young rabbit can travel long distances (up to 20 km) to find a new home. In newly colonised areas, they will live in a shallow hollow within long vegetation or under fallen timber such as windrows and log piles.

Low rabbit numbers within a population can actually stimulate breeding. Unless control attempts remove more than 95% of rabbits, the remaining rabbits may actually be encouraged to breed more rapidly. Control must be carefully planned, executed and followed up.

Pic. 8: Rabbit nest in hollow log.

2.4 The rabbit warren

Rabbits prefer to live in warrens for protection from predators and extremes of temperature. However, they will survive in above-ground harbours such as logs, windrows and dense thickets of scrub, such as blackberry and lantana. In newly colonised areas without warrens rabbits tend to live in what is called a ‘scrape’ (or ‘squat’) under fallen timber and in long grass.

Without protection from the elements, rabbits are not able to breed successfully. The newborn rabbit has little or no hair, making it very susceptible to temperature extremes.

With warren protection, rabbits are able to produce up to 10 kittens per litter compared with only four per litter when forced to breed in above-ground harbours. If a warren is available, the number of litters produced per year will also be more than if the rabbit is breeding above ground.

Rabbits do not find it easy to dig new warrens. They prefer to take over the burrows of native animals such as burrowing bettongs and bilbies. The native animals are effectively excluded from their burrows and the rabbits subsequently form their own warren. This ready-made underground breeding area proved to be a great resource for rabbits when they colonised Queensland.

The size of a warren depends on the soil type. Typically, warrens can be around two metres deep, although warrens in sandy soils are more likely to be smaller and have fewer underground interconnections than warrens in hard soils. This is because it is easier for rabbits to start a new warren in sandy soil but in harder, clay-type soils it is easier to extend an existing warren. On average, one warren will have 3 to 15 entrances, with each active entrance likely to house two adult rabbits.

Most rabbits will remain within 300 m of their warren, though this will vary depending on the season and the availability of water. In severe drought, rabbits have been recorded moving 1.5 km to drink. Rabbits will generally spend most of the night above ground feeding and remain in the safety of the warren during the day.

Destroy the warren and stop the breeding cycle.

Pic. 9: Typical rabbit warren in the dune country of western Queensland.

2.5 Understanding rabbit dispersal

In Australia rabbits have high rates of dispersal from the warren where they were born. Understanding this can help with control programs.

Run rabbit run! Rabbits have high rates of dispersal.

Young rabbits disperse to new areas throughout the breeding season. Dispersal rates peak when food becomes scarce and rabbits have to find more food. Dispersing rabbits have been known to move 20 km or more away from their warrens, often moving from areas of high-density rabbit numbers to areas of low density. After dispersal a rabbit will take up residence in a vacant warren if one is available, or it will shelter in a surface harbour and try to become part of another social group of rabbits.

2.6 Rabbit harbour

Rabbits dispersing from a source area will rarely find suitable long-term harbour straight away but can survive for at least a short period in typical harbour areas such as:

- around and under logs (Pic. 10) and rocks
- around and under property buildings (Pic. 11)
- in dense low-lying vegetation such as lantana (Pic. 12 and 13)
- around man-made structures such as timber (Pic. 14)
- in haysheds (Pic. 15).

This is where they begin to establish warrens but it is also where they are very vulnerable—rabbits will not breed at their maximum rate until they, or those that replace them, complete a warren. If nothing is done to limit the activity of the rabbits at this stage, they will establish a good warren and a new source area. The new warren will then be a stepping stone for them to colonise more new areas—and the cycle will continue.

Pic. 10: Rabbit harbour in logs.

Pic. 13 : Rabbit warren in lantana.

Pic. 11 : Rabbit hole under building.

Pic. 14 : Rabbit harbour under pile of timber.

Pic. 12 : Rabbits using lantana as harbour.

Pic. 15 : Rabbit harbour in hayshed.

Section 3: To control or not to control—gathering the data

This section provides you with the tools and information to prepare a simple cost–benefit analysis in order to make sound decisions about which rabbit management options will suit you and your property best.

3.1 Sensible rabbit control

A properly planned control program will prevent rabbits from becoming a recurring problem. However, before you can make any decisions about methods of control and likely costs, you need to begin your rabbit management program by finding out how many rabbits you have, where they are located and what damage they are causing. (See Figure 3 for the process of developing a rabbit control program.) This will help you decide whether to take action, what action to take and which method of control is the most viable. Methods of estimating the number of rabbits on your property are outlined in section 3.5.

Rabbit control checklist:

- Determine the location of all warrens and other breeding places.
- Map all areas of the property with rabbits, particularly where breeding occurs.
- Estimate rabbit numbers.
- Establish the amount of damage per year rabbits are causing on the property.
- Select areas likely to benefit most from control for the least cost.
- Determine the best methods of control for each situation.
- Conduct rabbit control at the best time of the year.
- Use a combination of different control methods to get the best results (integrated control).
- Include rabbit monitoring and control in the yearly management program.
- Monitor and follow up all control work.

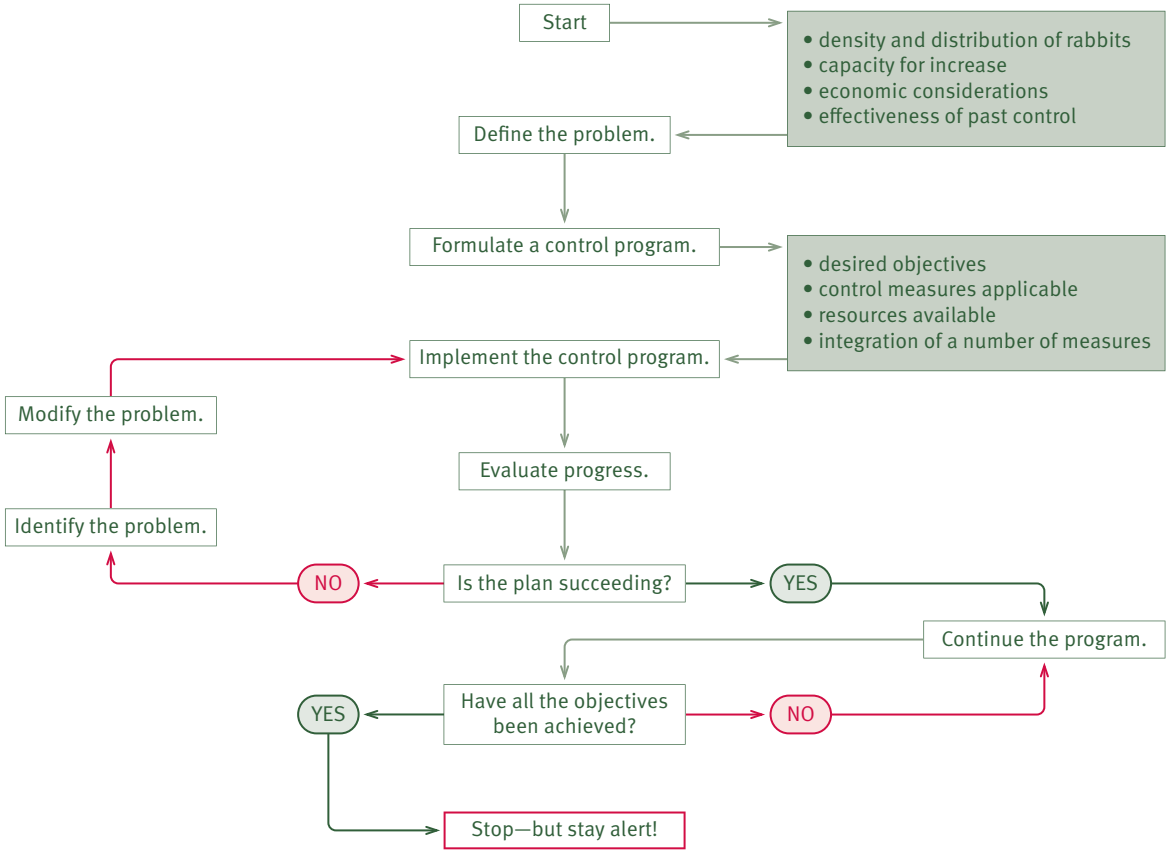


Figure 3: Development of a rabbit control program.

3.2 Management options: which one is best for you?

There are four main management options or approaches when it comes to rabbit control, as outlined in Table 2.

Table 2: Four main options for rabbit control.

Management option	Likely outcome
Do nothing	• no control costs • high cost in lost production and ongoing damage to the environment
Panic management (when rabbit numbers are high and damage is obvious)	• high cost and minimal benefit • control less effective, more costly and more temporary than control when rabbit numbers are low • short-term satisfaction
Planned, ongoing control	• high initial cost but maximum benefits likely • good chance of success • ongoing commitment required to maintain rabbits at very low densities • long-term satisfaction
Local eradication	• high short-term costs • generally only feasible in small areas • monitoring required to detect possible reinvasion • no further control needed

3.3 How to know if you have rabbits

The presence of rabbits will be self-evident if you have seen them on your property, but young hares can be easily mistaken for rabbits. Careful observation will enable you to distinguish between the two species. (Refer to section 2.2.)

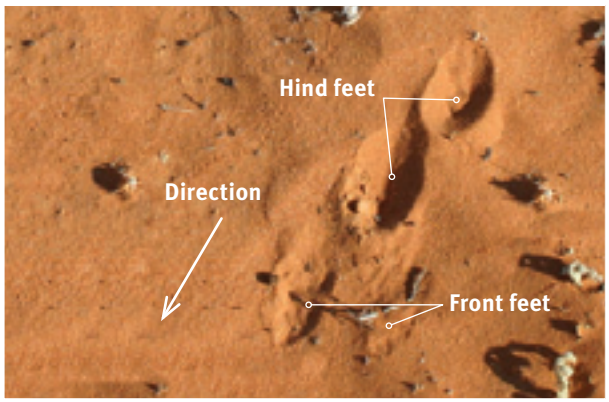
Other signs indicating the presence of rabbits include:

- **dung piles**: areas that are predominately used by bucks to mark territory; a sign that rabbits are quite well established in the area; usually only formed when underground warrens are present (Pic. 16)
- **active warrens**: identifiable from the fresh dirt cleaned out of the entrance and absence of spider webs/debris in the hole (Pics 17 and 18)
- **scratching and soil disturbance**: evidence of rabbits foraging for food (but can be confused with the similar behaviour of echidnas and possums) (Pic. 19)
- **tracks**: characteristic front and hind footprints of a moving rabbit (Pic. 20)
- **shrubs**: will have a grazing line at 40 cm (Pic. 21).

Pic. 16 : Rabbit dung pile.

Pic. 19 : Rabbit scratchings.

Pic. 17 : Active rabbit warren.



Pic. 20 : Rabbit footprints.

Pic. 18: Active rabbit warren.

Pic. 21 : Rabbit grazing line on a shrub.

