

Biology, ecology and management of vertebrate pests in NSW



RABBIT

FERAL PIG

WILD DOG

FOX

MOUSE

FERAL GOAT

PEST BIRDS

MONITORING TECHNIQUES

Title: *Biology, ecology and management of vertebrate pests in NSW*

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Foreword

This manual was written primarily for individuals including government officers involved in the control of vertebrate pests in New South Wales (NSW). It should be used in association with the Vertebrate Pest Control Manual which is essential reading for staff of Livestock Health and Pest Authorities (LHPA), National Parks and Wildlife Service (NPWS) and all agencies involved in pest control. It is intended to promote uniform standards for vertebrate pest control throughout the State.

Acronyms, definitions and abbreviations

1080	Sodium fluoroacetate
ACO	Authorised Control Officer
APVMA	Australian Pesticide and Veterinary Medicines Authority
AQF	Australian Qualifications Framework
DSE	Dry sheep equivalent
EPA	Environment protection Authority
FAAST	Feral animal aerial shooting team
KTP	Key Threatening Process
LPHA	Livestock Health and Pest Authority
LPI	Land & Property Information
NPWS	National Parks and Wildlife Service, part of Office of Environment and Heritage
NSW DPI	NSW Department of Primary Industries
OEH	Office of Environment and Heritage
PCO	Pesticide Control Order
PPE	Personal Protective Equipment
RHDV	Rabbit haemorrhagic disease virus
SDS	Safety Data Sheet

Authorised Control Officer is a person who is a member of an LHPA, a Wild Dog Destruction Board, NSW DPI, OEH or other NSW public authority and has completed all training requirements as specified in the relevant Pesticide Control Orders.

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Rabbit biology & control

RABBIT BIOLOGY

Origin

The European wild rabbit, *Oryctolagus cuniculus*, is native to north-western Africa, Spain and Portugal and it is now found in the USA, Chile and most of western Europe as far north as Scandinavia. The rabbit is considered a pest in many of the countries it was introduced to, but the release into Australia and New Zealand caused the greatest problems.

Domesticated meat rabbits arrived in Australia with the First Fleet and rabbits were released onto many islands in the Bass Strait and the Tasman Sea to provide sustenance for shipwrecked sailors. The first genetically wild rabbits were imported into Victoria in 1859. This small population of 24 individuals grew to over 20,000 within 6 years.

Rabbits quickly spread across Victoria and the rest of the continent. By 1880 rabbits had reached and crossed the Murray River and by 1886 had reached the Queensland border. Rabbits had also crossed South Australia and into Western Australia, arriving at Geraldton in 1907; a journey of 1,760 kilometres in just 16 years. This rate of spread suggests that humans contributed to their distribution with swaggies known to carry rabbits around. Trappers and shooters were probably also responsible for the rapid spread.

Rabbits presently inhabit approximately 5.3 million square kilometres or 70% of southern Australia. They have established in environments ranging from subalpine areas to stony deserts, from subtropical grasslands to wet coastal plains, and particularly prefer Mediterranean type climates where soils for warren construction are suitable; these areas are generally associated with livestock production and support much of Australia's rural production.

Distribution in New South Wales

The rabbit is found throughout most of NSW with the general exception of the black soil areas, Figure1. Although there is no accurate figure on the present distribution, past surveys indicate that at least three-quarters of the State has some degree of rabbit infestation. Approximately 8% would have a high and detrimental population of rabbits.



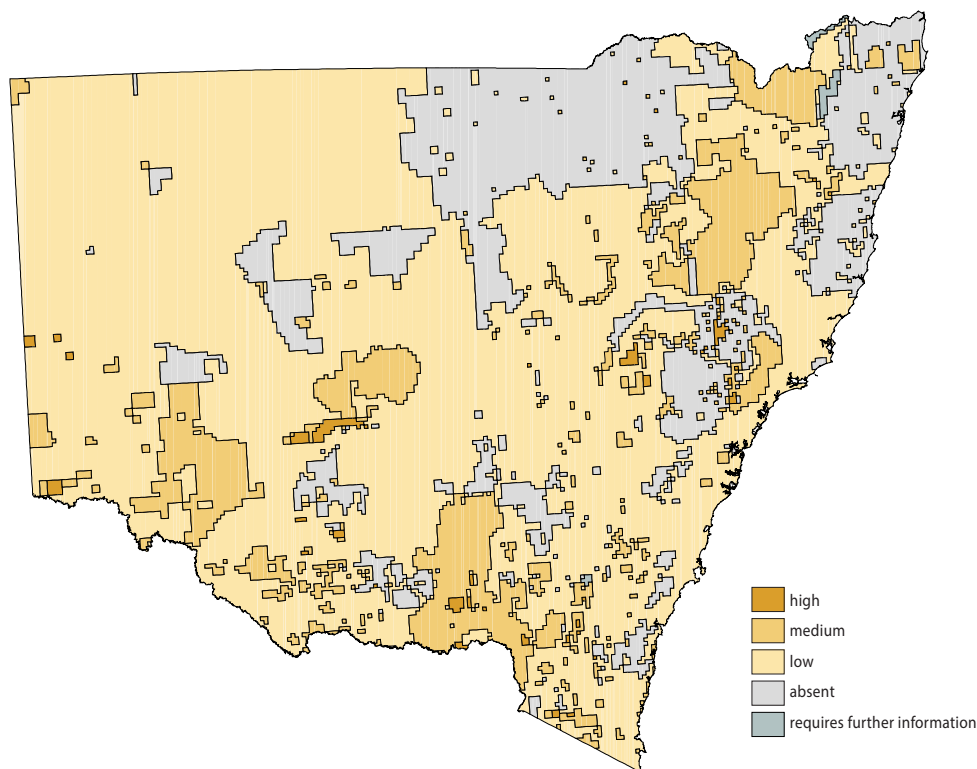


Figure 1. Rabbit distribution and density map.

Recognition and sign

The only animal in Australia that could be confused with the rabbit is the hare. However, the hare (*Lepus capensis*) has longer, black-tipped ears, longer legs and a loping gait. Rabbits and hares are generally easier to observe during daylight than other introduced pest animals because they frequent open ground and are at least partly diurnal. They can be distinguished from all other mammals by their long ears, long hind legs and short fluffy tails. Their footprints are also distinctive. Rabbits and hares are most active at dawn and dusk and feed by grazing and browsing.

Rabbit droppings are often similar to hares', depending on the food eaten, but they are distinguished from lamb faeces by the absence of flat facets on the surface. Scrapes, dung heaps, burrows and warrens are evident when rabbits are present.

Habitat

Rabbits prefer short grass areas either found naturally as in semi-arid areas or resulting from heavily grazed pastures, with harbour, warrens, blackberries or fallen logs nearby. These animals can adapt to a wide variety of habitats, though in general they avoid large cultivated areas, forests, floodplains and black soil country. Human habitation does not deter rabbits and they may become a problem around home gardens, shearing sheds and other farm buildings.

Behaviour

Rabbits are most active from late afternoon until early morning, but they can be active at any time if they are undisturbed or if their numbers are high. Activity appears to decrease at night if there are high winds or rain, which limits their ability to detect predators.



Communication is mainly by smell, but alarm signals are given by flashing the tail while running and by thumping with the hind feet.

Daily movements are generally within 150 to 200 m of the warren, but this distance can increase during droughts (up to 1,500 m has been observed) or decrease during the breeding season.

The dominant buck has freedom of movement within the home range and so has access to the greatest number of females. Territorial boundaries are well defined and are marked mainly by the dominant buck with urine, faeces and scent exuded from a chin gland. These boundaries are strictly maintained and defended by all the members of the group. At the end of the breeding season these boundaries may break down, allowing for the dispersal and spread of the young rabbits but the group tends to stay together.

Social structure and breeding

The warren complex forms the basis for a distinct social structure with a well-defined hierarchy closely aligned with the breeding season. Once breeding ceases the structure weakens.

The main breeding season is determined primarily by rainfall and the early growth of high protein plants and so varies throughout the State. In the south, it usually starts after the autumn break and finishes in late spring, whereas in other parts of the State breeding results from the increase in vegetation during spring. Rabbits can breed at any time provided there is short green feed supplying sufficient protein.

Harsh conditions occurring during the breeding season may induce anoestrus and cause the doe to cease lactating and/or resorb any foetuses. This mechanism allows the breeding nucleus to be preserved at the expense of the more vulnerable young.

With the onset of breeding, social groups of 7 to 10 rabbits form, governed by a dominant buck and a dominant doe. There is a high level of aggression, strong territorial behaviour and the evolution of social hierarchies. A few breeding groups together form a social entity and occupy a common grazing and sheltering ground.

Both males and females reach sexual maturity between 3 and 4 months of age. Does are induced ovulators, a phenomenon that results in synchronisation of oestrus. With a large number of receptive females, subordinate bucks are able to mate while the dominant buck is mating with other does.



Figure 2. Kitten rabbits at 1 day old (L), kitten rabbit at 20 days (R). (Photo David Croft)



The gestation period for rabbits is 28 to 30 days. There is no post-partum anoestrus and the doe generally mates again within an hour of giving birth. Under favourable conditions an adult female can produce 7 or 8 litters in a year. Although the litter size varies according to the doe's age and social status, seasonal conditions and nutrition, the average number is 4 or 5 kittens in the first litter, rising to about 8 by the end of the season. Consequently, one doe may produce between 50 and 60 offspring, however, 30 is about average in a single breeding season. When the females from this doe's first litters reach sexual maturity they too will reproduce. So in one breeding season one adult doe may be responsible for the production of in excess of 100 rabbits.

CSIRO researchers found that although dominant females made up only 24% of the population, they produced 51% of the kittens. The second-ranking does made up 43% and produced 42% of the kittens, while the third- and fourth-ranking subordinates 33% produced only 7%.

The young are usually born in nests of grass and belly fur, which may be in part of the warren complex or, if from a subordinate female, in a breeding stop. The breeding stop is a short single-entrance burrow less than a metre long and about 30 cm below ground. After the birth and first feeding, the doe leaves the stop. She will visit the stop four or five times each 24 hour period to feed the young, concealing the entrance at each departure.

The kittens are born blind and eyes open after 7 to 10 days and they emerge from the warren at about 18 days. They are usually weaned at this stage, leaving the nest when 23 to 25 days old. If the doe dies or abandons her young, they can survive from 16 to 18 days of age.

Dispersal

Very young rabbits 20 to 60 days old are more likely to disperse than older rabbits. Adult rabbits rarely disperse. Most dispersal is from warrens with a high rabbit density to warrens with a low density or to adjacent social groups.

Rabbits usually do not travel vast distances, but movements in excess of 20 km have occasionally been recorded.

Newly emerged kittens may move up to 1.5 km to a new warren complex. The general rule of thumb is that movement and reinvasion of control areas can and will occur, yet mass movements over long distances occur mostly when food is limiting. It is usually difficult to distinguish between recolonisation and reproduction in situ after a control program, so it is better to conduct a control program that includes a buffer area against migration.

Diet

Rabbits are herbivorous, and eat a wide variety of plants, including crops, roots, pastures, young trees and young vines and prefer short, succulent plants.



*Figure 3. Rabbits in the corner of a fence.
(Photo David Croft)*



With an average body weight of 1.6 kg, a rabbit can consume up to one-third of its own weight daily, although the average daily intake is around 100 to 150 g. The maintenance requirements for a rabbit and a 45 kg sheep are 284 MJ (megajoules) and 2438 MJ respectively. This equates to a ratio of approximately nine rabbits to one dry sheep equivalent (DSE).

The skulls of lagomorphs (rabbits and hares) are easily recognised by their very obvious chisel-shaped incisors (as in rodents) with a small second pair of upper incisors close behind the first. The lower incisors fit between these upper pairs, keeping them well ground and sharp. While rabbits can graze plants to ground level, they have a small mouth and prefer soft, short and succulent plants rather than woody or stalky taller species. Grazing generally continues throughout the night for 2.5 to 6 hours. Where the warren complex supports a large population of rabbits, feeding grounds or 'rabbit lawns' develop a short distance from the warren.

Coprophagy

Food is well masticated, entering the stomach as fine particles. As part of their digestive process they form both soft and hard faecal pellets. The soft pellets, which have a high bacterial content, are produced mainly during the daylight hours when the rabbits are not grazing. These soft pellets are eaten directly from the anus during the day and reingested. This process, called coprophagy, is used to extract the remaining protein and moisture from food and allows a more complete digestion of the fibrous plant material. It also enables rabbits to survive with minimum free water.

The hard pellets seen on the ground and at dung heaps are the end result of the digestion process and are usually dropped during the normal grazing period from late afternoon and throughout the night.

Mortality

Apart from human intervention for control or sport, natural adult rabbit mortality does not generally suppress a rabbit population. Kitten mortality in the wild is extremely high, with up to 80% dying before they reach 3 months of age. However in a favourable year with a temperate Mediterranean climate 85% mortality is needed to suppress a 10-fold population increase.

Disease: There are currently only two diseases that are known to impact heavily on rabbit populations. Myxomatosis is a poxvirus which in its natural host, the South American jungle rabbit (*Sylvilagus brasiliensis*), causes non-fatal, localised fibromas. However, in the European wild rabbit it forms a pustule that affects the lymphoid tissue leading to profound suppression of the immune system and generalised systemic disease. Lesions develop around the infection site, usually the head, followed by severe conjunctivitis. The rabbit, because of a suppressed immune system, is unable to fight off subsequent secondary bacterial infections which result in death. Death can occur within 8 to 12 days in acute cases or 3 to 5 days after clinical signs develop.

Rabbit haemorrhagic disease virus (RHDV) (a calicivirus) was first reported in China in 1984 where it killed 140 million domestic rabbits in less than 12 months. RHDV generally only infects adult rabbits. Rabbits with RHDV usually develop signs of fever within 36 hours of infection and are often dead within 6–12 hours after the onset of fever. Rabbits with RHDV often become lethargic and can die suddenly. Occasionally rabbits may squeal, become excited or exhibit paddling behaviour. Outwardly, animals that have died from RHDV appear healthy. On occasions a bloody discharge from the nose may be present.



Both of these diseases have been introduced into Australia as biological control agents to suppress rabbit numbers across the landscape. When each virus was first released (myxomatosis in 1950 and RHDV in 1995) they reduced rabbit populations by up to 98% in some areas. Both diseases are transmitted by vectors and as such, flies, mosquitoes and fleas are important in disease spread. Neither disease is lethal to any other species nor has RHDV ever been identified in any other species of animal, including other species of rabbit or hare.

Myxomatosis currently kills about 50% of the rabbits it infects and is still an effective biological control agent in some areas of the country. RHDV is still effective across much of Australia, particularly in the arid and semi-arid regions with an average mortality of 75%.

Coccidiosis may also impact rabbits. Coccidiosis is a common worldwide protozoal disease of rabbits that occurs in two forms – hepatic and intestinal. Hepatic coccidiosis is caused by, *Eimeria stiedai* with intestinal coccidiosis caused by a number of other species of *Eimeria*. Young rabbits are most susceptible to hepatic coccidiosis with severe infections resulting in death. Intestinal coccidiosis is rarely fatal.

Predation: Predation can account for substantial losses of both healthy and starving rabbits. Besides the fox, dingo, cat and dog there are a number of avian species that prey on the rabbit in Australia. The wedge-tailed eagle is probably the most effective, followed by goshawks, falcons and barn owls. Ravens, goannas and snakes may also prey on kittens.

When rabbit numbers are low, predation can reduce the annual crop of young by approximately 25%. In denser populations this proportion decreases to about 10%, with predation playing little part in population control.

Starvation: The only factor that seems to operate in a density-reducing manner is starvation. The lack of food stops reproduction and can result in the deaths of nestlings; then the adults eventually die. Drought causes dispersal, which leads to exposure and vulnerability to prey. This is the time when control programs are the most effective.

IMPACTS

The annual cost of rabbits to agriculture in Australia exceeds \$200 million making it the most costly vertebrate pest animal. Rabbits impact 75 commonwealth listed threatened plant species and five threatened ecological communities.

Australian native vegetation is very sensitive to rabbit damage. With densities as low as 0.5 rabbits per ha all seedlings of the more palatable native trees and shrubs, including threatened or endangered plant species, can be removed preventing regeneration. Forestry and tree plantations may also suffer extensive losses due to grazing rabbits.

Erosion caused by denuded vegetation from rabbit grazing has a major impact on dam catchments, water supplies and maintaining topsoil. The burrowing behaviour of rabbits may undermine roads, culverts, buildings and sites of cultural significance.

Rabbits directly compete in agricultural enterprises with livestock for pasture. This may result in running fewer livestock, lower wool clips and breaks in the wool, lower reproduction rates, lower weight gains and possibly earlier deaths during drought. The colonisation of rabbits across much of Australia has undoubtedly facilitated the spread of other introduced animals such as the fox and reduced lambing rates may occur due to higher fox numbers being maintained by a high rabbit population.



Rabbits have been strongly implicated in the extinction of native species such as the burrowing bettong. While there have been few known native mammal extinctions north of the range of the rabbit since European settlement. Many species disappeared from records after the rabbit arrived in 1859 and before the successful introduction of the fox in 1871.

Rabbits can also significantly affect native fauna through their aggressive and territorial behaviour. Rabbits have been observed attacking yellow-footed rock wallabies and in one observed case injured a burrowing bettong so badly it died from its wounds. Large animals such as the red kangaroo may be vulnerable to competition when both species rely on refuge areas of some green pasture during drought. Both The Eyrean grasswren and the plains-wanderer are impacted due to the destruction of habitat by rabbits.

Competition and grazing by rabbits is listed as a Key Threatening Process under the *Threatened Special Conservation Act 1995* (KTP) see www.environment.nsw.gov.au/threatenedspecies

INTEGRATED RABBIT MANAGEMENT

In order to ensure rabbit numbers remain low, it is important to apply a number of techniques to control rabbits. The integration of conventional control techniques such as warren ripping and shooting, in conjunction with the arrival of myxomatosis or RHDV, will maximise effort and suppress rabbit numbers over a longer period.

The primary goal in rabbit control is to minimise the economic and environmental damage caused by rabbits by reducing the population to a level where it cannot quickly build up. This requires a number of steps. Too often the control program is halted after the first step and rabbit numbers rapidly build up again. The success of a rabbit control program is not the number of rabbits killed, but the number of breeding females that remain after to re-establish the population.



Figure 4. Rabbits western NSW. (Photo Mark Fosdick)



The steps to follow for effective control are explained below.

Step 1 – Initial reduction

If rabbit densities are medium to high, the first step is to reduce the population to a manageable level. This initial control can be achieved by a poisoning program, or by capitalising on the arrival of myxomatosis or RHDV. If the rabbit density is low, go straight to Step 2.

Step 2 – Extensive control

This phase is the most important part of the control program because it is where an effective reduction of rabbits and harbour should be achieved. The initial control brings the population down to a manageable level, while extensive control further reduces the population to a level where it cannot recover quickly. On a property where rabbit numbers are low, the control program can often start with the extensive control phase. Extensive control consists of harbour destruction, usually by ripping warrens, using explosives, fumigating, burning fallen logs and eliminating blackberries and other weeds.

Step 3 – Advanced control

Advanced control is optional and dependent on economics, but it should be the future goal of land managers. At the completion of the extensive control phase, there are usually small numbers of rabbits surviving. Assuming no immigration, further control at this point pays the biggest dividends by making it impossible for the population to build up. Techniques used here are spotlight shooting and trapping around active areas. Regular and effective monitoring of the rabbit population is an important part of this phase.

If these steps are followed correctly, and the last two steps repeated as part of the overall property management program, then it should be unnecessary to repeat the initial reduction step, except possibly in drought years. This should be the goal of all land managers.



Figure 5. Preparing rabbit warrens for ripping by removing excess timber. (Photo David Croft)



MONITORING OF RABBIT POPULATIONS AND THE EFFECTIVENESS OF CONTROL

When managing livestock or pests in crops, weeds and insects, land managers continually assess the problem and determine the most cost-effective management option. Therefore, it is important for successful rabbit control that the population abundance and distribution of rabbits is determined.

Property maps – Creating a property map of where rabbits occur is the first step in determining the abundance and distribution of rabbits on a property. This map may be refined to warren locations, feeding grounds and harbour sites. Information of abundance and the potential for rabbit habitation can also be recorded using the codes in Tables 1 and 2 (see below). Probable trail lines, priority numbering and timing, as well as possible control techniques, should also be suggested. These maps may be used as part of the overall property management plan and to assess progress over the years.

Table 1: Codes for rabbit abundance and how to determine the level of rabbit abundance

CODE	DENSITY	DEFINITION
0	nil	No rabbit sightings or sign.
1	low	Few or no sightings and/or little active sign.
2	medium	Some rabbits seen at any time and/or much active sign.
3	high	Rabbits seen at any time much sign of activity – active warrens, dung hills, scratchings.

Potential is indicated by the factors that contribute to the quick build-up of rabbits. Such as the presence of warrens, logs, blackberries, boxthorn and pressure from nearby heavily infested areas.

Table 2: The potential for rabbit habitation

CODE	DEFINITION
A	No factors present.
B	Little harbour, single holes, easily destroyed.
C	Significant harbour, warrens, burrows, logs, bushes, etc., which with concentrated effort could be eliminated.
D	Intractable harbour, ie. areas where it is impossible to eliminate all harbour, e.g. rocky hills, steep gullies, etc.

* This system was developed by Eric Dekkers, former Ranger of Tamworth RLPB.

Spotlight counts – A spotlight count is a way of estimating rabbit abundance. A simple spotlight count consists of a drive through an area known to harbour rabbits to get an estimate of the population and location of the feeding grounds. Counting and recording the rabbits over 100–200 m at 500 m intervals and locating where they feed makes it easier to determine bait placement and bait application rates and provides for more cost effective control. Complex spotlight counts are usually conducted along a 10 km route usually 30 minutes after sunset over three consecutive nights, travelling at a speed of 10 to 15 km per hour. Where possible the count should include rabbits seen 50 m either side of the vehicle or within 100 m if only spotlighting one side from within the vehicle. The average count over the three nights divided by the length (km) of the path will give the number of rabbits per km. Spotlight counts can be used before and after control programs to measure effectiveness.

Other types of monitoring –The simplest form of monitoring is a visual observation of sightings and scratchings, however other forms of monitoring such as dung counts, vegetation damage scores and active warren entrances as an example may also be used. For details of spotlight counting and other monitoring techniques, see *Monitoring techniques* section in this Manual.



INITIAL REDUCTION

Poisoning

Poisons can be an effective way of reducing rabbits as a first step. Two main poisons are utilised in NSW, compound Sodium fluoroacetate (1080) and pindone. In NSW rabbit poisoning is regulated by the *Pesticides Act 1999* and is carried out under the conditions set out in Pesticide Control Order (1080 Liquid Concentrate and Bait products) Order 2012 (1080 PCO) and for pindone in accordance with the label or where specified under the Pesticide Control Order (Pindone products) Order 2012 (Pindone PCO). Copies of the PCOs can be obtained on line at www.environment.nsw.gov.au/pesticides/pco/htm or your local LHPA. The use of the poisons currently requires a minimum chemical use accreditation at Australian Qualification Framework level 3 (AQF3).

Essential points

- The time to poison rabbits is when they are not breeding. During breeding, rabbit movements are much more limited by territory boundaries and consequently the rabbits are less likely to find the bait unless much more trail is laid. Moreover, kittens over 18 days old may survive, even if the female is poisoned, and subsequent breeding by these survivors may cause rapid rebound of the population numbers.
- Poisoning should be carried out in paddocks that have been heavily grazed. This helps rabbits to find trail and eat the bait. It also allows the land manager to graze those paddocks to fully utilise the pasture before poisoning. Paddocks where bait has been laid must not be grazed until bait has been covered or weathered sufficiently for 1080 to be leached out.
- The objective is to decrease the population and consequent rabbit damage and prevent rapid population build-up. If only a small part of an infested area is successfully poisoned, even a total kill will be ineffective because the population will rapidly re-establish due to immigration from surrounding areas.
- A kill of close to 100% over a large area must be obtained for a successful poisoning operation. Keep in mind that it is not the number of rabbits killed but the number left alive that is important. Percentage reductions mean little if rabbit numbers are large. A 5% residual from an original population of 5000 is 250 rabbits, whereas 5% of an original population of 500 is only 25 rabbits and the latter is much easier to manage in follow up control treatment.
- Land managers must adhere to all the requirements of the PCOs and inform all adjoining neighbours at least 3 days before laying poison baits.
- Rabbit poisoning is only the first step in the control program. Poisoning should be followed rapidly by harbour destruction, including warren ripping, log burning and weed removal e.g. blackberries; and by continual fumigating, shooting and dogging the survivors of the initial poisoning.