3.4 How many is too many?

While you may see what appears to be only a small number of rabbits, this doesn't mean that you are not losing a substantial amount of pasture and/or crop to rabbits each year.

Rabbit populations rise and fall according to seasonal conditions and, as they breed extremely rapidly, numbers will inevitably increase unless some action is taken.

Most land managers know that high numbers of rabbits can 'eat the country out'. However, even in low numbers rabbits remove a large amount of the available feed—and it's usually the best feed they take. Table 3 summarises the results of studies conducted in Western Australia matching rabbit densities with pasture consumed. If no rabbit control is undertaken, stock numbers need to be decreased to cope with the reduction in available pasture and property productivity will decline.

Table 3: How much pasture rabbits can eat.

Estimated rabbit density	Pasture eaten by rabbits (%)
light–moderate	10–47
heavy	62–77
very heavy	86–100

Rabbits will generally eat around 15% of their body weight per day—approximately 250 g. This compares dramatically with the averages for stock—sheep and cattle eat around 3% of their body weight per day, while horses eat only about 2%. Further comparisons are given in Table 4, with consumption rates expressed in rabbit equivalents.

Pic. 22: Rabbits at waterhole in South Australia during the drought in 1963.

3.5 Estimating and monitoring rabbit numbers

An estimate of rabbit numbers can be made quickly and easily, and is the most practical indicator of a potential rabbit problem. The simplest methods are spotlighting and warren counts.

Monitor rabbits to effectively manage them.

When counting rabbits, it is important to use the same method every time. If possible, also conduct counts at the same time of night and in similar weather conditions. This ensures that other factors remain constant and the only variable that will change is the number of rabbits.

Ideally, monitoring should be started before any control work begins, and needs to continue well after control work has ceased. For best results, monitoring should involve measuring changes over time and throughout seasons. If done methodically, it can help detect changes in rabbit numbers before they become obvious to the casual observer.

Monitoring will:

- promptly detect changes in rabbit numbers
- reveal the level of success of control methods
- reveal if, when and where follow-up control is needed.

Table 4: DSE (Dry Sheep Equivalent) comparison table.

Animal	Mean body weight (kg)	Approx daily feed intake (kg)	Dry Sheep Equivalent (DSE)	Rabbit equivalents (DSE)
rabbit	1.5	0.25	0.11	1
wether	50.0	1.50	1.00	9
ewe & lamb	50.0	1.50	1.40	13
ram	60.0	1.80	1.50	14
steer (1–2 yrs)	400.0	12.00	10.80	98
steer (2+ yrs)	500.0	15.00	13.50	123
steer (2+ yrs)	600.0	18.00	16.20	147
cow & unweaned calf	500.0	15.00	16.10	146
bull	800.0	24.00	18.00	163
horse	600.0	12.00	11.00	100
kangaroo	35.0	1.05	0.70	7

However, this level of monitoring may be impractical for some land managers. In those cases, it is suggested that rabbit numbers be determined just before control work starts and again within a month of completing the work. Before- and after-counts will give you an indication of how the rabbit population has changed and whether control methods were successful. Ongoing annual monitoring will help you decide on the amount of follow-up control required.

3.5.1 Spotlight and headlight counts

Using this method, rabbits are counted at night from a vehicle moving at a slow, constant speed (about 10–20 km/hr) over a fixed route, with the aid of a hand-held spotlight.

This ideally requires at least two people—one to drive and another, holding a spotlight and counting the rabbits, to stand on the back of the ute. All rabbits seen within approximately 100 m on both sides and in front of the vehicle are counted and recorded.

If only one person is available, this method can be modified and a headlight count can be used instead. This is where a person drives at night, at a constant speed, over a fixed route and all rabbits seen in the headlights of the vehicle are counted and recorded.

Numbers of rabbits counted using these methods can be used to either compare the success of control measures, or for ongoing monitoring. For a crude approximation of actual rabbit numbers (to estimate damage caused by rabbits), multiply by 17 the number of rabbits spotlighted per kilometre. This will yield a minimum total number of rabbits per square kilometre.

Spotlighting is not as reliable for accurate estimates when rabbit numbers are low. For a good estimate of numbers in a small area, footprint counts may be a more precise alternative.

Signs of an active entrance:

- fresh soil scratched out of entrances
- impressions of feet and claws in the soil
- fresh urine or faeces
- rabbit hairs.

Signs of an inactive entrance:

- no fresh scratches at entrances
- spider webs in hole entrances
- layers of old faeces
- vegetation/debris in holes.

3.5.2 Footprint counts

This method involves siting 15–20 sand plots, which are one metre in diameter, in and around warrens, harbour areas and feeding areas. The sand plots need to be raked smooth to ensure there is a soft surface on which rabbit footprints will be clear.

It is best to set the plots in the late afternoon and then check them in the morning. Repeating this procedure for three consecutive days should result in an accurate count. This method is good to use for an indication of rabbit numbers before and after control has been undertaken. (See Pic. 20 for a picture of rabbit footprints.)

3.5.3 Warren (active entrance) counts

This method is useful only where there are plenty of warrens and most of the rabbit population live in them. However, where most of the rabbits are living above ground or in log piles, counting warren entrances will not provide an accurate estimate of rabbit numbers. (Rabbits using above-ground harbour will continue to scuttle from one area of harbour to another and never appear to go underground, whereas their burrow-living counterparts will dive for a burrow entrance as soon as possible.)

If the property is small, inspect and count all warrens; if the property is large, only 10–20 warrens need to be inspected. For each warren, count the number of active (used) and inactive (not used) entrances and record the information. To estimate actual numbers of adult rabbits, multiply by 1.6 the number of active warren entrances. (See Pics 17–19 for pictures of active warrens and scratching.)

3.6 Identifying and mapping rabbit areas

Mapping the active rabbit areas on your property will show exactly where a problem exists and how serious it is, which will help when deciding on the best place to start control and how much it might cost.

The property map should be current and accurately show scale in order to help when working out potential control costs but it can be an aerial map, a satellite image or hand-drawn. Separate transparent overlays can be useful when mapping different areas of the property as it can make the map easier to interpret.

On the map, outline all natural features, improvements and property boundaries. Then mark areas where rabbits are breeding. This needs to include warrens and above-ground structures. Also show areas where rabbits are living underneath buildings such as sheds.

When mapping rabbit-breeding areas, look for them carefully and thoroughly—they are often hard to see and there are always more places rabbits are living and breeding than you anticipate.

Once all rabbit breeding areas on the property have been mapped, the next step is to prioritise the areas for control. Start at the source of rabbits: where most of the breeding is occurring; where the largest, most active warrens are; and where rabbits are causing most damage.

3.7 How much are rabbits costing you?

Rabbit damage can be measured in dollar terms. Depending on the type of enterprise you run, the cost per rabbit will be different. For a simple guide, see Table 5 which provides an estimate of the cost of rabbits to a variety of enterprises. When working out the costs of damage to a crop, the length of time that the crop is in the ground should also be taken into account. (See Table 15 in the appendix.)

Table 5: Approximate cost of rabbits to agricultural enterprises (based on worksheets in the appendix).

Enterprise	Approx. equivalent cost (2007 prices) per rabbit per year ($)
wool	1.70
store cattle (property bred)	2.20
trading cattle (grow out for 12 months)	2.60
stud cattle	12.70
broccoli (per hectare)	9.05
lettuce (per hectare)	2.15
lucerne (irrigated; per hectare)	6.25
wine grapes (per hectare)	60.00

Table 5 shows that there is a quick and easy way to roughly calculate the cost of rabbits to a store cattle property:

1. Use the monitoring methods outlined in section 3.5 to calculate the number of rabbits on your property.
2. Multiply that figure by $2.20 (store cattle property figure from Table 5) to calculate how much rabbits are costing you each year.

For example:

1000 rabbits x $2.20 = $2200 equivalent annual cost

1700 rabbits x $2.20 = $3400 equivalent annual cost

However, if you need a more accurate calculation of the equivalent cost per rabbit per year for a store cattle property, the following equation can be used:

Cost per rabbit per year = (X – Y) ÷ DSE

Where: X = income per head of stock

Y = variable costs per head per year

DSE = dry sheep equivalent for appropriate class of stock (see Table 4)

Note: Sample worksheets along with specific examples of calculations have been provided in the appendix to help you work out exactly how much rabbits are costing you

Figure 4: Rabbits can certainly impact upon a land manager's hip pocket.

3.8 Climate and timing of control

The best time to conduct rabbit control is when populations are small and more easily managed—when costs will be low and effectiveness will be high.

Periods of drought are particularly good times to control rabbits as they will be concentrated around the last available source/refuge areas, just waiting for the coming rains. It is to these areas that rabbits retreat when times are tough so if the source areas can be identified, the rabbits can be controlled.

When times are tough (drought) get tough on rabbits.

Section 4: Control options

4.1 Coordinating control

Rabbit control is best done as a joint exercise involving all land mangers in the district. This may not always be possible but with landcare groups operating in most areas and funding often available, it makes sense to talk to other land managers in the district to coordinate efforts. Cost-effective, long-term results can be achieved in rabbit control by following the methods outlined in Figure 5.

Coordinating control efforts counts!

The effective (long term) rabbit control cycle

Figure 5: Effective rabbit control through coordinated community control programs.

4.2 Where to start control

For effective long-term rabbit control, efforts should be directed at destroying source areas. These can be readily identified by the presence of rabbits even during the worst drought or after a myxomatosis or RHDV epidemic. Source areas will all have well-established warrens or ready-made structures that are cool and provide protection from predators. A source area must also have a good supply of green feed during the cooler seasons.

Target source areas—hit 'em where it hurts!

The reason for targeting source areas is that they are the areas where rabbits breed and the birth rate exceeds the death rate. This leads to an increase in the rabbit population with the excess rabbits dispersing and continually repopulating the surrounding districts—particularly in good seasons when they can flourish. The dispersing rabbits are less of a concern than those in the source areas, however, because droughts, disease and predators routinely impact upon them to reduce numbers. It will always be new rabbits from the source areas that will become the new wave of dispersing rabbits in the coming months or seasons.

Learning how to identify source areas on the property and in the district is critical for long term rabbit control. Some identifying characteristics to look for on a property are areas where:

- rabbits have survived during droughts
- you know you can always see rabbits
- kittens are seen regularly
- multiple dung hills are visible on the ground
- large warrens are present
- permanent water or other relatively moist areas are available nearby.

4.3 Costs of control

The cost of rabbit control will vary depending on the control method chosen, the type of country you have, the total area that needs to be controlled, and the number and density of rabbits. High-cost control options are not necessarily the best for all situations.

Listed below are a few of the costs and benefits you need to weigh up before beginning control. This includes environmental and social benefits, not just dollars. Also consider the cost of doing nothing—this could mean ongoing production losses and environmental damage.