Rabbit baits for poisoning – carrots, pellets and oats

Carrots are effective rabbit bait, being used extensively throughout more than two-thirds of NSW and combining high acceptability with reasonable economy. Carrot baits are cut in a carrot cutter before the poisoning operation. This cutter should have a swift, clean action that avoids cutting too many small chaffy pieces or large chunks. Carrot pieces should be roughly 2 cm cubes and about 5 g in weight.



While carrots are generally recommended, oat grain has certain advantages in dry seasons because it is readily available, suitable for storage, and easier to handle and it does not deteriorate or require processing. Pellets, when available, have similar advantages to oat grain. However, caution is required when using oats or pellets, particularly during dry times when livestock may be being hand fed with similar products. After poison is added the bait is bagged and transported to the control site. Baited carrots should be kept cool prior to use and used as soon as possible to avoid bait sweating, which may degrade the carrots and poison.



Figure 6. Serious rabbit problem – note bait trail. (Photo David Croft)

Free feeding

A minimum of three free feeds is required prior to laying poison bait except where an Authorised Control Officer (ACO) recommends otherwise. Free feeding provides a more accurate determination of the amount of poisoned bait required to give maximum knock-down yet leave minimum bait for non-target species. Rabbits vary in their readiness to accept strange food so free feeding over a number of days allows rabbits to become accustomed to the food. Some dominant rabbits may monopolise the trail and keep the shy feeders away. Consequently, the longer free feeding bait is available the more chance there is of controlling the maximum number of rabbits. Failure to administer the required number of free feeds is poor practice and a breach of the current PCOs and penalties apply.

For different infestation levels, a general rule of thumb is to start the first free feed with the quantities shown in Table 3. The amount of bait in the second free feed should be increased if most of the first free feed was taken during the first night or decreased if bait remained after the second night. If the rate of acceptance is variable during the first and second free feeding, then it is essential to put out a third free feed.



Table 3: Suggested quantities of bait for first free feeding of rabbits.

LEVEL OF INFESTATION	TRAILING		HAND BROADCASTING	AERIAL & MECHANICAL GROUND BROADCASTING
	CARROTS & OATS (KG/KM)	PELLETS (KG/KM)	CARROTS (KG/HA)	CARROTS (KG/HA)
light	4–8	1–2	4–8	n/a
medium	6–10	2–3	8–10	4
heavy	15–30	> 3	10–15	6

Poisoned bait is laid after the free feed period at two-thirds to three-quarters of the optimum free feed rate. Poisoned baits are applied at the following intervals after the last free feed:

- Trailing (carrots and oats) – minimum of 2 days
- Trailing (pellets) – minimum of 4 days
- Broadcasting (carrots) – 3 to 5 days.

Placement of baits – trailing

Trailing is cutting a continuous furrow with a disc or bait layer. This furrow should be cut cleanly, about 10 cm wide and 2 cm deep. A cut furrow provides a visible guide to the location of the trail and to the bait. Also, the freshly turned soil is intended to attract rabbits.

Prior to trailing, warrens, any other surface harbour and the feeding grounds should be located, Figure 7.

Feeding grounds and areas around and between warrens should be trailed. Feeding grounds can often be identified during a spot light count or by open areas where the grass is short and lawn-like and where scratching is common. Rabbits do not feed on the warren. Trails may circle a warren however a gap of 3 to 5 m should be kept between the trail and the warren. If rabbits are in small isolated areas they too should be trailed. A general rule of thumb is to use up to 16 km of trail per 100 ha, with trails about 40 m apart.

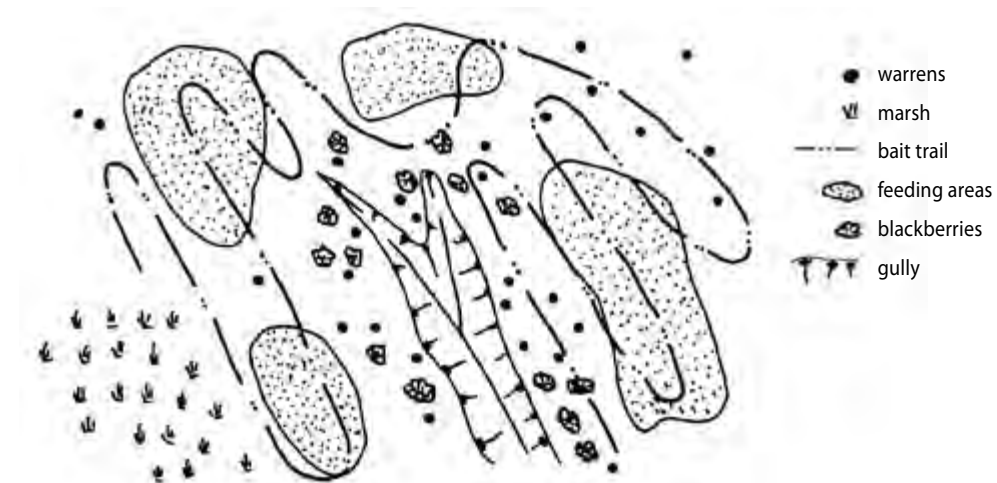


Figure 7. Ideal placement of a bait trail around warrens but through feeding areas.



Placement of baits – broadcasting

Broadcasting is where bait is spread over the area to be poisoned by hand, by rotary super spreader or by aircraft. This method is mainly used in areas where it is impractical or impossible to run a trail because of the presence of terrain, large rocks, fallen timber or crops; or because trailing may lead to erosion. Free feeding with 3 free feeds at least 2 days apart should be used.

Broadcasting bait by hand

Hand broadcasting from horseback, motor bike or on foot is an effective means of dealing with rabbits in areas inaccessible to the trailing. Baits are simply broadcast by hand close to warrens and on feeding or play grounds. Rabbits will not feed on or in the burrow, so all bait should be placed at least three metres away from the burrow mouth. Hand broadcasting may be used in conjunction with a trailing program or as a separate spot poisoning program. If carried out along the same lines as that for trail baiting, excellent results can be obtained.

Aerial baiting

Aerial baiting requires approval by NSW Department of Primary Industries (NSW DPI) and needs to be coordinated in conjunction with the local Livestock Health and Pest Authority (LHPA). A land manager should discuss the intended program with the local LHPA several months in advance and the authorising officer must ensure that all the conditions in the current 1080 PCO can be met.

Aerial baiting programs are an effective means of dealing with a rabbit problem in steep, rocky and hilly areas where ground baiting techniques cannot be employed.

- The program needs to be undertaken at a time when rabbits are stressed for food, usually about mid to late summer so they will readily seek out the bait
- The area to be baited should be heavily grazed before the program. However the area cannot be restocked until sufficient rain has fallen to render baits safe because it is not possible to collect or cover baits. This may take some time.

Application for approval must be made by the LHPA. Approval will be based on:

- the extent of the rabbit problem requiring aerial baiting
- why the problem cannot be dealt with by the conventional means of ground baiting and harbour destruction
- written permission from all government authorities and private land managers whose land will be treated under the proposed program. National Parks and Nature Reserves require a separate application
- an appropriate map of the area to be treated including bait flight lines and bait lines must be digitised and provided to the aerial contractor prior to aerial baiting
- the name of the ACO and manager who will have the overall supervision and responsibility for the program.

Applications must be submitted from the LHPA to the NSW DPI officer, at least two months before the proposed date of baiting.



Poisoning – important points

In addition to the information required in the application, the baiting program itself must adhere to the following conditions:

- All the requirements specified in the current 1080 PCO must be met
- GPS coordinates must indicate to the aircraft where the bait is to be laid.

Some important factors to remember about toxicity and use of pindone are:

- As an anticoagulant it will take a number of days to kill. Poisoning programs should not be assessed until 10 to 14 days after the first poisoned feeding up to 21 days in some instances
- Increased application rates have little influence on shortening the time until death if the bait is constantly available
- Excessively large doses have little influence on shortening the time until death if the bait is constantly available
- Most anticoagulant concentrates have been formulated to be more acceptable to the target species, therefore increasing above the recommended rate may significantly diminish bait acceptance.



Figure 8. Preparing for a major rabbit poisoning campaign. (Photo Reg Eade)

Post-poisoning procedure

Any poisoned bait remaining after poisoning is a danger to livestock unless it is thoroughly covered or broken down. The use of an agricultural implement, such as a scarifier, to cover the bait will reduce the possibility of excessive baits remaining accessible to non-target species. While it is generally agreed 100 mm of steady rainfall for carrots and 50 mm of steady rainfall for oats and pellets may breakdown 1080 this is only a guide and is not guaranteed. **The longer the period before restocking, the less likely is the hazard, especially if a good growth of pasture results from the rain.**



Myxomatosis or RHDV

An effective epidemic of either myxomatosis or RHDV should be followed up with extensive control efforts. Regular monitoring of the rabbit population for signs of myxomatosis (rabbits with obvious skin lesions and pustules) or RHDV (dead rabbits that appear outwardly healthy and show no obvious cause of death) should be undertaken to maximise opportunistic control efforts.

RHDV is available through the LHPA on baited carrot. Baiting should not be undertaken during the breeding season as rabbits younger than 12 weeks are more likely to become immune adults. A free feed of carrots should be applied in the feeding areas of rabbits. Follow the label instructions carefully and be sure to lay the bait as soon as possible after preparation. It is best to lay bait late in the day, just before rabbits come out to feed in the early evening

RHDV has the potential to spread rapidly from individual infected rabbits to rabbits within the same warren and to new warrens in the same area or some distance away from the initial site of infection if weather conditions are suitable. However, the rate of movement and the proportion of warrens affected are highly variable. No guarantee can be given that the virus will spread from an infected rabbit or warren to other rabbits.

Transmission of myxomatosis

Rabbits usually become infected with myxomatosis after being bitten by an insect vector that has picked up virus particles from the blood of an infected rabbit. These virus particles are carried on the mouthparts of insects that bite or pierce the skin of rabbits.

Mosquitoes are the usual vectors of myxomatosis virus during summer outbreaks of the disease. An outbreak caused by mosquito transmission generally spreads rapidly and infects a large number of rabbits at any one time. The European rabbit flea, *Spilopsyllus cuniculi* brought to Australia in 1966 is a useful vector for myxomatosis, being present on the rabbit throughout the year. The flea breeds only when the rabbit breeds, since it requires a hormone present in pregnant rabbits to mature its eggs. Flea numbers are therefore greatest during the breeding season, when they are most useful for spreading myxomatosis. However, the European rabbit flea cannot tolerate hot dry conditions and requires the blood from pregnant rabbits for its own survival. Therefore the Spanish rabbit flea, *Xenopsylla cunicularis* was released in the 1990s into a number of rabbit populations in the semi-arid areas of Australia, including a number of sites in western NSW. Although the distribution of European and Spanish fleas may overlap in the central districts of the State, the Spanish rabbit flea thrives in dry climates. Spanish rabbit fleas do not require rabbit hormones to breed and thus can breed all year round, albeit slowly in winter. They spend most of their time in the warren, jumping on to a rabbit only to feed. Thus they feed on many different rabbits and as a result are excellent vectors of myxomatosis. Several other insects that parasitise rabbits, including the stickfast flea and several small mites, also transmit myxomatosis, but their importance in field outbreaks is thought to be insignificant.



Transmission of RHDV

RHDV is a virus that affects only rabbits. This includes both the wild type and the derived domestic strains of the European rabbit. Unlike myxomatosis, the virus is normally transmitted by direct contact, so it does not necessarily need a vector to spread it from one rabbit to another. Trials have shown however, that the Spanish flea, mosquitoes and in particular, bush flies are vectors of the disease.

EXTENSIVE CONTROL

Harbour destruction

The removal of harbour is the most effective means of reducing the rabbit population during the initial reduction phase. The main forms of rabbit harbour are warrens and woody weeds such as blackberry bushes, African boxthorn, other vegetation and fallen logs. Any property with extensive harbour will almost always become re-infested with rabbits after initial control. Fallen logs should be heaped and burnt and a woody weed control implemented. For more information on weed control, consult with the local council weeds officer.

Warren Ripping

Warren ripping can be the principal control method or in combination with poisoning an advanced control method. Ripping techniques depend heavily on soil type and location of the warren such as, the slope or waterways and erosion potential, as well as the equipment available. The tractor and rippers used must be suitable for the job and the driver should be accredited, experienced and competent. The land manager will have to rely on local experience to determine the most suitable techniques for the area.