Although environmental and social benefits are difficult to measure in dollar terms, these factors alone may justify spending money on rabbit control.

Costs

- Control
  - –initial control
  - –follow-up control
  - –maintenance control
- Equipment
  - –purchase
  - –loan
  - –hire
- Labour
  - –staff
  - –contractors

Benefits include:

- increased livestock production
- increased crop yields
- environmental benefits—improved biodiversity, reduced erosion
- better sale price for produce—meat, wool, crops
- increased property value
- better pasture recovery
- social benefits.

Table 6: Estimated costs of some control measures (2008 prices).

Control method	Density (rabbits/ warrens per hectare)	Cost ($/ha at 2008 prices)	Comments
baiting	low (20–30 rabbits) high (70+ rabbits)	3.00–64.00	• initially fairly cheap but ineffective in the medium term (requires continual follow-up) • 3 x poison feeds required for effective kill
warren destruction/ ripping*	N/A	3.00–20.00 (4.00–12.00 per warren)	• cost-effective and long-lasting • minimal ongoing control required after ripping • does not include transportation of bulldozers etc. in cost estimate
fumigation	low (1–5 warrens) medium (5–10 warrens) high (10+ warrens)	6.00–26.00 26.00–66.00 66.00+	• high level of labour required • more than one treatment often required
rabbit-proof fencing	N/A	4000.00–6000.00 (per kilometre)	• very expensive (with high labour costs—not included in cost) • suited only to special situations • costs vary with terrain/soil type

* For further details on ripping costs see section 5.1.1.

4.4 Integrated control

Integrated pest management is like using a shotgun as opposed to a single bullet—you're more likely to hit everything in your target range. By combining several complementary treatment options, you can achieve successful, long-term control.

There are many methods available for managing rabbits including warren and harbour destruction, baiting, warren fumigation, biological control, and shooting. However, it is important when choosing the control methods best suited for your property that all factors are taken into account—each situation will be different. Factors to consider include:

- current number of rabbits
- size of the property
- equipment already available for use
- land types
- location and type of existing breeding areas
- time of year
- climate.

The ability of rabbits to survive is dependent on where they live and breed. This could be a warren, log pile or patch of noxious scrubby weeds such as lantana or blackberry. All these places provide protection from predators and extremes of temperature. It is this dependency that can be exploited for long-term control by destroying the warrens and/or harbour.

Given the number of factors that can influence the effectiveness of control methods, suitable property-wide control can only be achieved after a paddock-by-paddock assessment. Choosing the right control methods at the start is the key to reducing costs in the future.

4.5 Which control methods will suit you?

The following three tables (Tables 7, 8 and 9) give a brief overview of the control methods that are suitable for different circumstances in eastern, western and urban Queensland.

It is important to remember this is a guide only and that other factors such as time of year, climate and current number of rabbits should be taken into account. This information, used in conjunction with Table 10 provides a general rabbit control guide. More detailed information on each method is provided in section 5.

Table 7: Control options for eastern Queensland.

Situation / Control method	Steep country	Open pasture	Dense woody scrub/weeds	Riverfront/ riparian areas	Undulating hills	Granite and basalt/rocky country	Crops
Physical control							
warren and harbour destruction	***	***	**[b]	*[b]	***	***	×
shooting[a]	*	*	×	*	*	*	*
trapping	*	*	*	*	*	*	*
exclusion fencing	×	×	×	×	×	×	**
Chemical control							
warren fumigation	**	**	×	**	**	**	*
baiting	**	**	**	**	**	**	*
Biological control							
RHDV	**	*	*	*	*	**	**
myxomatosis	*	*	*	*	*	*	*

* marginal

** moderate

*** very good

× not suitable

[a] Shooting should only be used as a 'mop-up' technique when numbers have already been reduced by other methods.

[b] Care must be taken not to damage native trees and shrubs, or promote erosion of riverbanks.

Table 8: Control options for western Queensland.

Situation / Control method	Rangelands	Channel country	Forest/scrub country	Riverfront/ riparian areas
Physical control				
warren and harbour destruction	***	***	**[b]	*[b]
shooting[a]	*	*	×	*
trapping	*	*	*	*
exclusion fencing	×	×	×	×
Chemical control				
warren fumigation	**	**	×	**
baiting	**	**	**	**
Biological control				
RHDV	**	**	**	**
myxomatosis	*	*	*	*

* marginal

** moderate

*** very good

× not suitable

[a] Shooting should only be used as a 'mop-up' technique when numbers have already been reduced by other methods.

[b] Care must be taken not to damage native trees and shrubs, or promote erosion of riverbanks.

Table 9: Control options for urban areas and rural towns.

Situation / Control method	Under building foundations (e.g. houses, sheds)	Under gravesites	Garden beds
Physical control			
warren and harbour destruction	×	×	*
shooting	×	×	×
trapping	**	*	**
blocking warren entrances[a]	**	**	*
exclusion fencing	*	*	***
Chemical control			
warren fumigation	**	**	×
baiting (Pindone)[b]	**	**	*
Biological control			
RHDV	**	**	**
myxomatosis	*	*	*

* marginal
** moderate
*** very good
× not suitable

[a] Using wire netting, concrete in holes etc.

[b] Pindone baiting is only available in built-up areas.

Table 10: Rabbit control calendar.

Month	Rabbits breeding	Destroy warrens/ harbour	Shoot	Trap	Fumigate	Bait	RHDV active	Myxo active
January								
February								
March								
April								
May								
June								
July								
August								
September								
October								
November								
December								

Best time of the year to conduct control.

4.6 Finish the job

Rabbits in low numbers are not always evident to the casual observer. To make sure rabbit populations don't bounce back, be prepared to remain vigilant and ready to stamp out any new incursions or recovering populations.

While rabbit control will generally result in more productive pasture and increase the feed available, it is best not to simply replace rabbits with livestock. Giving the country time to regenerate should further improve pasture quality and lead to greater productivity.

4.7 When a rabbit control program is not working

The most common reason that a rabbit control program is not successful is that source areas have not been effectively destroyed. The control program may have killed a lot of rabbits by shooting/trapping/baiting/bio-control and fumigation but the rabbits that are missed are still capable of breeding in the undisturbed source areas.

Usually, these rabbits in the source area will actually increase breeding in response to the gap left by the controlled rabbits. This can happen because, with fewer rabbits in an area, there is an increase in available feed per rabbit.

The source area may be located on surrounding properties, so coordination of control with neighbouring land mangers is very important.

Section 5: The rabbit control toolkit

The rabbit control toolkit is aimed at giving land managers in Queensland the best available knowledge on rabbit control. As the result of research, methods have changed slightly over the years and the most effective methods for rabbit control in Queensland are now well understood. These methods are outlined below.

5.1 Physical control

Physical control of rabbits should focus on destroying the source areas such as warrens and other breeding areas. This method alone can give long-term results. Shooting and trapping can also be used but labour costs are high and long-term results are not achieved. Fencing is very effective for rabbit control, especially for complementing conservation programs or protecting valuable crops, but it can be very expensive.

5.1.1 Warren and harbour destruction

Summary

Ripping:

- for sandy soils—must be done when soil is dry
- for clay soils—must be done when soil is slightly damp
- for warrens around waterholes—must be done when conditions are dry
- needs to be done to a depth of at least 50 cm
- needs to be done to a width of at least 2 m outside the edge of the warren
- must be supplemented with cross-ripping to be effective.

Advantages	Disadvantages
long-term control	need to locate warrens and breeding refuges
additional productive land available for stock	site access required for tractors
can be used near urban areas	unsuitable where site has large rocks
rabbits rarely reopen ripped warrens	native burrowing animals unable to use warrens again

Warren destruction (ripping)

In areas where rabbits live in warrens, destruction (ripping) is the most effective method of long-term control. Ripping is so successful because the warrens can rarely be reopened and the rabbit is unable to recolonise these areas. While some of the older rabbits may still be around for a year or two, once these rabbits die out there will be no younger ones to replace them.

An alternative to warren ripping on steep rocky terrain is to use a backhoe or excavator to either move rocks over the opening of warrens, or to dig up the warren structure.

Combined with other control methods, ripping can reduce a rabbit population to 1–2% of its original size. To get the best results it is important to chase as many of the rabbits inside the warren as possible. Dogs can be used to drive rabbits into the warren before ripping starts.

The aim of ripping is to completely destroy the warren. It involves using a tractor with a tined (sharp pronged) implement—one tine or many—that rips through the warren and collapses it. Larger tractors and dozers are more appropriate for properties with many warrens as they are able to move faster and rip wider.

Pic. 23: Tractor ripping warrens in shed.

Pic. 24: Single tine ripper on farm tractor.

Pic. 25: Bulldozer ripping warrens in western Queensland.

Obviously, ripping is not suitable for warrens located underneath buildings or on steep rocky country. In such cases, other methods (poison baiting, releasing virus or fumigating burrows) should be used instead to reduce rabbit numbers. Warrens should then be either filled in or covered to stop rabbits from re-establishing. Burrows can be blocked with small boulders or rocks.

To properly destroy warrens, a 'cross-ripping' technique should be used—the whole warren is ripped in one direction and then ripped again at right angles across the previous rip lines, as illustrated.

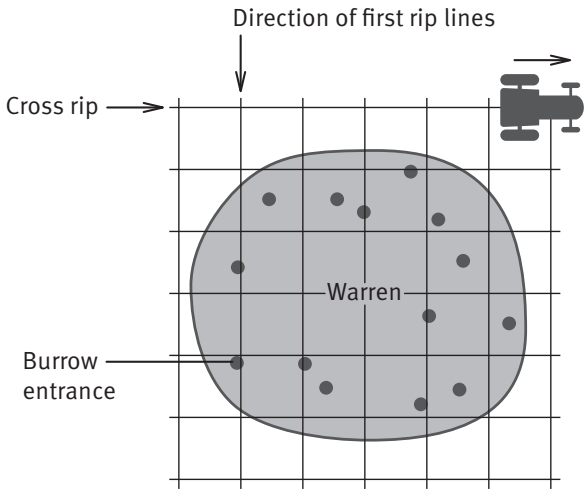


Figure 6: Rabbit warren-ripping plan.

Warrens can be over two metres deep so it is important to rip at least 50 cm into the ground. In sandy areas, where rabbits are able to excavate more easily and warrens are likely to be deeper, ripping should be to a depth of 70–90 cm.

Rip the entire warren area, plus at least two metres outside the identified edge of the warren, to make sure that all holes and tunnels are destroyed. If holes are reopened, it is a good indication that the warren has not been ripped properly and the area of ripping needs to be extended.