Rabbits do not readily dig new warrens so destruction of warrens greatly inhibits resurgence and recolonisation of poisoned areas, especially if surface harbour is removed and follow-on control by ripping or fumigation is undertaken.

Start by running barking dogs over the area to force surface rabbits into warrens before the start of ripping.

Use tines at least 900 mm long and keep tine rip-lines ≤ 50 cm apart. Start ripping at least 3 m beyond the outermost burrow opening of the warren. This allows the ripper to get to a maximum depth before the warren is reached and increases the chance of ripping tunnels outside the visible warren diameter. Obstacles and harbour such as logs and blackberries should be removed to increase the effectiveness of ripping. If the warren is uneven then it is worth levelling the warren with a bulldozer or front end loader blade to allow better and more even penetration of the tines on a level surface.

If parts of a warren cannot be ripped because of obstructions such as trees or fences, be sure to fumigate these burrows a few hours before ripping. If ripping near trees or stumps back the tractor up to them and rip away from the trees so that the tines travel along roots and not cut across them.





Figure 9. Warren ripping: note length of tynes. (Photo David Croft)

In general, clay soils should be ripped when damp and sandy soils when dry, but be guided by local experience. Where possible, scatter some grass seed over the ripped area to allow for faster regeneration of the site. Unless ridges and hollows are severe there is no need to smooth them over. These ridges tend to catch water and wind-blown seed and disperse the 'rabbit' smell, allowing for a faster rejuvenation of the site. Back filling with the tractor blade can remove excessive ridges or furrows to prevent rabbits digging back in. Smaller or shallow warrens can be successfully destroyed with a chisel plough or discs, but regular monitoring is essential with openings treated as soon as they occur.

An economical ripping technique, particularly applicable to open country, is to begin ripping from one of the long sides of the warren and to avoid turning completely around for the second rip line, move across and follow with the second rip down the centre. Next rip towards the centre from the first rip and out toward the other edge from the second rip, Figure 11a; repeat until the warren is fully covered.





Figure 10. Warren ripping in deep sand – Menindee Lakes. (Photo David Croft)

An alternative ripping technique that can also be used in more hilly terrain is to begin ripping from one of the long sides of the warren, each time reversing over the last rip, Figure 11b. Each new rip starts only in the same direction as the first rip. This technique increases the packing effect of the ripped warren. It is recommended that all ripping be done across the slope, and that slopes exceeding 18° should not be ripped. If it is not possible to rip the entire warren across the slope, at least two or three cross-rips should be used to reduce the risk of erosion.

In some cases cross-ripping might be necessary or advisable if the soil type is 'tight'. Cross-ripping means to rip in one direction and then again at 90° to the original rip line to completely destroy the warren complex.

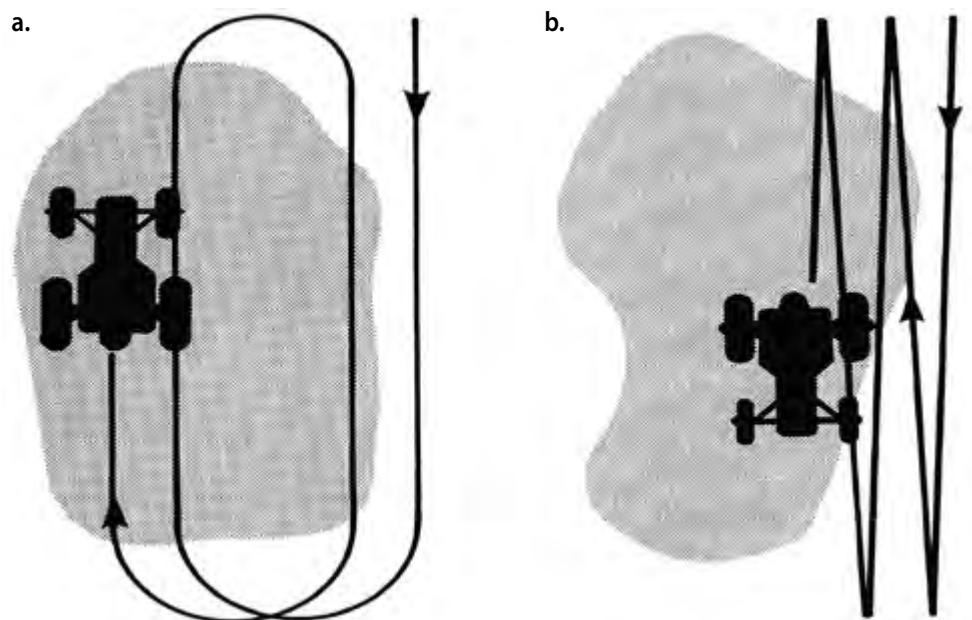


Figure 11. Typical ripping patterns (a) on flat ground and (b) on hilly terrain.



Warren destruction by blasting

Blasting is a follow-up technique sometimes used to destroy warrens that cannot be ripped, such as those among rocks and boulders and under trees. However, explosives may be used only by trained and licensed operators. Contact WorkCover Authority NSW for licensing requirements or go to www.workcover.nsw.gov.au

FUMIGATION

Phosphine is the recommended fumigant for rabbits. Phosphine is produced from aluminium phosphide tablets available under a number of registered brand names. Tablets come in tubes, strips and packs ranging from 30 to 100 tablets.

Fumigation can be very effective for controlling rabbits:

- as a follow-up technique to ripping or blasting
- in inaccessible places such as rocky outcrops, along fences and around trees, on riverbanks where it is not possible to rip
- for treating small, isolated infestations
- in places where ripping is undesirable because of the risk of erosion
- as an alternative to 1080 poisoning on properties where 1080 cannot be used: the property may be too close to town; the occupier may not allow 1080; the removal of livestock may not be possible; or the use of poisoning is not advisable because the rabbits are breeding.

There are some basic rules when undertaking fumigation:

- Fumigants may be lethal to humans. Labels and safety directions must be read and approved personal protective equipment (PPE) worn
- Run dogs over the area to chase rabbits underground
- All openings of a warren must be found and sealed
- Follow-up is essential and fumigated burrows must be checked for re-openings on the sixth day, sixth week and sixth month.

This is a very dangerous procedure and the relevant PPE is essential. Phosphine is extremely dangerous in enclosed spaces. Partly used tubes of phosphine tablets must not be returned to storage. Phosphine tablets may be placed inside resealable flasks kept on hand especially for that purpose. Do not store phosphine tablets in an open tube, unless the tube is placed in a sealable can.

Fumigation Procedure

Following the dogs prepare the warren for fumigation by cutting back each burrow mouth until there is at least 30 cm of soil between the surface and the burrow tunnel see Figure 12. This not only ensures a better seal when blocking the hole, but also exposes any branches of the tunnel that are close to the outlet.

Once the hole is cut back, place the fumigant at least 60 cm down each burrow. With phosphine this only requires placing a tablet well down the hole by rolling the round tablet down a length of poly pipe. Under dry condition it is advisable to place wet newspaper down the hole before adding the tablet.



Once the fumigant is in the burrow, carefully seal the opening with a clod of dirt that has a tuft of grass attached with the grass facing down the hole or with a ball of crumpled newspaper. This prevents loose dirt from covering the fumigant and also makes it more difficult for a rabbit to dig out. Finally, break in the sides of the hole level with the surrounding soil and tramp down to give a good seal.

Repeat process until all entrances and pop holes in the warren are sealed. Fumigation can be a slow process.

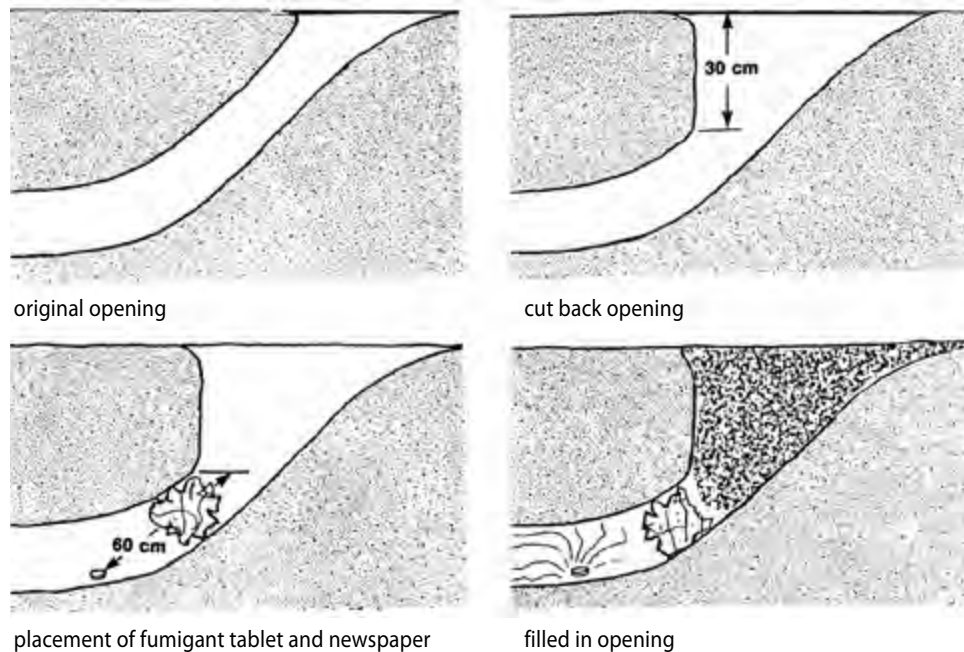


Figure 12: Static fumigation steps.

FINAL MOP-UP (ADVANCED) CONTROL

Mopping-up is used when rabbit numbers are at a very low level. When rabbit numbers are very low, the removal of each rabbit has a far greater long-term effect on the potential for reinfestation. When the rabbit population is high, each individual rabbit removed does not have much effect therefore a large percentage must be removed to have any effect.

Once this advanced stage is reached, only periodic checks and the occasional use of a specific control method will be necessary to keep a property rabbit-free.

Shooting

On smaller properties regular shooting can help maintain rabbit numbers at low levels so that their impacts are minimal. Shooting is largely ineffective at controlling a large, rapidly breeding population of rabbits. Shooting is an easy and effective way to remove rabbits when numbers are low. Good numbers can be taken this way. Shooters can sit off warrens or cover and shoot animals as they appear. Dogs can also be used to flush animals from cover for shooting by shotgun. Night shooting using a rifle or shotgun and a spotlight can be effective. A .22 calibre rifle or shotgun is recommended.



Trapping

Trapping is permitted under the *Rural Lands Protection Act 1998* if it is part of a rabbit control program but it should be used only to clean up the last few rabbits. Trapping should not be used as a primary method of control when rabbit numbers are high because it is largely ineffective at removing sufficient numbers in a large population of rapidly breeding rabbits. All traps, particularly soft-jawed spring traps must be used in accordance with the Code of Practice.

Traps may be placed in any area showing signs of rabbit activity including entrances to burrows or warrens, dung heaps, earth mounds, along rabbit netting fences or near hollow trees and logs. Traps set on dung heaps, along fences and on mounds near warren openings usually trap only older rabbits. Traps set in burrow openings will trap both kittens and older rabbits

When using it is essential that:

- all traps are to be checked as soon as possible after dawn to reduce unnecessary suffering to captured animals
- all traps are to be inactivated after dawn to prevent capture of non-target animals during the day
- when setting traps where other animals could accidentally be caught, dig a deeper trench so that the trap is set in a depression of 5 to 6 cm. Most larger animals will step over such a depression, while rabbits will be attracted to the fresh soil.

Barrel netting or mesh traps

These traps are relatively easy to make. The trap consists of a cylinder, 12 to 15 cm in diameter and a metre in length, made from rabbit netting or light mesh. One end is closed off and the cylinder has two hinged gates or flaps, making three sections about 35 cm long. At the gates, heavy-gauge wire on light steel rod supports the trap and acts as a non-return frame for the gate. When the rabbit pushes into the cylinder and moves past a gate, the gate closes behind it. If the rabbit pushes back, the gate will press against the retaining circle of wire and prevent escape Figure 13. Place the trap in the entrance and peg it to prevent it rolling. Rabbits may take a few days before using the trap. Free feed in the trap may assist in attracting rabbits out of the entrance.