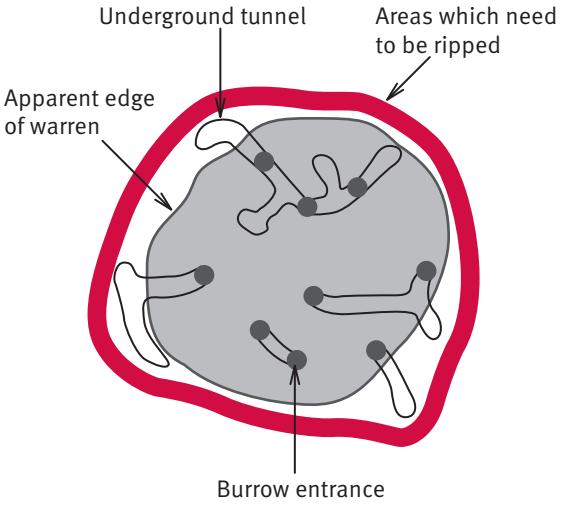


Figure 7: How to rip around warrens to cut off tunnels leading outwards.

While ripping can be done throughout the year, the best time for this form of control is either during the breeding season or when numbers are low. (Rabbit numbers will be suitably low during dry seasons or drought, after an outbreak of myxomatosis or RHDV, or after fumigation or baiting.) If warrens contain large numbers of rabbits, it's a good policy to poison the area before ripping.

If warrens occur under infrastructure or buildings and ripping is not an option, use other control methods such as baiting and fumigation to decrease numbers, then either:

- secure chicken wire over all warren entrances

  or
- fill the warrens with concrete or rocks.

This will prevent rabbits from re-establishing the warren.

Following ripping, 'mop-up' methods such as trapping, shooting and baiting can reduce rabbit numbers further by removing animals that were not in the warren at the time of ripping. This should reduce the population to an extent where it may not recover. To be certain, all ripped warrens should be checked 1–2 weeks following ripping for reopenings.

Particularly on small properties, ripping can also be coordinated with neighbours—this produces better results than if a single property is ripped. This is an opportunity to share resources and some costs, and reduces the risk of rabbits moving next door and/or recolonising from next door.

In times of drought on larger properties (such as those in western Queensland), studies have indicated that it may not be necessary to rip all warrens on the property. In dry seasons, moisture levels can become so low that rabbits need to be close to a reliable water source to survive. Therefore, in times of drought, it is enough to rip only those warrens close (within 1–2 km) to a permanent water supply (i.e. the source areas)—this will be just as successful as ripping the entire property. This can dramatically reduce costs, making control more achievable and appealing.

See case study 2 on Bulloo Downs Station for an example of where rabbit control has occurred over a large property.

Pic. 26: Rock and wire covering hole to prevent use by rabbits.

Costs

On small properties in relatively high rainfall areas, the cost per rabbit hole (and even the cost per warren) may be considerably higher than the figures provided below. This could potentially be due to a range of factors including:

- low warren density in some areas
- fewer holes per warren complex
- difficult access to warrens due to surrounding vegetation, logs, rocks, hilly and/or boggy terrain
- use of smaller, less efficient machinery
- effect of averaging machinery ferry costs for a smaller ripping area.

Bearing this in mind, the approximate costs of ripping for small and large properties is outlined below.

- **Small properties—approximately 1000 hectares**

  On small properties where small tractors and single tines can be used, the cost (including labour) of ripping is estimated at $4–12/ha (depending on warren densities).
- **Large properties—approximately 500 000 hectares**

  On large properties in the arid rangelands where large-scale ripping using a bulldozer is possible, the cost (including labour) is estimated at $1200–2000/sq km (depending on the warren densities).

Harbour destruction

Where there is abundant surface harbour, a high proportion of rabbits may live above ground rather than in underground warrens. Rabbits can make their homes in windrows, dense thickets of shrubs such as blackberries and lantana, and even in old machinery.

To eliminate these above-ground breeding areas, it may be necessary to:

- burn windrows and log piles
- remove noxious weeds through chemical and physical control
- remove movable objects (such as old machinery) from paddocks.

Sometimes removing harbour can expose warrens underneath. If this happens, the warrens will need to be ripped.

Pic. 27: Burning log piles to destroy rabbit harbour.

Pic. 28: Cars and old rubbish near short green grass—perfect rabbit harbour.

5.1.2 Shooting

Summary

Shooting:

- will not eradicate every rabbit
- is best used to 'mop-up' small numbers after ripping
- used alone is inadequate—the rabbit population will quickly recover.

Advantages	Disadvantages
can be used as a 'mop-up' technique	labour-intensive and high-skill method
humane if used correctly	does not give long term control
	can only be used over limited areas

When used alone, shooting is not considered an effective method of rabbit control as it will only have a small impact on the population. It is just not possible to shoot all the rabbits on a property and the population will quickly breed up again to replace those shot.

Shooting is most useful when used to 'mop up' after other methods—such as ripping—have been used. To get the best results, shoot at the time of day when rabbits are active—rabbits in hiding can recolonise. This is usually in the early morning, late afternoon or at night. The best and most economical firearm to use is a .22 calibre rifle.

If the property is within an urban area, you will need to comply with local government regulations and the *Police Powers and Responsibilities Act 2000*, which restrict the use of firearms.

5.1.3 Trapping

Summary

Trapping:

- is not effective for reducing rabbit numbers
- is best used as a 'mop-up' method.

Trappers:

- must be skilled
- must abide by animal welfare and ethics obligations.

Advantages	Disadvantages
can be used as a 'mop-up' technique	not effective if used as the only control method
non-targeted animals can be released	animal welfare concerns
recommended for removing rabbits from hay sheds	labour-intensive and high-skill method

Trapping alone is not considered an effective method of control as rabbit populations will quickly recover and trapping will need to be repeated year after year. This is also an extremely labour intensive method and requires a skilled operator to set the traps to successfully capture rabbits.

If you do plan to trap rabbits on your property, common sense and respect for animal welfare are essential. While there are currently no strict guidelines for the use of traps in Queensland, it is an area of growing concern for animal welfare advocates.

Cage trap

A cage trap has a lever that closes the cage when a rabbit steps on it. The rabbits are lured into the cage with bait—usually diced carrot. Traps need to be disabled and left open for two or three nights with bait leading into the cage. This entices rabbits to enter. A trap can be set once the trail of bait is being removed all the way into that trap. Traps should be checked and emptied regularly—usually a couple of times a night.

This effective and humane technique is most useful for removing any remaining rabbits from places like hay sheds after the shed has been fenced to prevent additional rabbits from entering and leaving. Free-feed then trap, and keep the shed rabbit-proof to prevent rabbits recolonising.

Pic. 29: Cage traps used in hayshed to remove rabbits.

Barrel trap

A barrel trap is designed specifically for rabbits. It is cylindrical, made of light mesh, and is about 1 m long and 15 cm in diameter. The trap has one open end with two hinged trap doors along its side. The open end is placed in the burrow, and the hinged gates close and trap the rabbit after it enters from the burrow.

The trap can be left in the burrow entrance for a number of days. However, it must be checked at least daily so that if a rabbit has been caught it does not suffer and animal welfare responsibilities are met.

Pic. 30: Barrel trap for rabbits placed in hole.

Foothold traps (soft-jaw or padded)

Although foothold traps are not widely used in Queensland, they can sometimes be useful in situations where other control methods can't be used. They are considered more humane than the older, serrated, steel-jawed leghold traps which cause pain and suffering, and should not be used.

Soft-jaw foothold traps have a piece of rubber attached to the inner surface of the trap. These traps will hold the animal firmly by the foot without causing damage.

Foothold traps are placed on the warren entrance path about 20–30 cm out from an active warren entrance. The trap should be placed in loose, sandy soil. One trap should be placed at the entrance for each active hole in a warren. (The signs that help to identify a warren entrance are outlined in section 3.5.3.)

Pic. 31: Old style rabbit trap and new style with rubber padded jaws.

5.1.4 Exclusion fencing

Summary

Fencing:

- excludes rabbits from a certain area—does not control numbers
- is good for small areas e.g. high value crops, home gardens and hay sheds
- is impractical for large areas
- requires frequent maintenance
- must be built to a minimum standard.

Advantages	Disadvantages
considered humane	expensive
can provide a rabbit-free area	does not eradicate rabbits—only prevents them from entering an area
	only suitable for small areas

Rabbit exclusion fences are built with the aim of keeping rabbits out of a particular area. This control method can be very expensive and impractical over large areas. It is only appropriate for small areas that require protection. A fully fenced area will only remain rabbit-free in the long term if all rabbits are removed from the enclosed area after fencing and the fence is regularly maintained and checked for holes.

A rabbit-proof fence should be made of wire mesh netting (40 mm^2 or smaller) and needs to be at least 900 mm high. The netting should also be buried to depth of at least 150 mm. Gates into the fenced area need to be rabbit proof as well. For fencing costs see Table 6.

Electric fencing is a cheaper alternative, but it is not a complete physical barrier and is also prone to damage from other pest animals and stock.

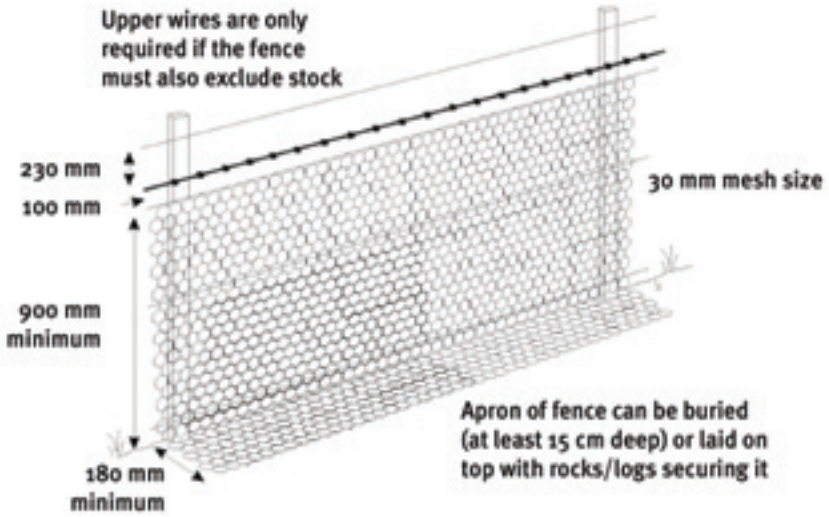
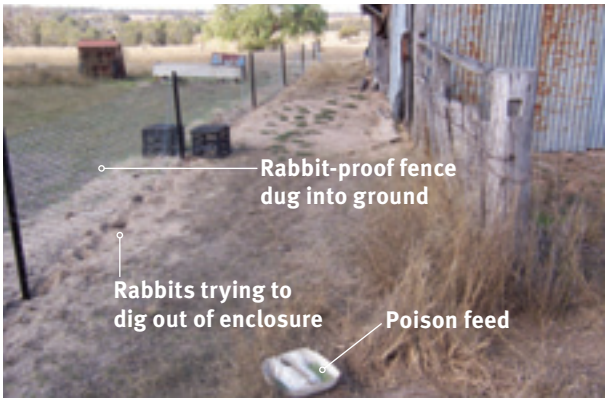


Figure 8: Design for a rabbit-proof fence.



Pic. 32: Rabbit fence used to enclose rabbits into a shed harbour area as part of an eradication program.

Pic. 33: DDMRB rabbit-proof fence in southern Queensland.

5.2 Chemical control

Chemical control works best when used **before** the physical destruction of rabbit warrens and their associated harbour has occurred. (This is because rabbits become timid after their warrens and harbour are disturbed and they may disperse into surrounding areas where physical control will be ineffective.) While chemical control used in this way can help in the overall control program, its use **after** physical control is only effective as a mop-up tool for cleaning up remaining surface rabbit populations.

5.2.1 Warren fumigation

Fumigation is labour intensive and time consuming, and is not usually an effective method if used alone. However, as a 'mop-up' technique or for use in areas where ripping is not practical (e.g. steep and rocky parts of the granite belt in South East Queensland) it may be a good alternative.

Safety precautions when using fumigants:

- Wear safety gear—follow the poison label for specific advice.
- Do not touch the tablets with bare hands.
- Avoid breathing in the fumes.
- Work upwind of the gas.

Because this technique relies on directly affecting the rabbits and does not affect the structure of the warren, it is absolutely crucial that as many rabbits as possible are underground when fumigation is carried out. Rabbits usually take refuge in their burrows from mid-morning to mid-afternoon and during hot weather so these are the best times to fumigate. Dogs can also be used to drive rabbits into their warrens.

Summary

Warren fumigation:

- is useful when ripping is not practical
- affects only rabbits inside the warren
- works best when rabbit numbers are low
- works only if all warren entrances are blocked so rabbits cannot escape
- can use either static or pressure fumigants
- must be used with care and appropriate safety precautions (fumigants are toxic to people).

Advantages	Disadvantages
can be used as 'mop-up' technique	labour intensive
relatively target specific	all entrances to warrens (active and inactive) need to be located
can be used when ripping is not practical	does not stop rabbits reopening and reinhabiting warrens
can be used near urban areas	some animal welfare concerns

To get the best results, fumigation should be carried out in two stages: initially, before the breeding season starts (as this reduces the breeding stock), and then again during the breeding season.

There are two types of warren fumigation—static and pressure. In Queensland, static fumigants are a more popular and safer option for controlling rabbits.

Static fumigation

This method is easy to use, and time- and cost-effective. Static fumigation comes in the form of aluminium phosphide (phosphine) tablets which can be purchased from most agricultural suppliers. These tablets are small and round (size of a marble), and weigh three grams. Trade names for phosphine include Pestex®, Quickphos® and Gastion®. General directions for the use of phosphine tablets appear below, but always refer to the manufacturer's specific recommendations for use.

To fumigate warrens using phosphine tablets:

1. Find all warren entrances—both active and inactive.
2. Cut back the warren entrance at right angles using a shovel.
3. Separately wrap two tablets in moistened absorbent paper (toilet paper/paper towels).
4. Insert the tablets as far down into the entrance as possible. (Polypipe and a push rod can be used to help push the tablets down.)
5. Push some scrunched-up newspaper down the hole to block the entrance and then cover it up with soil and, if possible, a rock.
6. Treat all entrances to the warren (active and inactive) the same way.
7. Check warrens about a week after fumigation and re-fumigate any reopened entrances.

Once in the warren, the moistened tablets react with air to release a toxic gas, which spreads quickly throughout the warren. The phosphine gas itself is invisible and odourless but leakages from the warren can be detected by the smell of ammonia. (This is a safety mechanism that is built into the tablet.) Any leakages need to be blocked immediately.

Pressure fumigation

The chemical used in pressure fumigation is chloropicrin, sold as Larvicide™. This chemical is **highly toxic** to humans and can even be fatal—because of this, **its use is not recommended**. If you do choose to use chloropicrin, it is critical that you strictly follow the manufacturer's recommendations regarding appropriate safety equipment.

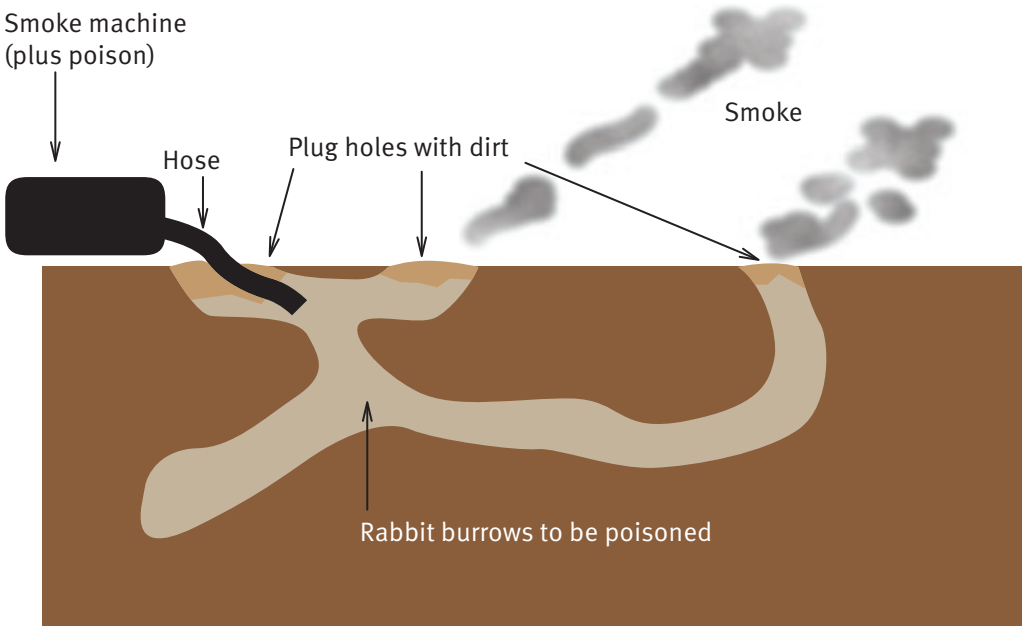


Figure 9: Pressure fumigation of a rabbit warren.

This method uses a fumigating machine attached to the exhaust of a vehicle. The fumigator contains a mixture of one-third Larvicide™ and two-thirds power kerosene or diesel fuel. (The kerosene or diesel fuel enables the operator to locate any unsealed openings by the smoke given off.) The machine's hose is inserted into each warren entrance and the entrance should then be sealed with soil. Smoke is then pumped throughout the warren to spread the chemical.

Due to the highly toxic chemical used, it is absolutely vital that all warren entrances are thoroughly blocked with soil before fumigation begins. The indicator fuel produces smoke and if this is seen escaping from any holes, they must be blocked immediately. When fumigating, it is also essential to be upwind of the warren to avoid inhaling any fumes.

Care should also be taken when handling containers and applicators. Containers should not be carried inside a vehicle.

Pic. 34: Pressure fumigating a rabbit warren.

5.2.2 Baiting

Summary

Baiting:

- used on its own will only provide short-term control
- involves mixing the poison with food that is attractive to rabbits
- achieves best results if used in combination with warren ripping and fumigation.

Fluoroacetate (1080) poison:

- is only available from an authorised officer under certain situations
- requires pre-feeding of the target rabbits.

Advantages	Disadvantages
can achieve good knockdown in numbers	restrictions on the use of 1080
relatively cheap	pre-feeding needed with 1080
antidote available for pindone	concerns that pindone may be eaten by other animals/birds
pindone suitable for urban areas	does not stop rabbits reinhabiting and quickly re-populating warrens
large areas can be treated	erosion problems if scratched trails are not laid properly (down slope etc.)

Baiting is not effective as a sole control method and will not get rid of the entire rabbit population. Numbers will quickly increase again, and you will have to continue baiting year after year with no permanent overall change in the rabbit population. Rabbits can also become 'bait shy' and the method becomes less and less effective over time. Ideally, baiting is best used either before ripping/fumigation to reduce a population, or after ripping/fumigation as a 'mop-up'.

Baiting works best when rabbits are not breeding because during breeding season the majority of the population is feeding over a larger-than-normal area, and it is the young that are most likely to take the baits. While numbers will be reduced, animals of breeding age are not likely to be affected.

There are two types of poison available in Queensland to control rabbits by baiting: pindone and fluoroacetate (1080). Carrots, oats or cereal pellets are usually used as bait. While carrots are generally more expensive, require chopping into a standard size and deteriorate quickly, they may be more attractive to rabbits, particularly in dry conditions. Oats should not be used in areas available to stock.

The choice of food bait is up to the individual land manager and will depend on local conditions, past experience, convenience and availability. Whichever bait type is chosen, it should be clean and of good quality—otherwise the rabbits may not eat it.

It is important that bait trails are laid properly to ensure the best results. Baitlayers make it easier to put out bait trails at the correct rate, and they can be towed behind most 4WD vehicles, quad bikes and tractors.

Pic. 35: Bait laying apparatus for distributing chopped carrot bait.

It is essential to mark the surface with a light surface scratch when laying the first free-feed for 1080 and the first poison feed with pindone oats or carrots.

When scratching and laying a trail, these points need to be considered:

- Rabbits like freshly scratched/disturbed soil—this may be because rabbits are territorial and inspect newly disturbed soil, and/or the disturbed vegetation smell attracts them.
- Trails should be laid around warrens and in the areas where rabbits most often feed.

- Laying trails on slopes and hills requires care—it can cause erosion in some soils types e.g. granite and traprock. Trails are best laid in a zigzag pattern in steep terrain to minimise erosion.
- A trail that has been scratched for the first feed is easy to follow for the rest of the baiting program.
- The soil should be turned only enough to scratch the surface—don't plough the ground.
- A trail that has been scratched too deep will spook the rabbits because they will not have full sight of their predators.
- Where vegetation is thick or it is difficult to find the main feeding areas, bait trails should be laid in a grid pattern across the site.
- As a general rule, crossing the bait trail should be avoided—it can cause confusion when you try to follow the same trail on subsequent occasions. (If crossing is unavoidable, do it at right angles so that the direction to take is clear when the trail is re-laid or inspected.)

Bait trials will be most effective if these guidelines are followed:

- Use good quality, non-contaminated bait material. (Simple rule: if you wouldn't eat it the rabbit won't either.)
- Use enough feed to bait all the rabbits in the area. (The pre-feed will give an indication of the potential bait take.)
- Expect a greater uptake of pre-feed and bait material when vegetation is scarce, dried off or soured.
- Ensure that all the preparation equipment is clean and free of any chemical residues or smells—rabbits can be very shy of unusual odours.
- When there are kittens in the warren, lay the bait trail close to the warrens.