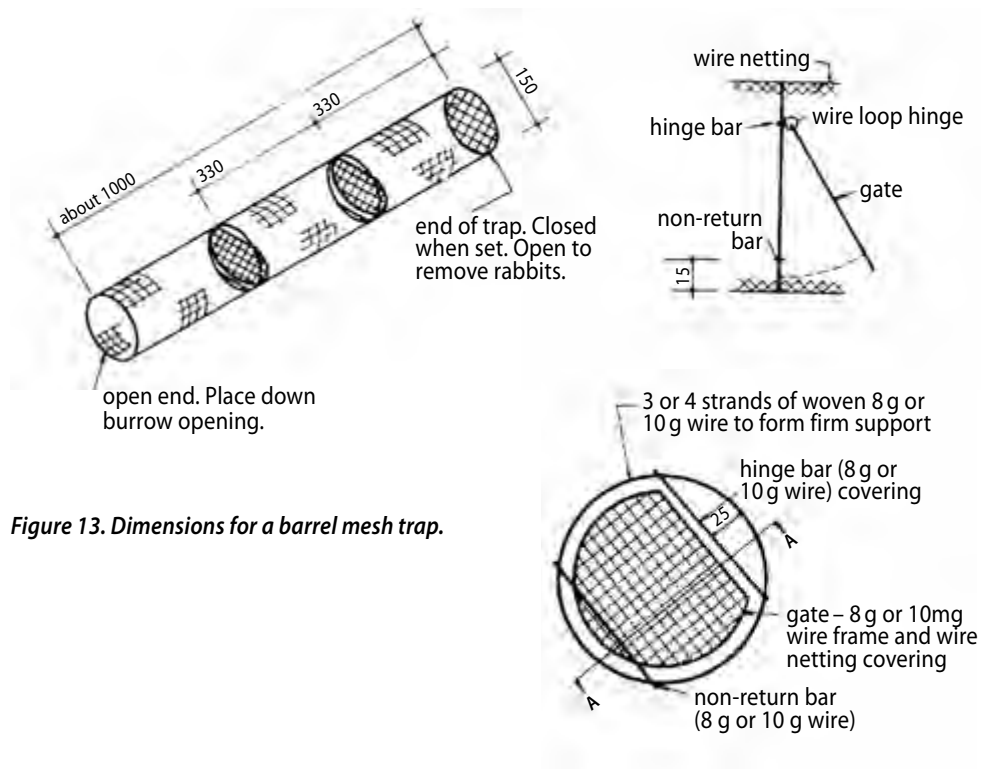


Figure 13. Dimensions for a barrel mesh trap.

OTHER TECHNIQUES

Fencing

Rabbit-proof netting fences are very expensive and the extra cost and time involved in construction means they are generally not used by many land managers.

Rabbit-proof netting fences are now most often used to protect a relatively small, high-value crop or a tree lot or to exclude harbour areas such as rocky hills. Yet, when stressed, rabbits will climb over or dig under most rabbit-proof fences. It is important that all fences are checked regularly for holes or for any object leaning against the fence if the integrity of the fence is to be maintained. If necessary, a capping or electric wire or foot netting may be needed to stop rabbits going over or under the fence.

If a rabbit-proof fence is required, netting barriers should be used to protect posts and stays and gates should be swung so that rabbits can't move between the gate and posts or get underneath. A correctly positioned bedlog will prevent rabbits from moving under a gate.



Deterrents and revegetation

After a major harbour destruction program with ripping, explosives, fumigation or poisoning freshly treated warrens need to be seeded to re-vegetate the area as quickly as possible and minimise recolonisation. The use of fertiliser or commercial animal repellents may reduce the rate of rabbit visitation and allow vegetation to re-establish. Use clean seed suitable for the area that will give a reasonable cover. Cereal seed such as cereal rye is fast growing and useful pioneer species that will provide quick vegetation cover. The quicker the warren surface is covered in vegetation the sooner the area will recover and reduce reinvasion by rabbits.

FURTHER READING

Braysher M & Saunders G, *Best practice pest animal management*. Primefact 502, NSW DPI.

Mitchell B & Balogh S 2007, *Monitoring techniques for vertebrate pests: Rabbits*. Bureau of Rural Sciences, Canberra

Sharp T & Saunders G 2005, *Humane Pest Control: Codes of Practice and Standard Operating Procedures*. NSW DPI.

Williams K, Parer I, Coman B, Burley J & Braysher M 1995, *Managing Vertebrate Pests: Rabbits*. Australian Publishing Service, Canberra, or download from www.daff.gov.au/brs/publications

Further information is also available on the internet at www.feral.org.au





Feral pig biology & control

FERAL PIG BIOLOGY

Origin

The feral pig in Australia is a descendant of various breeds of *Sus scrofa*, the domestic pig. In the north of Australia there is some indication that a number of other species of pigs were also brought to Australia, including *Sus celebensis* and *Sus papuensis*.

Records indicate the presence of domestic pigs immediately following the arrival of the First Fleet. Pigs were kept by settlements unrestrained and in semi-feral conditions. Stock could readily escape and wander, and by the 1880s pigs had run wild in NSW.

Distribution

Feral pigs are widely distributed in NSW, Queensland, the Northern Territory and the Australian Capital Territory. Isolated populations also occur in Victoria and Western Australia, on Flinders Island in Bass Strait and on Kangaroo Island in South Australia. Tasmania occasionally has temporary populations due to accidental releases.

In NSW, feral pig populations are found primarily in western areas, their distribution closely related to the location of inland watercourses and flood plains. Increasingly, populations are appearing in the tablelands and coastal areas of eastern NSW, probably due to the deliberate release of animals. See Figure 14.

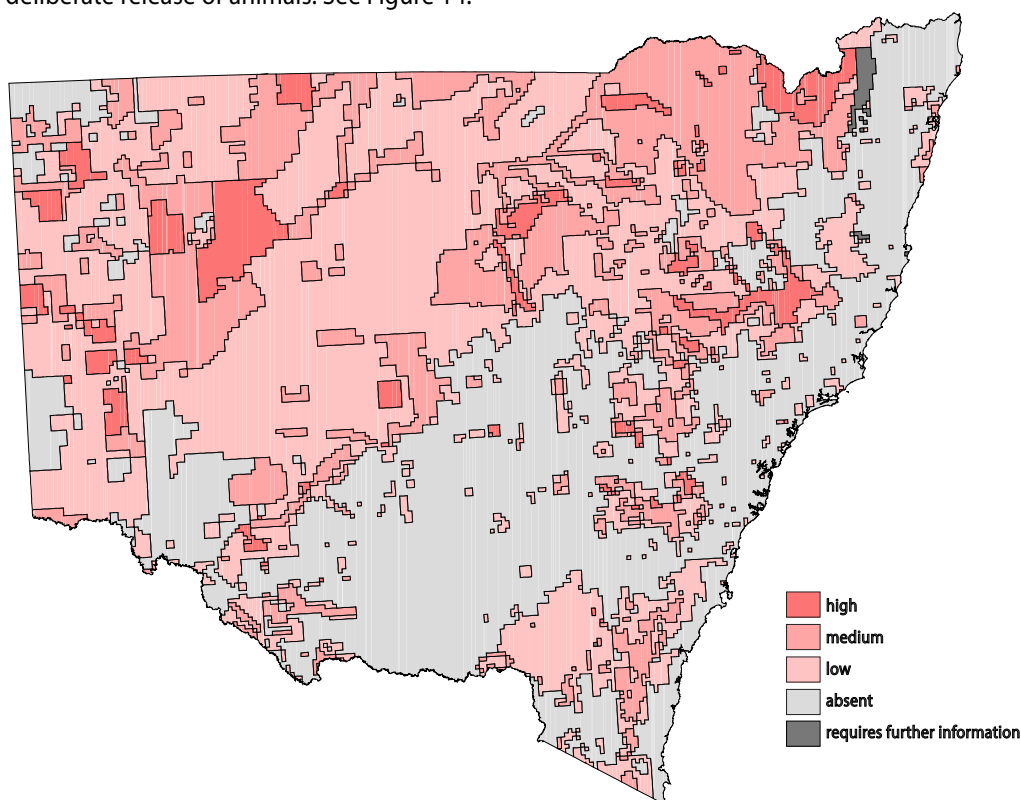


Figure 14. Distribution and density of feral pigs in NSW (2009).



Habitat

Feral pigs need to live in moist areas that can provide adequate food and water and enough shelter to protect against extremes of temperature. In particular, dense shelter is required for protection against high temperature.

In Australia, feral pigs are found in a variety of habitats that can provide these requirements; these areas include rainforests, monsoon forest patches, paperbark swamps, open floodplains, marsh areas, semi-arid floodplains, dry woodlands and subalpine grasslands and forests.

Home ranges and movement

Home range is determined by habitat type, food supply, the size of individual animals and population density. On a daily basis feral pig ranges are quite small, although the seasonal or overall home ranges may be much larger. Mature males tend to have a larger home range than sows. In the Western Division of NSW a boar may have a home range of 43 km², whereas in north-west NSW a boar may have a home range of only around 10 km².

Weather conditions and food availability affect the movement of feral pigs. In hot weather days may be spent in one area and nights spent feeding in another. In many habitats there is a seasonal trend of movement between specific areas, depending on the current food supply. Feral pigs will readily swap between food sources so that excessive movement is not required. Even if disturbed, feral pigs will not move far and will readily return to their home ranges.

Behaviour

Feral pigs restrict their activity to cooler parts of the day. In hot weather they are primarily nocturnal. Even in cooler weather they tend not to be active during the middle of the day.

Feral pigs consistently use trails from one area of use to another, such as from shelter to food supply or water. They also use sheep and cattle pads to and from water. Marking of these trails is common, with trees or logs rubbed or tusked. Rubbing also helps to reduce ectoparasite infection, as does wallowing in mud or dusty depressions. Mud and dust also help to regulate body temperature.

Social structure

Sows and piglets generally run together as a group. Immature males and females may also stay with the group until they reach maturity, or they may run as a juvenile group until they mate. At about 18 months males become more solitary rejoining a group only for mating or to feed on localised food sources.





Figure 15. Feral pig rooting in a pasture. (Photo Brian Lukins)



Figure 16. Feral pigs in a trap – note radio tracking collar. (Photo David Croft)

Group sizes vary depending on the season and habitat. In forested areas of south-west WA group sizes rarely exceed 12, whereas in more open country up to 40 or 50 pigs may form a mob. In times of severe food and water shortage large groups of 100 or more may gather around remaining waterholes.



Diet

Feral pigs are opportunistic omnivores. They prefer succulent green vegetation, fruit, grain, and a wide variety of animal material such as frogs, fish, reptiles, birds, small mammals and carrion. They will also eat underground plant material such as roots, bulbs, corms and fungi. The requirement for protein and energy is high, particularly for breeding, successful lactation and growth of young.

Reproduction

Feral pigs are polyoestrous, being able to breed throughout the year. Breeding success depends on the availability of nutrients, in particular energy and protein. Successful mating normally coincides with the seasonal abundance of food in different habitats.

Female feral pigs reach sexual maturity once they reach a weight of 25 to 30 kg, which normally occurs between 7 and 12 months. Males become sexually mature around 18 months. The gestation period is 112 to 114 days and an average litter size is 5 or 6 piglets.

A litter is weaned after 2 or 3 months and mating can occur again around the same time. Under favourable conditions two litters can be weaned in a period of 12 months. This breeding capacity allows feral pigs to quickly recover from a population setback, and to rapidly increase their populations in periods of favourable conditions.

Mortality

Mortality of feral pigs in their first year of life, particularly from the foetal stage to weaning, is high, varying from 10% to 100%, depending on conditions. Mortality is due to factors such as loss of foetuses, adverse weather conditions, accidental suffocation by sows, loss of contact, predation from wild dogs and starvation.

Starvation can affect pigs of all ages: lactation of sows can cease if protein levels are not adequate and excessive tooth wear in older pigs can interfere with eating. Lack of appropriate nutrients also leaves feral pigs more susceptible to parasites and diseases. Adult mortality may vary from 15% to 50%, with few feral pigs in the Western Division of NSW living more than 5 years.

Disease

Feral pigs can be hosts or vectors of a number of endemic parasites and diseases, some of which can affect other animals or people. Livestock health can be significantly affected by:

- leptospirosis
- porcine brucellosis
- melioidosis
- tuberculosis
- sparganosis
- porcine parvovirus
- Murray Valley encephalitis and other arboviruses.

A number of worm species also carried by feral pigs can affect livestock.