Fluoroacetate (1080)

Pre-feeding is required when using 1080 because rabbits will not readily take new feed. The poison-free bait should be laid at least three times over a one-week period before the poisoned bait is laid. (1080-impregnated carrot baits are the most common form of bait used.) This practice helps to ensure that, when the poisoned bait is laid, it will be eaten by most of the rabbit population.

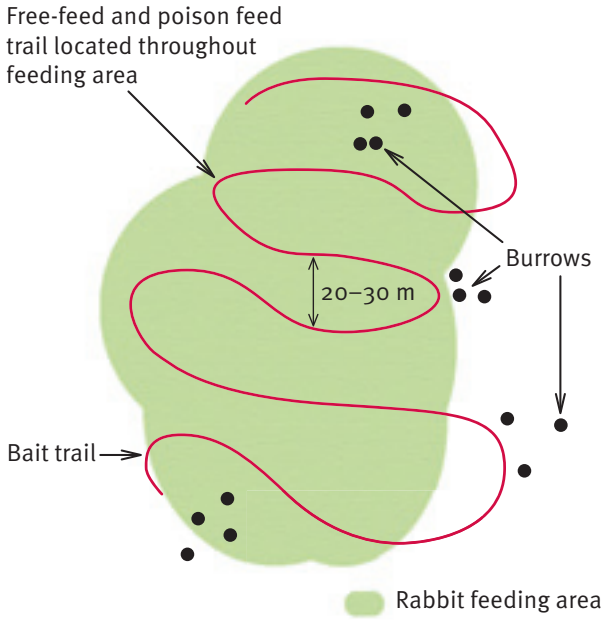


Figure 10: Bait trail should be located throughout a rabbit feeding area.

Pre-feeding enhances the success of the baiting programs—it is considered essential before 1080 baiting and is recommended before pindone baiting.

The use of 1080 is controlled by strict guidelines. In Queensland, only land protection officers from the Department of Primary Industries and Fisheries (DPI&F), officers from the Darling Downs Moreton Rabbit Board (DDMRB), or local government officers who are 1080-authorised officers licensed by the Health Department may prepare bait material for land managers. If you want to use 1080 for rabbit control, you will need to contact one of these authorised officers.

All dead animals that can be found in the treated area should be removed to reduce the possibility of secondary poisoning of carrion-feeding native animals.

Pindone

Pindone is an anticoagulant registered for rabbit control. This poison works by preventing blood from clotting. In Queensland, it is not recommended for broadacre use and is mainly used in urban areas and near farm buildings.

Pindone works best when given as a series of small doses/feeds over a period of three days. Although pre-feeding is not essential, it does enhance the bait uptake by shy rabbits as they get used to the feed prior to the poison bait being laid. To be effective, pindone requires the rabbit to have a few feeds of bait so that the poison can build up in the body until it becomes fatal. Feeding over a number of nights provides plenty of opportunity for most of the rabbit population to consume the required lethal dose. Rabbits poisoned with pindone will usually die within 10–20 days.

Pindone baiting does not work well when there is a lot of green pick around for rabbits. This is thought to be because the fresh grass contains enough vitamin K1 (pindone's antidote) to counteract the pindone consumed.

While pindone is a serious toxin for rabbits, it is also toxic to other animals and should not be used where the conservation of wildlife, particularly kangaroos and wallabies, is a concern. (Pindone is 100 times more toxic to rabbits than to humans, 24 times more toxic to rabbits than to sheep or cattle, 5 times more toxic to rabbits than to dogs, and 4 times more toxic to rabbits than to eagles, hawks, kites, kangaroos and wallabies.)

An antidote, vitamin K1, is available if pindone baits have been consumed by domestic animals or humans. The antidote is readily available from hospitals and veterinary practices so advice should be sought immediately to ensure the correct dosage is administered.

As with 1080, the use of pindone is strictly controlled and the preparation of poison baits using pindone in concentrated form is restricted to DPI&F land protection officers DDMRB officers and authorised local government officers. However, the use of prepared oats blended with pindone is unrestricted and readily available at agricultural suppliers.

5.3 Biological control

Summary

Biological control agents:

- used on their own will not get rid of rabbits
- must be followed up with another control method to be effective
- survive in the environment from year to year.

RHDV:

- needs large rabbit numbers for it to successfully spread.

Myxomatosis:

- needs vectors such as fleas to spread it throughout the rabbit population.

Advantages	Disadvantages
target specific	labour-intensive and high-skill method (if active reintroduction of virus is to be successful)
effective over large areas	immunity can be developed and passed onto offspring
relatively cheap	high density of susceptible rabbits essential for virus to spread

5.3.1 Rabbit haemorrhagic disease virus (also known as rabbit calicivirus disease)

Rabbit haemorrhagic disease virus (RHDV) is a virus specific to rabbits. The virus escaped from Wardang Island (off the coast of Yorke Peninsula, South Australia) during trials in 1995 and reached Queensland in the same year. The virus works by infecting the lining of the throat, lungs, gut and liver.

Despite its success in controlling rabbit numbers, it should not be considered a 'silver bullet' but simply another tool which can be used to complement other control techniques.

Ideal times to release RHDV:

- during autumn and spring when there are not many young rabbits (less than 8 weeks old) present
- when there aren't many resistant rabbits (those that have survived previous contact with RHDV) present.

Ideal places to release RHDV:

- where rabbit numbers are high
- where the virus has not spread naturally in the previous two years (or ever)
- where it will be supported by other methods of control.

While there are indications that insects may help to spread the disease, RHDV relies primarily on direct rabbit-to-rabbit contact in order to spread. High rabbit numbers are therefore needed before this control method will be effective. Somehow the virus survives from year to year in an area and revisits rabbit populations (provided there are enough rabbits to support its spread).

After RHDV has been released in an area, it is important to use another method for follow-up control to increase the likelihood that the population is eradicated before it is able to develop resistance and increase its numbers again.

Resistance to RHDV depends primarily on the age of the rabbit. (See Table 11.) Therefore, it is better for RHDV to go through a rabbit population after rabbits have bred and the young are old enough to be affected by the virus. Rabbits that survive RHDV develop antibodies against the virus. Breeding females can also pass these antibodies on to the young (through antibodies in their milk), conferring temporary protection on rabbits up to 12 weeks old.

Latest research indicates a benign virus that may help immunise rabbits against RHDV is present in Australia. This benign virus helps rabbits develop antibodies to protect them against RHDV. If a rabbit with antibodies to the benign virus is infected with RHDV that rabbit is likely to survive and develop extra-strong immunity to RHDV. Such rabbits may become immune from RHDV for life.

Table 11: Rabbit resistance to RHDV according to age.

Age (in weeks)	Effect of RHDV
less than 3	protected by maternal antibodies
3 to 6	60% death or immunity if not infected
9 or more	90% death or immunity if not infected

Climate has a large influence on how well RHDV works. Best conditions usually occur in spring or autumn. While isolated outbreaks can occur during summer in places where there is a high density of susceptible rabbits, no summer outbreaks have been recorded in western Queensland. However, in these drier parts of the state, it has been a very effective control method in the cooler months. In the more temperate climates of eastern Queensland, RHDV seems to be less effective overall.

Pic. 36: Death from RHDV—typical position of head.

5.3.2 Myxomatosis

Myxomatosis is a virus that was released in Australia in the early 1950s. It is transferred from rabbit to rabbit by mosquitoes and two species of fleas—the European rabbit flea and the Spanish rabbit flea.

Populations of these fleas were distributed in locations throughout Queensland, particularly where rabbits were in high numbers. The Spanish rabbit flea is more suited to hot and dry semi-arid to arid conditions, whereas the European rabbit flea is more effective in higher rainfall areas.

When the virus was released, Australia's rabbit population initially decreased dramatically. However, because it was the only control method used, rabbit numbers began to increase again within a few years. Although the virus is no longer produced as a laboratory strain, field strains of myxomatosis still commonly recur and affect rabbit populations.

Over the years, myxomatosis has mutated several times and rabbits in Australia have built up a naturally high resistance to it—unfortunately, it is no longer as effective as it once was. Nevertheless, myxomatosis still significantly suppresses the rabbit population.

Pic. 37 : Rabbit showing typical signs of myxo.

Section 6: Case studies

6.1 Sheep and cattle property in south-eastern Queensland

Benandre is a 1178 hectare sheep and cattle grazing property located in the border ranges of southern Queensland, approximately 60 kilometres east of Texas. In 1997, with the assistance of the property owner, a rabbit control demonstration was set up at Benandre with the aim of demonstrating to land managers in the local area that effective and long-term rabbit control was possible.

Prior to the control measures, rabbits were living in warrens and were competing heavily with stock for feed, particularly in times when feed was scarce. An olive plantation had been established in the hope of growing a commercial crop but rabbits were also threatening the success of that endeavour. Significantly, rabbit numbers were low as a result of outbreaks of myxomatosis and RHDV—an ideal time to implement follow-up control measures, ensuring the control would be longer lasting.

What was done?

Most of the warrens on Benandre were located in a key rabbit area of roughly one square kilometre. All the warrens in this key area were located and pegged (using steel star pickets) by a person—known as the spotter—on a motorbike. The warrens were then ripped using a 50 horsepower tractor.

A total of 154 warrens were identified, of which 94 were ripped. There were 33 warrens in areas that were inaccessible for the tractor, so these were fumigated using a pressure fumigator. The remaining 23 warrens, which couldn't be ripped using the small tractor because they were located under logs, were destroyed by a bulldozer that could clear the logs away. All the warrens were checked two weeks after treatment for any reopened holes, which were re-treated with fumigation tablets. Table 12 provides a brief summary of the results.

Table 12: Benandre rabbit warren ripping—a summary.

Area treated	1 km²
Number of warrens ripped	94
Number of warrens fumigated	33
Tractor hours (ripping only)	14
Cost per warren to rip[a]	$2.65
Total cost for ripping per km² (including labour)[a]	$470.00

[a] Costs are in 1997 dollars.

What was the outcome?

An inspection of the property in 2007 (10 years after the control measures were undertaken) confirmed that rabbits had not returned to re-establish warrens in those areas that were ripped. This was despite their presence on the neighbouring property. The olive plantation was thriving and the land manager had also found that he could leave the sheep on the property during dryer times, rather than de-stock.

The Benandre work showed that it is possible to control rabbits with a small budget, using equipment that is readily available on most properties. Many land managers do not have access to large bulldozers with multiple ripping tines, or the funds to hire such equipment. However, most farming enterprises have access to suitable tractors (2- or 4-wheel drive) and the ripping at Benandre illustrates that effective and long-lasting warren destruction and rabbit control can be achieved by most land managers once they are armed with the right information.

Pic. 38: 50 horsepower tractor with a single ripping tine.