Human health can be affected by:

- leptospirosis, through contact with the urine of affected feral pigs
- porcine brucellosis, through handling raw feral pig meat
- tuberculosis and sparganosis, through eating inadequately cooked feral pig meat.

Feral pigs are also susceptible to, and can be hosts or vectors of, a number of exotic parasites and diseases. Feral pigs would also be capable of carrying and spreading a number of exotic diseases and parasites if these were to enter Australia. These include:

- foot-and-mouth disease
- swine vesicular disease
- African swine fever
- Aujeszky's disease
- trichinosis
- classical swine fever.

IMPACT OF FERAL PIGS

Pest status

Feral pigs are declared pest animals under the *Rural Lands Protection Act 1998*. This declaration means that feral pigs are to be continually suppressed and destroyed by land managers. It is illegal to keep or transport live feral pigs. The definition of feral pigs includes pigs born in the wild, pigs that have lived in the wild, pigs that demonstrate wild and erratic behaviour, pigs that are not domesticated and pigs that have some or all of the following morphological features; long coarse hair, elongated snout, sloping hindquarters.

Agricultural impact

Feral pigs prey on newborn lambs. They also reduce yields in grain, sugarcane, fruit and vegetable crops through consuming or trampling plants. Fences and water sources can be damaged and dams and waterholes fouled through wallowing and defecation. Feral pigs also compete with livestock for pasture and damage pasture through up-rooting vegetation.

Environmental impact

Feral pigs disturb natural environments through rooting up soils, grasslands and forest litter and consuming a range of native plants. There is some evidence that they may also help spread the rootrot fungus that is responsible for dieback disease in native vegetation. Feral pigs also eat a range of live native animals including, earthworms, beetles, centipedes, amphipods, snails, frogs, lizards, snakes, turtles and their eggs and small ground-nesting birds and their eggs.

Feral pigs are listed as a KTP due to predation, habitation, degradation, competition and disease transmission, see www.environment.nsw.gov.au/threatenedspecies/keythreateningprocesses.htm



Recognition and signs

There are a number of signs and pieces of evidence to indicate feral pig activity and abundance in an area. Regular sightings of pigs and abundant fresh sign normally means high numbers of feral pigs; some sightings of pigs and obvious fresh sign indicates medium numbers of feral pigs; no or few sightings of pigs and very little fresh sign indicates low numbers of pigs.

Direct observation: This is the least reliable method to detect the presence of feral pigs. Pigs can be detected directly by using dogs, by spotlight observation at night, tracking collared pigs and by aerial survey.

During daylight, feral pigs shelter in deep cover and are rarely seen. The presence and number of pigs are more reliably evaluated by observing signs of their activity and impact. An experienced observer can rapidly estimate the presence and abundance of feral pigs by carefully examining these signs. However, a beginner may see nothing.

Lamb predation: Persistent low marking percentages that are otherwise unexplained may be caused by feral pigs. Pigs prey on lambs at dawn, dusk and during the night, leaving very little of the carcass, which can be easily missed. Often little or no sign of lamb carcasses may also indicate pig problems. Significant lamb mortality can result from predation by a small number of adult feral pigs.

Rooting: Feral pigs use their snouts and teeth to dig for underground food, including small animals and tubers, particularly where soil is soft or after rain. The result varies from selective uprooting of specific types of plants to the creation of extensive areas resembling ploughed paddocks. The distribution of rooting areas is a reliable guide to the location of pigs at night.

Crop damage: Feral pigs damage crops by eating them, by trampling and bedding in them, and by uprooting seed and seedlings. Their rooting is distinctive, but their trampling, pads/paths and bedding may also resemble damage caused by kangaroos.

Fence damage: Pigs will push through fences, usually next to a post or picket and these holes are then used by other animals. Mud or coarse bristly hair on the wire or post indicates feral pigs.

Pads: Pigs often create pads when travelling in single file to frequently used food and water sources. Pads are an unreliable sign of feral pigs unless there are no other animals about, or there are more signs of feral pigs, such as tracks or faeces, because feral pigs, domesticated animals and other wildlife all use the same pads.

Tracks: Feral pigs leave hoof-prints in any soft surface. Their tracks have a distinctive shape but can be easily confused with sheep tracks if the outline is blurred.





Figure 17. Feral pig with sheep carcass.
(Photo Peter O'Brien)

Faeces: Pigs defecate on and off pads. The size, shape and consistency of the scat varies with age and diet, but it is typically 3 to 6 cm wide, 7 to 22 cm long and fairly well formed. Close examination will reveal finely chewed plant matter and occasional bone fragments, pig bristles, wool and kangaroo or wallaby hair.

Wallows: Throughout the summer pigs wallow by lying in moist or wet areas, often near permanent water. Wallowing may help to control the animal's temperature and protect it against insects. Wallows are distinctive oval depressions in mud and can show how recently pigs have been in the area.



Figure 18. Pig in a bore drain. (Photo David Croft)

Mud-rubs: After wallowing, pigs often rub their heads, shoulders and sides on nearby vertical objects such as tree trunks and fence posts. The result is a distinctive muddy rub site at pig height.



Tusk-marks: Adult boars slash the trunks of growing trees with their tusks, leaving a distinctive pattern of cut-marks. The trees selected for cutting and rubbing are often next to pads and near water. Because boars stand on tip-toes and reach up when tusk-marking, the height of the mark is a guide to the size of the carver. Marking may serve to notify other boars of the marker's presence and size.

Nests: Just before farrowing, sows make nests from the available vegetation, which they uproot and carry by mouth. If long, grassy vegetation is plentiful, the nest can be very large – up to 3 m by 1.5 m and 1 m high, with a domed roof. For the first 1 to 5 days of life, the piglets stay in the nest and the sow is usually also inside or nearby. Nests are usually less than 2 km from permanent water. They should be approached with caution.



Figure 19. Mud rub on a tree trunk. (Photo Trent Fordham)

INTEGRATED FERAL PIG MANAGEMENT

Management of feral pigs can include population reduction by using a number of control techniques, reducing damage through enterprise substitution, or fencing. Management of feral pigs and the impact they cause will normally require a number of methods in combination.

Initial control of a population with any method to which a high percentage of the population is susceptible is important. This is normally followed by secondary control methods designed to reduce the population and feral pig impacts further and prevent it building back up.

Initial control methods include shooting from helicopters and large-scale poisoning. Secondary control methods include trapping, shooting from the ground and strategic poisoning.



ENTERPRISE SUBSTITUTION

A decision may be made that a viable option is to change the type of enterprise in areas susceptible to the impact from pigs, for example, to change from lambs and lambing paddocks to wethers, from grazing to farming or from farming to grazing. This is normally a last resort but does occur in some instances.

FENCING

Fencing is sometimes used to protect valuable enterprises in small areas. Effective pig-proof fences have been designed but need to be thoroughly maintained to sustain their effectiveness Figure 20.

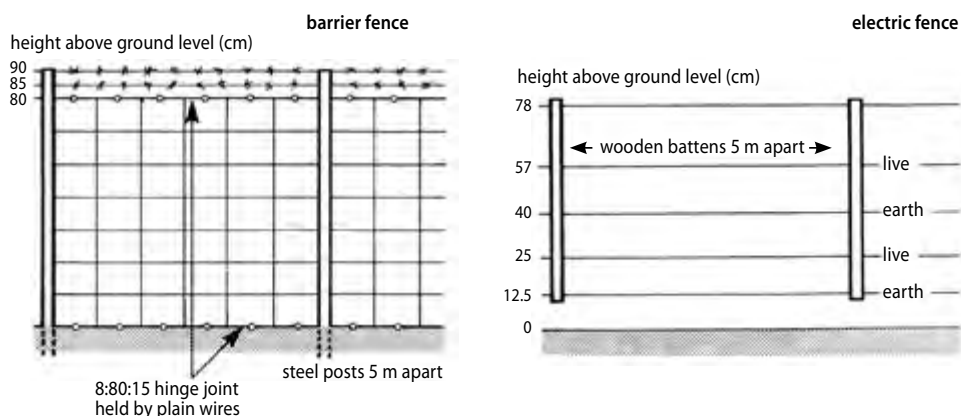


Figure 20. Feral pig fence

POISONING – GROUND BAITING

1080 poisoning: 1080 poisoning can be an effective initial control of pig numbers if undertaken in a methodical manner. It is particularly effective if green feed and other food sources are scarce. Feral pig baits can be prepared by mixing 1080 poison with grain or manufactured pellets. PigOut®, a manufactured bait product, is also available to control feral pigs. Grain, pellets, cucurbits, root vegetables, apples or quinces can be used as attractants in bait stations or traps.

Only ACOs in NSW can prepare bait and supply it to land managers. 1080 bait can only be used in bait stations. 1080 poison is regulated under a current 1080 PCO that details the particulars of its use.

The use of 1080 currently requires a minimum chemical use accreditation at AQF3 level or training specified in the 1080 PCO.

Bait stations are constructed by enclosing an area, normally about 1000 m², with fencing that will not allow livestock and non target species in, but can allow pigs to enter by pushing underneath. Bait material is placed in a furrowed area or on the ground within the fenced area.



Simple bait stations can be plain or barbed wire run around a group of trees, with the bait in a pit in the middle where pigs can push in but livestock and non target species are restricted.

Bait stations are used in areas where livestock cannot be removed and where it is preferable to have a permanent structure to be re-used when needed.

If pigs are readily using set trails and livestock have no access to an area, setting up bait stations along trails may be appropriate.

For bait stations it is essential that adequate 'free-feeding' of unpoisoned bait material occurs prior to poisoning. Free feeding ensures that the maximum numbers of pigs are attracted to, and feeding on, the bait material and that excessive poisoned bait is not laid.

Feral pigs may take some time to begin to feed on the bait material provided, depending on what food sources are already available. Once they begin to feed at the bait station, progressively offer more bait material until consumption is no longer increasing.

Once the amount being taken is consistent, adjust accordingly to ensure the minimum amount of bait material is left at the end of a night.

The period of free feeding may take up to 2 weeks or more and must be a minimum of 3 nights. Poisoned bait material of the correct volume can then be provided for a maximum of 3 consecutive nights. After this time all remaining poisoned bait must be removed and, where possible, carcasses of poisoned pigs should be collected and buried to prevent poisoning of non-target wildlife or domestic animals.

Other poisons: There are a number of toxic substances that are currently being used or investigated for the control of feral pigs.

Warfarin is an anticoagulant poison that is permitted in some States for use with grain bait. It is a slow acting poison and can cause severe joint pain and is considered inhumane by some groups.

Hog-gone® is a new feral pig product currently being researched and developed. It uses sodium nitrate which causes a rapid and apparently humane death of feral pigs in 2–3 hours.

Poisoning – aerial baiting

Aerial baiting programs may be an effective means for dealing with a feral pig problem where ground control is impractical or where impacts are significant or potentially significant.

There are a number of restrictions and legal requirements associated with aerial baiting programs. A land manager should discuss the intended program with the ACO of the local LHPA several months in advance.

A person who undertakes aerial baiting must only use Pigout® Feral Pig Bait and it can only be applied by helicopter.

Free feeding is compulsory and must be undertaken for at least 3 nights before undertaking any aerial baiting using Pigout® Feral Pig Bait, unless an ACO specifically recommends otherwise.



Aerial 1080 baiting of feral pigs will not be permitted without specific prior approval from NSW DPI. Application for approval must be made by the LHPA. Approval will be based on:

- the extent of the feral pig problem requiring aerial baiting
- details of why the problem in the specific area cannot be dealt with by the conventional means of ground baiting or trapping
- written permission from all government authorities and private land managers whose land will be treated under the proposed program. National Parks and Nature Reserves are not to be included in the area to be baited as they require a separate application
- an appropriate map of the area to be treated including mapped bait flight paths
- the name of the person who will have the overall supervision and responsibility for the program.

To receive approval, the LHPA must demonstrate that there is no practical alternative to aerial baiting. Applications must be submitted from the Authority to the relevant NSW DPI officer at least 2 months before the proposed date of baiting.

HELICOPTER SHOOTING

Shooting feral pigs from helicopters is an effective method for an initial knockdown of numbers. This type of shooting is species-specific and can be used in areas that are inaccessible from the ground. Helicopter shooting can be expensive if not properly planned, so it is important to have coordination and cooperation from a number of groups or organisations.

Usually a helicopter carries one shooter and a spotter who looks for and keeps track of the pigs, including the number successfully shot. Wherever possible use a pilot who is experienced in pig-shooting: a good pilot readily provides the best position from which the shooter can make a successful shot.

Government employees who shoot from helicopters must attend a Feral Animal Aerial Shooter Training Course (FAAST) course conducted by NSW Police, NSW DPI, NPWS and LHPA.



Figure 21. Helicopter and dead feral pig during an aerial shoot. (Photo Sydney Morning Herald 2003)



GROUND SHOOTING

Shooting feral pigs from the ground is a method normally used opportunistically to follow up and maintain numbers after an initial knockdown program has occurred. Often ground shooting is conducted using dogs to locate feral pigs. This can be effective as long as both the dogs and the pigs are treated in a humane fashion. Ground shooting should not be conducted prior to, or during, any other program of control, as it disrupts normal feral pig activity and may cause feral pigs to temporarily disperse to other areas.

TRAPPING

Trapping of feral pigs is an effective technique to use as a follow-up after an initial knockdown of a population and as a maintenance technique to prevent numbers from quickly building back up. Trapping is flexible, as most traps can be easily moved to where pig activity is current. The exact numbers of pigs controlled is known and there is no danger to livestock or other domestic animals; where available, carcasses can be sold to a chiller. As traps are checked daily they pose little risk to wildlife.



Figure 22. Well used pig trap. (Photo Simon Oliver)

Feral pig traps can be as simple as silo mesh formed into a heart shape and secured with steel posts Figure 23. These traps are relatively portable and easy to set. The more substantial traps are constructed mesh panels secured with steel posts Figure 24. These traps can have either a swing gate or a more solid top-hinged drop gate. A number of trap designs are effective. The construction of the entrance door to the trap is the most important part of the design Figure 25. The door must work effectively to allow pigs to enter the trap but not allow them to back out. Trap selection is

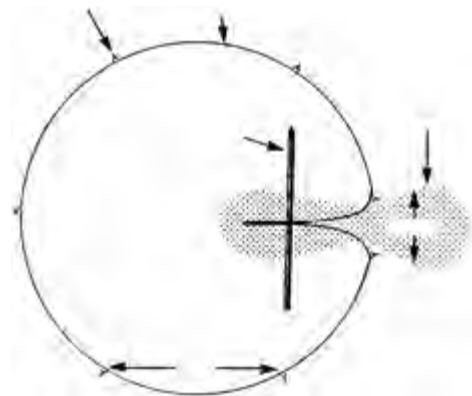


Figure 23. Heart-shaped or silo pig trap.



reliant on permanency and ease of access or portability. Each design has proven to be very effective.

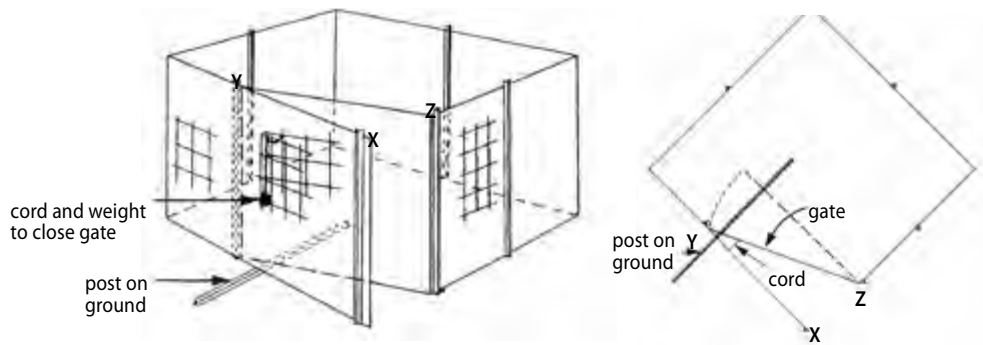


Figure 24. Enclosed feral pig trap.

Traps should be set up where feral pig activity is current. It is normal to set up traps near waterholes, on regular trails, or at other sites where pigs are moving regularly, such as through a hole in a fence.

Begin by providing bait material at the site. Bait types can include grain, or fermented grain, pellets, vegetables and fruit that they are already feeding on. Once pigs are readily consuming the bait, construct a trap around the bait site with a trail of bait leading to the trap entrance. Leave the trap door tied open for a number of nights until pigs are readily entering the trap to feed. The trap can then be set. Check the trap regularly, every day and humanely destroy any pigs caught. Pigs should not be left for excessive periods in traps.

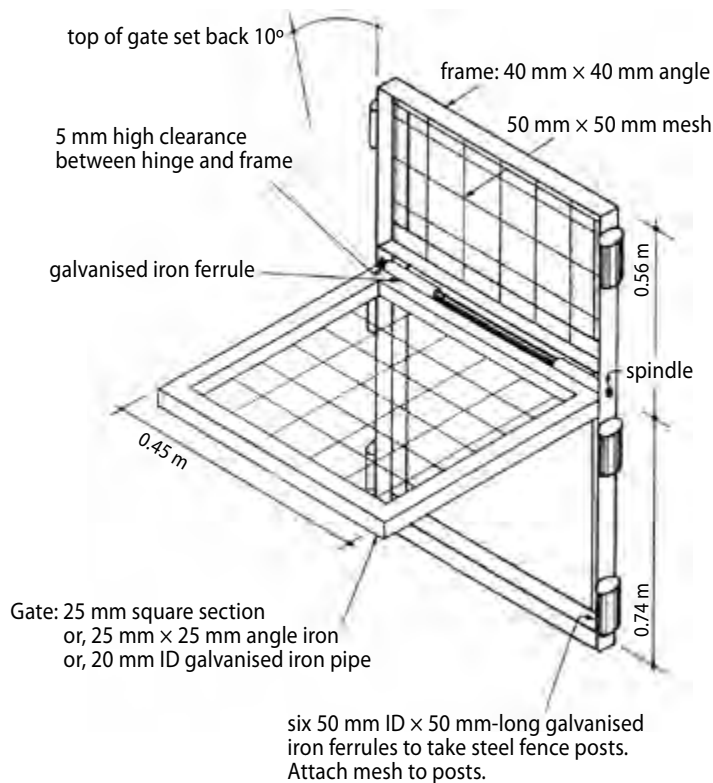


Figure 25. Drop gate for use in pig traps – top-hinged gate.



FURTHER INFORMATION

Braysher M & Saunders G 2007, *Best practice pest animal management*. Primefact 502, Industry & Investment NSW.

Choquenot D, McIlroy J & Korn T 1996, *Managing Vertebrate Pests: Feral Pigs*. Bureau of Resource Sciences, Australian Government Publishing Service, Canberra, or download from www.daff.gov.au/brs/publications

Mitchell B & Balogh S 2007, *Monitoring techniques for vertebrate pests: Feral pigs*. Bureau of Rural Sciences, Canberra.

Sharp T & Saunders G 2005, *Humane Pest Control: Codes of Practice and Standard Operating Procedures*. NSW Department of Primary Industries.

Further information is also available on the internet at www.feral.org.au



Wild dog biology & control

WILD DOG BIOLOGY

Origin

Wild dogs, *Canis familiaris*, are believed to have originated from the Thai wolf about 10,000 years ago. They are a cosmopolitan species and found across Asia and include the 'singing dog' of Papua New Guinea. They were first introduced to Australia approximately 3,500 to 4,000 years ago, probably by Asian seafarers who landed regularly on northern Australia.

Wild dogs are a 'declared pest animal' under the *Rural Lands Protection Board Act 1998* and are defined as: 'any dog, including a dingo, that is, or has become wild, but excludes any dog kept in accordance with the *Companion Animals Act 1998*, the *Exhibited Animals Protection Act 1986*, or the *Animal Research Act 1985* or any legislation made in replacement of any of those Acts'.

Distribution

Wild dogs may be found across NSW, however, the eastern ranges, the coastal hinterland and tablelands have the highest populations. Increasingly, wild dogs are found close to towns where they intermingle with local dogs and become identified as 'strays'. The wild dog is highly adaptable and may live successfully in arid to rainforest environments, providing there is an adequate supply of food, water and shelter.

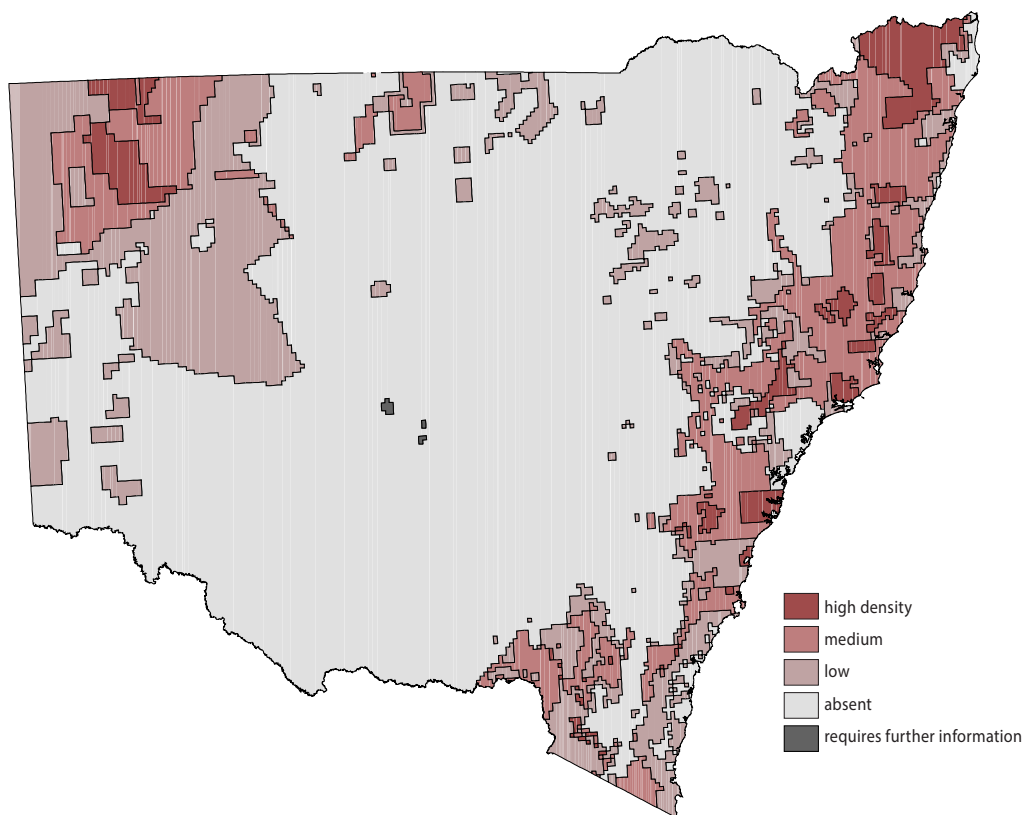


Figure 26. Wild dog distribution and density map (2009). Note: The relative densities in western NSW are much lower than corresponding densities in eastern NSW.



Characteristics

Wild dogs are predominately golden or yellow but can also be white, black, black and tan, brown, brindle, patchy and any combination of these.

Weights of adult wild dogs range from 11 to 25 kg for males and 7 to 22 kg for females.

Habitat

Wild dogs live in a wide variety of habitats and prefer areas where human disturbance is limited and where shelter, food and water is abundant.

Diet

Wild dogs mostly eat fresh meat and carrion. Food habits vary between locations and seasons, but medium-sized mammal including wallabies, rabbits, possums, wombats are preferred. Smaller animals, including rodents, echidnas, birds, reptiles, small mammals and plugging insects are also eaten when available. Domestic livestock may constitute a larger portion of the wild dog's diet in agricultural areas and large kangaroos are important foods in some areas.

Behaviour

Social structure and home ranges

Wild dogs have a flexible social system based on small groups that occupy and defend a territory. Each member of the group occupies a home range within the territory and home ranges of pack members may overlap.

Individual home ranges vary from 400 to 100,000 ha, averaging about 2,700 ha in size in the tablelands and up to 90,000 ha in dry western environments.

As could be expected, areas with the greatest food sources and key water points within home ranges are used most frequently and others parts may be rarely visited. Consequently, the group rarely meets as a pack. Instead, members meet and separate over time or rely on vocal communication. This explains why some wild dogs are mostly seen as individuals. Most preferred prey is hunted by individual dogs but when prey availability changes, wild dogs will form packs to hunt larger prey such as cattle and kangaroos. Sheep and goats can be hunted by individuals or small groups working together.