6.2 Cattle property in far south-western Queensland

Bulloo Downs is a one million hectare cattle station in south-western Queensland, located approximately 120 kilometres west of Thargomindah. Bulloo Downs had probably been the main source area for the rabbits that recolonised much of the surrounding area after droughts. It is ideal habitat for rabbits—sand dunes are intersected by clay flats that are regularly inundated by local rainfall or flooding of the Bulloo River. Approximately one quarter of the property (2500 square kilometres) is suitable rabbit habitat.

Many rabbit warrens had been established close to long-lasting natural waterholes, which provided plenty of drought refuge. It was probably these extensive drought refuge areas that enabled rabbits to survive dry seasons in large numbers and then to spread back out across the region during good seasons.

What was done?

Major control measures were begun in 2002 and took three years to complete. Given the size of the property and extent of the problem, this time was chosen because rabbit numbers were comparatively low due to the extended drought. To survive the drought, the remaining rabbits had become more densely located in areas close to permanent water. This meant that control measures could be targeted over the relatively small areas in which the rabbits were concentrated but the end result would be control over very large areas of the property.

All permanent water sources were located and all warrens within one kilometre were ripped—a total of 48 000 warrens covering 215 square kilometres. Two large rubber-tracked tractors were used together. One was a 220 horsepower Caterpillar Challenger with a 5-tine ripper and a stick rake at the front; the other was a 280 horsepower John Deere tractor with a 5-tine ripper and a stick rake behind the ripping blades.

Most of the warrens were located on sand dunes adjacent to permanent water sources, both man-made and natural. Some of the larger, deeper warrens needed cross-ripping but most were able to be ripped one way only due to the effectiveness of the ripping equipment and the softness of the sandy soil.

The total cost of the work, which was jointly funded by government grants and property-owner contributions, was $260 000. This compared favourably with the pre-control cost to the owners of Bulloo Downs in lost cattle production directly attributable to rabbits. This loss had been estimated at up to $600 000 in each year of a two-year scientific study prior to the control.

Pic. 39: Ripping machinery in use on dunes.

What was the outcome?

Ripping the warrens in the rabbits' drought refuge at Bulloo Downs resulted in a 99% reduction (at least) in rabbit numbers. Although rabbits were still active in a couple of spots that had not been ripped, an inspection of the control area in late 2007 showed that rabbits had not returned to those areas that had been ripped. Importantly, the numbers of small native mammals on the property doubled in the three months after control. (These figures were based on data from the scientific study conducted in 2001–02 prior to control.)

The Bulloo Downs work is an example of a large-scale rabbit control operation that required the assistance of many people including ripping contractors, property managers and staff, and government officers. The project was very successful and illustrates that control over a large area can be achieved if the areas that are key to the rabbits' long-term survival are identified and treated. A control operation on this scale needs to be well planned and well resourced.

6.3 Cattle property on the Darling Downs (Queensland)

This 150 hectare cattle property is located 10 kilometres east of Warwick and lies within the region controlled by the Darling Downs Moreton Rabbit Board (DDMRB). The aim of the board is to maintain the rabbit-proof fence that protects areas to the west, and also to coordinate rabbit control works within the DDMRB area. (See section 7.1 for more information on the fence.) Officers from the DDRMB worked with the land managers on this project to try and eradicate rabbits on the property.

In late 2005 the property had come to the attention of the board because rabbits had been sighted in the area. The property had an extensive amount of rabbit harbour made up of three large and active warrens in a contour bank, and 30 large stick-raked piles of timber that were also sheltering rabbits.

When spotlight counts on the property indicated a medium level of rabbit infestation, shooting and trapping were commenced immediately. This short-term control technique had initially reduced numbers but the rabbits bounced back so that, after many months of shooting and trapping, the number of rabbits was about the same as when control had started.

What was done?

After the property changed hands in 2007 the new owners were keen to get rid of the rabbits once and for all. The DDMRB was sounded out for advice on the best approach to the problem and the owners then followed that advice.

With the help of the board, the property owners used a tractor with a bucket on the front to collapse the three warrens. This work took just one hour. The piles of timber that were harbouring rabbits were burnt using nothing more than 20 litres of drip-torch fuel and a box of matches.

What was the outcome?

Spotlighting conducted after the control work revealed no remaining rabbits at all. The removal of rabbits from the property improved its grazing potential and also reduced the risk of environmental damage due to the soil erosion that rabbits cause.

Once the land manager had made the commitment to ridding the property of rabbits, this became an example of a small-scale but very successful control program that involved little cost and very few people. In the end the results speak for themselves—a rabbit control program that focuses on the removal of harbour and breeding areas can achieve impressive and long-term results.

Pic. 40: Destroying warrens on a contour bank.

6.4 Peri-urban rabbit control

Taabinga Cemetery is located just five kilometres south of the town centre of Kingaroy, in the South Burnett region. The cemetery is surrounded by cultivated land, making it an island refuge for any rabbits in the area. The site's rabbit population was an isolated one in a relatively small and confined area.

Rabbits had established 22 warrens in the cemetery. Most of these were in/under cement graves, which were being damaged and made unstable—to the point of collapse in some cases—by rabbits burrowing under the cement structure.

What was done?

In 2002 the site was used to conduct a trial to determine if RHDV applied on carrot would be a suitable delivery technique for wild rabbits. Prior to releasing the virus, spotlight counts were carried out in the area to estimate rabbit numbers, and all warrens were located and mapped.

To give the rabbits time to become accustomed to a new food source, approximately 500 g of carrots were chopped into small pieces and placed in the entrances of the most active warrens—the rabbits were free-fed like this for two nights. On the third night, by which time the rabbits were eating most of the chopped carrot, it was baited with live virus and placed in the same spots as the previous two free-feeds. Any carrot not eaten was picked up the following morning and removed from the study site.

What was the outcome?

The first dead rabbit was found only three days after baiting and after six days there was very little rabbit activity at the site. One week after the virus was released there were no rabbits sighted in spotlight counts and no visible signs of rabbit activity. Follow-up spotlight counts three weeks after the control operation also found no rabbits.

The release of RHDV at the Taabinga cemetery decimated the rabbit population within the site, indicating that all the rabbits at the site were susceptible to the virus. The method of releasing the virus using baited carrots was relatively inexpensive compared to other control techniques and, in the short term, extremely effective in reducing rabbit numbers.

To capitalise on the success of this control operation, local government staff were urged to take measures to ensure that further rabbit damage could not occur to the cemetery landscape. While rabbit numbers were close to zero, it was suggested that warrens should be destroyed to permanently prevent future breeding and reinvasion—rabbits cannot breed without adequate shelter for their offspring.

Unfortunately, no follow-up work was done. An inspection of the site in early 2007 showed that rabbits had reinvaded the existing warrens.

The work at this site showed that biological control can be a very effective option to reduce numbers in susceptible rabbit populations. However, a single control option is usually not enough to permanently rid an area of rabbits and initial results can quickly be reversed—particularly if the warrens or other breeding places are not destroyed.

Section 7: Further information

7.1 The Darling Downs–Moreton Rabbit Board Fence

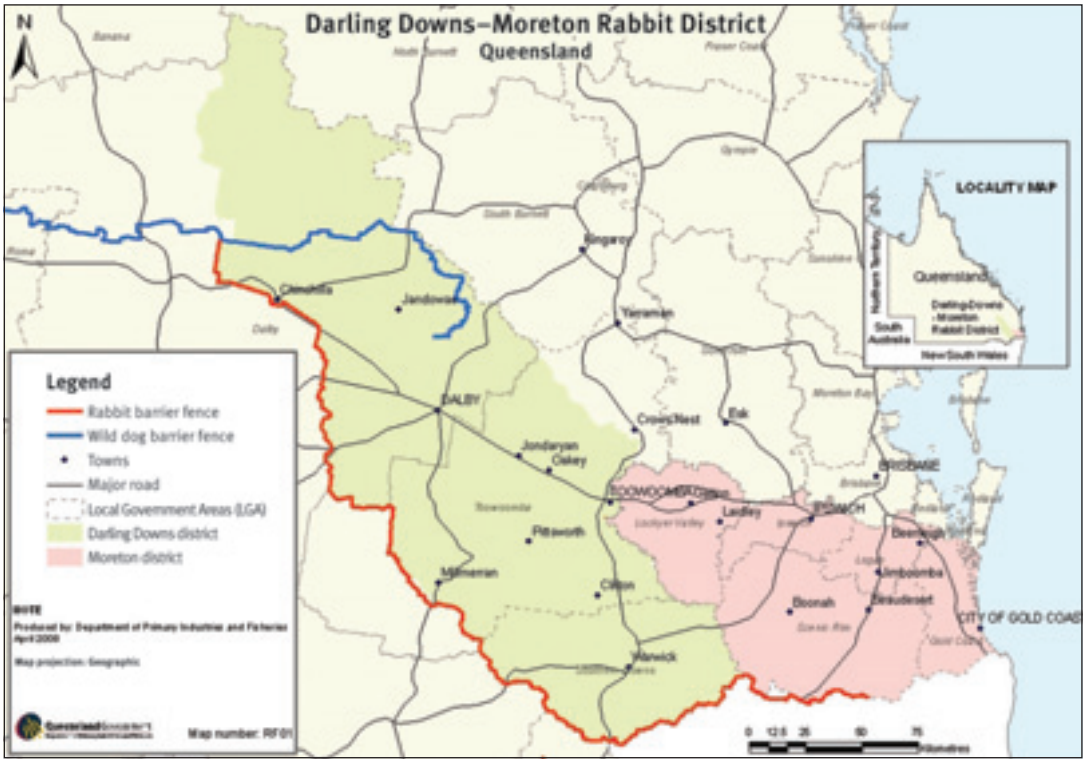
Of the fences that were constructed when rabbits first reached Queensland, the Darling Downs Rabbit Board and Moreton Rabbit Board fences were the only ones that were successful in excluding rabbits.

These fences were combined in 1964 and now form the Darling Downs–Moreton Rabbit Board (DDMRB) fence. The fence is 555 km long, stretching from Lamington National Park (in the Gold Coast hinterland) in the east, to Goombi (approximately 20 km west of Chinchilla) in the south-west.

The fence protects some of Queensland's most productive agricultural areas (a total of 28 000 km^2 in southern Queensland) from rabbit incursions and has successfully prevented rabbit populations being established within its boundaries for more than 100 years. If any rabbits are found inside the fenced area, a coordinated effort is made to ensure they are eradicated.

Each week, the entire length of the fence is checked, maintained and repaired where required. In the 2004–05 financial year, this maintenance cost more than $900 000. While this is a significant yearly cost, the value to land managers is far greater—it has been estimated that these protective measures save land managers (in the 19 shires and cities protected by the fence) approximately $30 million per year. These savings are achieved through better stocking rates, better wool production per head of sheep, a more productive small crops industry, reduced land degradation, and fewer accidents (due to the absence of rabbit burrows).

Rabbits have sometimes found their way through breaches in the fence, have arrived in stock feed or have been deliberately introduced—to date these rabbits have been prevented from properly establishing extensive warren systems in the DDMRB area. The risk is always present, however, and all land managers (whether private, local/state government or the DDMRB) within the area need to act responsibly and remain vigilant so that the fence's effectiveness is maintained.



Map 2: Darling Downs–Moreton rabbit district.

7.2 Troublesome neighbours

Rabbits are a declared pest throughout Queensland and it is the responsibility of all land managers (whether living on the property or not) to remove rabbits from their property.

If neighbours have rabbits on their property and fail to control them, this can also affect your property. In these situations, it is best to discuss the matter with the pest management officer for your local government area.

7.3 Legislation

Rabbits have such a negative impact economically, environmentally and socially in Queensland, that they are a declared pest animal under state legislation. This legislation gives state and local government officers, and Darling Downs–Moreton Rabbit Board officers powers to ensure rabbits are controlled by landowners.

7.3.1 *Land Protection (Pest and Stock Route Management) Act 2002*

The European rabbit (domestic and wild breeds) is a declared Class 2 pest under the *Land Protection (Pest and Stock Route Management) Act 2002*.

Under the Act all land owners are required to maintain ongoing and effective control of rabbits on their property. It is an offence to introduce, keep or release rabbits, or to supply or use rabbits for commercial purposes. Fines of up to $30 000 may apply for breaches of the Act.

All land managers (including owners who manage their own property, people employed to manage a property, and state/local governments that own land) must take reasonable steps to keep their land free of Class 2 pests, unless a declared-pest permit is held.

7.3.2 *Aboriginal Cultural Heritage Act 2003, Torres Strait Islander Cultural Heritage Act 2003*

Under the *Aboriginal Cultural Heritage Act 2003* and the *Torres Strait Islander Cultural Heritage Act 2003,* a person who carries out an activity must take all reasonable and practicable measures to ensure the activity does not harm Aboriginal or Torres Strait Islander cultural heritage (the 'cultural heritage duty of care'). This obligation applies regardless of land tenure. Fines of up to $750 000 for a corporation and $75 000 for an individual may apply if the duty of care under the Act is breached.

Under the Acts, Aboriginal or Torres Strait Islander cultural heritage is defined as:

- a significant Aboriginal or Torres Strait Islander area in Queensland
- a significant Aboriginal or Torres Strait Islander object
- evidence, of archaeological or historical significance, of Aboriginal or Torres Strait Islander occupation of an area of Queensland.

It may be difficult to determine if cultural heritage values are attached to an area. The heritage value of an area may be secret or sacred, incorporated into the landscape, or concealed under the soil surface. Disruption of the soil, as will occur if ripping or warren destruction work is done, runs the risk of damaging our valuable cultural heritage.

To meet your obligation under the Acts, it is vital you act in accordance with the gazetted cultural heritage duty of care guidelines. An assessment of your proposed activity against the duty of care guidelines will help determine whether, or to what extent, Aboriginal or Torres Strait Islander cultural heritage may be harmed by that activity. It will also help establish if you need to undertake a search of the cultural heritage database and register, which is maintained by the Cultural Heritage Coordination Unit (Department of Natural Resources and Water).

Detailed information on cultural heritage, together with a copy of the duty of care guidelines and cultural heritage search forms are available at www.nrw.qld.gov.au/cultural_heritage or by contacting the Cultural Heritage Coordination Unit (phone: 07 3238 3838 or email cultural.heritage@nrw.qld.gov.au).

If your assessment of the duty of care guidelines suggests that cultural heritage may be harmed by your proposed activity, you should contact the Cultural Heritage Coordination Unit for further advice. The unit can assist the land user and endorsed traditional owner to jointly develop a cultural heritage management plan that determines how land use activities can be managed to avoid or minimise harm to cultural heritage values.

7.4 Contacts

Further information regarding rabbits and their control can be obtained from your local government pest management officer, the Darling Downs–Moreton Rabbit Board or your local DPI&F land protection officer.

Organisation	Contact details (phone and website)
Department of Primary Industries and Fisheries (DPI&F)	13 25 23 www.dpi.qld.gov.au
Darling Downs–Moreton Rabbit Board	(07) 4661 4076 www.ddmrb.org.au

Appendix: Calculating the cost of rabbits

The following worked examples provide a guide to calculating the cost of rabbits for your particular enterprise (as outlined in section 3.7). Worksheets are also provided for your own calculations.

Once you have established the annual cost per rabbit for your property, multiply this figure by the number of rabbits your monitoring data indicates are on your property (section 3.5). This will give you a good estimate of the total economic cost of rabbits to your farming enterprise.

Note: In all the worksheets the symbol '/' means 'per'.

Table 13: Example for calculating the damage caused by rabbits on a wool (wethers) enterprise.

Wool class	**Yield (kg/head)**	**$/kg greasy wool price**
21 micron	6.1	4.93
Income/head ($) (yield kg/head × $/kg greasy wool price)	na	30.08
Variable costs/year	na	**$/head**
vaccine, drenches, marking, husbandry	na	3.00
shearing, crutching	na	6.08
selling, freight and marketing costs (including commissions and levies)	na	1.80
supplements	na	2.00
pasture expenses	na	2.15
Total variable costs/head ($)	na	15.03
Gross margin/head ($) (income/head – total variable costs)	na	15.03
Annual cost/rabbit ($) [gross margin ÷ wether rabbit equivalent (See Table 4.)]	na	1.67

Table 14: Example for calculating the damage caused by rabbits on a beef cattle enterprise (store cattle sold at 24 months of age).

Stock class sales	**Weight (kg)**	**$/kg**
store cattle	460	1.90
Total income (price)/head ($)	na	874
Variable costs/year*	**Calculation**	**$/head**
cattle purchase (weighing 250 kg per head @ $2.05/kg)	250 × 2.05	512.50
vaccine, drenches, husbandry	na	9.50
mustering, branding	na	10.00
selling costs (including commission @ 3.5%)	na	52.00
freight	na	10.00
supplements, forage	na	14.00
pasture maintenance		30.00
Total variable costs/head ($)	na	638.00
Total number years to grow stock out		**1**
Total costs/head ($) (total variable costs × number years)	na	638.00
Total income/head ($) (price – total costs)	na	236.00
Annual cost/rabbit ($) [total income ÷ steer rabbit equivalent (See Table 4.)]		2.41

*Does not take into account interest payments, drought feed costs and costs of other variables.

*Table 15: Example for calculating the damage caused by rabbits on a lettuce crop enterprise.**

yield (cartons/ha)	2800
price ($/carton)	8.00
Total income ($/ha)	22 400.00
Variable costs/year	**$/ha**
establishment and planting	2 120.00
fertiliser	400.00
weed control	50.00
insecticide and disease control	615.00
irrigation	180.00
harvest and packing	9 150.00
freight and selling costs	1 280.00
Total variable costs ($)	13 795.00
Gross margin/ha ($) (total income – total variable costs)	8 605.00
Gross margin/carton ($) (gross margin/yield)	3.07
Weight of carton	20 kg
Number of days crop in ground	70 days
Amount of crop one rabbit could eat in one year (number of days crop in ground × 0.2 kg)	14 kg
Equivalent cost/rabbit/hectare ($) (amount of crop a rabbit could eat in a year ÷ weight of carton × gross margin/carton)	2.15

*These are minimum figures based on rabbits eating already established crops. They do not take into consideration the costs of damage caused by rabbits making the product unsaleable, or the costs of rabbits digging up seedlings (so that crops need to be re-sown).

Worksheets—to calculate the cost of rabbit damage on your property

Table 16: Worksheet for calculating the damage caused by rabbits on a wool (wethers) enterprise.

Wool class	**Yield (kg/head)**	**$/kg greasy wool price**
(??) micron	(??)	
Income/head ($) (yield kg/head × $/kg greasy wool price)	na	
Variable costs/year	na	**$/head**
vaccine, drenches, marking, husbandry	na	
shearing, crutching	na	
selling, freight and marketing costs (including commissions and levies)	na	
supplements	na	
pasture expenses	na	
Total variable costs/head ($)	na	
Gross margin/head ($) (total income – total variable costs)	na	
Annual cost/rabbit ($) [gross margin ÷ wether rabbit equivalent (See Table 4.)]	na	

Table 17: Worksheet for calculating the damage caused by rabbits on a beef cattle enterprise (store cattle sold at 24 months of age).

Stock class sales	**Weight (kg)**	**$/kg**
store cattle	460	1.90
Total income (price)/head ($)	na	874
Variable costs/year*	**Calculation**	**$/head**
cattle purchase (weighing ? kg per head @ $?/kg)		
vaccine, drenches, husbandry	na	
mustering, branding	na	
selling costs (including commission @ 3.5%)	na	
freight	na	
supplements, forage	na	
pasture maintenance	na	
Total variable costs/head ($)	na	
Total number years to grow stock out		
Total costs/head ($) (total variable costs × number years)	na	
Total income/head ($) (price - total costs)	na	
Annual cost/rabbit/head ($) [total income ÷ steer rabbit equivalent (See Table 4.)]		

*Does not take into account interest payments, drought feed costs and costs of other variables.

*Table 18: Worksheet for calculating the damage caused by rabbits on a crop enterprise.**

Crop: (???????)	
yield (cartons/ha)	
price ($/carton)	
Total income ($/ha)	
Variable costs/year	**$/ha**
establishment and planting	
fertiliser	
weed control	
insecticide and disease control	
irrigation	
harvest and packing	
freight and selling costs	
Total variable costs ($)	
Gross margin/ha ($) (total income – total variable costs)	
Gross margin/carton ($) (gross margin/yield)	
Weight of carton	? kg
Number of days crop in ground	? days
Amount of crop one rabbit could eat in one year (number of days crop in ground × 0.2 kg)	? kg
Equivalent cost/rabbit/hectare ($) (amount of crop a rabbit could eat in a year ÷ weight of carton × gross margin/carton)	

*This worksheet will enable the calculation of costs for rabbits eating already established crops. It does not take into consideration the costs of damage caused by rabbits making the product unsaleable, or the costs of rabbits digging up seedlings (so that crops need to be re-sown).

Glossary

buck: a male rabbit

doe: a female rabbit

green pick: short green grass that rabbits seek out as a preferred feed; high in protein, which helps stimulate the female breeding cycle

harbour: an area of shelter that rabbits use during the day to hide from predators and also use sometimes to breed

kitten: an immature rabbit

RCV: rabbit calicivirus disease (now known as rabbit haemorrhagic disease virus—see 'RHDV')

RHDV: rabbit haemorrhagic disease virus—a virus released in Australia by CSIRO in 1995

scrape (or squat): a shallow scratched-out depression in the ground, usually under vegetation, rocks, logs, or man-made equipment; rabbits may use several in an area, running from one to another to find cover from predators

source area: a place where rabbits breed and survive during tough times before dispersing to repopulate surrounding areas

squat: (see 'scrape')

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