Movements follow well defined paths along topographic features. The shape of the territory is often determined to a large extent by topography and distinguishing features such as mountain spurs or rivers forming boundaries. Wild dogs may move throughout the day and night but are mostly active at sunrise and sunset and least active during the middle of the day.

Surplus killing occurs when a predator attacks and either kills or injures a number of prey animals such as sheep in one event. The number of prey animals killed is in excess to the predator's nutritional requirements. This behaviour occurs with many predators including wild dogs and foxes. The resulting multiple domestic livestock losses can be devastating for livestock producers.



Communication

Cohesion within groups and separation between groups is maintained by a variety of communication methods. Boundaries of territories are marked by scents in urine and faeces, scratching or raking, while vocalisations such as howling allow longer distance communication. When individuals meet, facial expressions and body postures are used to communicate dominance or submission. Aggression between animals is not uncommon and is used to establish or maintain social position.

Breeding

Wild dogs usually breed once a year. With the seasonal nature of food supply it is very rare for two litters to be successfully raised in one year.

After a 63 day pregnancy, a litter typically of 4 to 6 pups, is born in a hollow log or cave den. This den may be used in successive years by the bitch or taken over by other bitches in subsequent years. Small pups are confined to the den, suckled and fed solid food and water brought to them by the adults. This solid food may be carried and regurgitated for the pups by both adults.

Once old enough the pups are taken from the den to kills and to other dens throughout the home range of the adults. Weaning occurs at 6 to 8 weeks but the pups remain with the adults until 6 to 12 months of age. Older, more experienced pups have a higher survival rate than pups that become independent at an early age. These pups often die because of inexperience in food gathering.

Some bitches may breed in their first year but not all do. This may be the result of social dominance of younger animals by older animals.



Figure 27. Dingo in bushland. (Photo David Croft)



Diseases and parasites

Wild dogs can act as a reservoir for parasites and diseases that affect livestock, wildlife and domestic pets, including sheep measles, hydatidosis, mange, distemper, hepatitis, parvovirus, neospora caninum and toxoplasmosis.

Wild dogs may also act as a reservoir of infection for some exotic diseases such as rabies. This would make eradication of the disease difficult and may have far reaching economic and social implications.

Human health

Wild dogs harbour a number of parasites of significance to human health such as, roundworms, hookworms and hydatids.

The most important parasite of wild dogs in Australia is the hydatid tapeworm. This parasitic tapeworm is present in a high percentage of wild dogs and the intermediate stage, the hydatid cyst, is sometimes fatal to humans. Care should be taken to wear gloves and wash hands thoroughly with soap and water after handling wild dogs and domestic livestock with injuries.

AGRICULTURAL IMPACT

Wild dogs may significantly affect domestic livestock industries such as sheep, cattle, goats and poultry, through predation and disease. The sheep industry is the most significantly impacted but attacks on calves and larger cattle are quite common.

Livestock enterprises located adjacent to wild dog habitat may suffer severe localised predation. The cost of predation is not confined to direct losses through livestock deaths. Injured livestock require treatment and the livestock owner spends time supervising and protecting their flock. Indirect impacts include, poor weight gain, reduced wool growth in sheep and mismothering and loss of lambs. Financially, capital outlay for control techniques such as trapping, shooting and baiting may be substantial.



Figure 28. Sheep after a dog attack. (Photo Glen Saunders)



Contrary to common belief, cattle are also susceptible to wild dog attack. Young calves or young cattle are most vulnerable and older cows, steers and bulls may be maimed and killed. In areas where hydatids is endemic in wild dogs, a large proportion of cattle offal may be condemned at abattoirs to minimise risk of transmission.

Predation may occur in all months of the year and patterns vary slightly among areas but commonly peaks in March to June on the tablelands and inland, and in October to November on the coast. It is only through accurate reporting of wild dog sightings and attacks that wild dog management plans can be developed.

Recognition and signs of predation

The first signs of wild dog predation is often livestock carcasses, flightiness of livestock in response to disturbance or mustering with dogs or injured straggling livestock.

If adult sheep or calves are the prey then wild dogs would normally be implicated, whereas lambs may be killed by both foxes and wild dogs. When carcasses are fresh, inspect for signs of blood, saliva and bite marks and footprints around the animal. The presence of dog footprints at the carcasses does not necessarily mean predation was the cause of death. Pieces of wool with patches of skin attached and blood trails, are good indicators of wild dog attacks. If these are not apparent and there are no other obvious explanations for the death, skin the neck area and bruising and tooth marks will be obvious if dogs have attacked and killed the animal. One should never discount stray town or farm dogs as potential killers.

The age, body position and location of a sheep or calf carcass may give some idea whether wild dogs were involved. Wild dogs will attack sheep of all ages but rarely attack cattle older than 12 months. Attacks can occur anywhere, whereas livestock dying of natural causes generally die in a protected area. A carcass with signs of 'paddling' would suggest predation was unlikely.



Figure 29. Dog and fox prints in a sand pad. (Photo David Croft)



Wild dogs often attack from behind as sheep or calves move away. If attacked animals survive, they may have substantial tissue damage around the hindquarters, be lame, be without tails or have skin hanging from them. Sometimes, ears and tails are chewed on older cattle. Surviving calves often show only teeth marks as evidence of dog attack and the area around the bite becomes swollen through infection and flystrike.

Predation and hybridisation by feral dogs is listed as a KTP see www.environment.nsw.gov.au/threatenedspecies

BIODIVERSITY IMPACT

The impacts of wild dogs on native species varies between areas. Predation by wild dogs can have negative impacts on some threatened species. For example, wild dog predation can be a high source of mortality in koala populations and this combined with habitat fragmentation has the potential to cause local extinctions.

Management of wild dogs is challenging as some sections of the community view dingoes, wild dogs as a native species that needs to be conserved. In NSW, through the declaration of Schedule 2 lands, public land managers aim to control wild dogs in areas where they impact on agriculture or other values, while conserving dingo populations in identified areas.

INTEGRATED WILD DOG MANAGEMENT

The primary goal of wild dog control is to reduce livestock losses. Wild dogs may have large home ranges that include a number of land holdings. Therefore it is important for land managers to approach wild dog problems as a group. A general aim of reducing wild dog numbers might not reduce their impact because a few individual dogs may be causing most of the damage.

The aim of wild dog control should be to minimise the likelihood of wild dogs interacting with domestic livestock. No single control technique will solve a persistent wild dog predation problem. A combination of methods, such as ground or aerial baiting, trapping, shooting and fencing should be applied if the impacts of those pest animals are to be successfully managed.

1080 POISONING

Wild dog poisoning with 1080 in NSW is regulated by the *Pesticide Act 1999* and can be carried out only under the conditions set down in the current 1080 PCO. Copies of the 1080 PCO can be obtained on line at www.environment.nsw.gov.au/pesticides/pco.htm or your local LHPA.

The use of 1080 currently requires a minimum chemical use accreditation at AQF3 or the EPA accredited course delivered by LHPAs. Fresh meat and manufactured baits containing 1080 are available from the LHPA.

Distance restrictions from habitation, boundaries, roads and water sources; signage which must be displayed, before and for one month after the baiting program; notification of all neighbours within 1 kilometre of the baiting location; are all conditions contained in the current 1080 PCO.





Figure 30. 1080 meat bait. (Photo David Croft)

Ground baiting

For ground baiting, where practical, 1080 wild dog baits should be laid in such a way that uneaten baits can be found readily and destroyed. These baits should be placed in a shallow depression and lightly covered with earth. If practical, tether the baits to a fence or equivalent and mark the burial spot.

Ground baiting may be used when there is predation problem caused by wild dogs. The use of more than fifty 1080 baits on a large property or number of properties must be organised by an ACO employed by the LHPA or equivalent organisation. The ACO, who supplies the 1080 baits, must undertake a risk assessment of the program.

A person who lays 1080 baits on a property of less than 100 ha must check the baits within five days of laying the baits and must collect any untaken baits within seven days. All untaken baits are to be disposed of by deep burial as detailed in the current 1080 PCO. Replacement baiting for longer than seven days may occur if baits continue to be taken.

Emergency ground baiting

A person whose livestock are being injured, killed or harassed can lay up to 16 baits per 100 ha to a maximum of fifty 1080 baits, with the prior approval of an ACO. This is the only occasion where the normal 3 day public notice period is not required. The land manager must, however, notify anyone whose property boundary lies within 1km of a baiting location immediately before laying the baits. Where soil conditions allow, baits must be placed in a shallow hole and covered with earth. If practical, tether baits to a fence or fixed object to reduce the poisoning risk to non-target animals.





Figure 31. A trapper's wild dog skins. (Photo David Croft)

Bait stations

Bait stations may be set up using meat or manufactured 1080 baits. The baits are lightly covered by raked sand or soil or placed on the surface and soil mounded on top. The soil around the bait or mound is raked to form a square about 1 m². This allows for the identification of animals that visit the mound through tracks and scat observation. Soil from the immediate area is preferred because it avoids unusual odours that wild dogs may avoid. Wild dogs will often tear the bait mound apart to get the bait while foxes mostly make a neat hole in one side or above.

Wild dogs cover enough ground to encounter bait stations from 500 to 1000 metres apart. Fewer bait stations not only equates to fewer opportunities for non-target animals to take baits, it also means fewer opportunities for baits to be removed by foxes and cached elsewhere. When reducing the number of stations it is preferable to increase the area being baited and extend the length of time for which the baits are available.

Free feeding using non-poisonous baits in bait stations may be carried out to identify visitation by non-target species such as quolls. Bait stations visited by non-target species are discontinued. The remaining bait stations may then be poisoned with a single 1080 poisoned bait and regularly checked. Baiting should continue until wild dogs stop taking baits. Individual bait stations may then be stopped if non-target animals are taking poison bait.



Aerial baiting

Written approval is required from NSW DPI to conduct wild dog aerial baiting programs from helicopters or fixed wing aircraft in NSW. Aerial baiting can be conducted from fixed wing aircraft only in the Western Division of NSW.

The conditions for approval of wild dog aerial baiting programs, are stated in the current 1080 PCO.

Aerial baiting is arranged through the LHPA in close cooperation with the local Wild Dog Control Associations and relevant government agencies such as NPWS, Forests NSW, Land & Property Information (LPI) and local government.

The application form is available from the LHPA.

Information required on the application form includes:

- name and information on the objectives of the Wild Dog Management Plan for the aerial baiting area
- historical information on stock losses and wild dog sightings and sign
- livestock loss and injuries over the last 12 months
- sightings and sign of wild dogs
- participating land managers and property names
- specific reasons for aerial baiting such as steep terrain, inaccessible for ground control operations or historical evidence that wild dog predation is likely to occur
- ACO responsible for applying 1080 poison to bait
- timing
- quantity of 1080 poisoned bait required
- name, address and phone number of a contact person within the Wild Dog Control Association or LHPA
- topographic maps showing proposed flight paths for each baiting
- Approval to Bait written authorities should be obtained from all private and public land managers who participate in aerial baiting including Forests NSW and LPI.

NPWS are required to submit separate applications for aerial baiting of National Park estates.

If required, the LHPA may implement more than one aerial baiting program each year. However, each case for aerial baiting will require a new application and approval and must meet the established criteria. It is essential to establish through accurate historical data that predation is occurring or there is a high probability that it is likely to occur.



Planning of aerial baiting

The local Wild Dog Control Association meets with the ACO from the local LHPA, private land managers and government agencies such as Forests NSW, LPI and NPWS to prepare *An Application for Aerial Baiting for Wild Dog Control*.

Written approval from Forests NSW and LPI is submitted with the application.

At the meeting the application and maps may be modified if necessary. The fully completed application and maps of proposed bait transects and all the necessary public land manager approvals are submitted at least two months before the proposed date of baiting to NSW DPI.

NPWS is required to submit applications through their department for aerial baiting of National Park estates so sufficient time should be allowed for processing.

NSW DPI must consider the aerial baiting conditions stated in the current 1080 PCO when assessing the necessity of the proposed aerial baiting program. The history of predation, wild dog sightings and sign, a description of the terrain, the maps and that the proposed baiting is part of an agreed and signed Wild Dog Management Plan, in most cases, is sufficient to justify ongoing aerial bait transects or changes in bait transects.

The mapped bait flight paths must be digitised for the GPS navigation system in the helicopter prior to the aerial baiting program. Bait flight paths may be changed with prior approval of NSW DPI as long as amended digitised maps of the bait flight paths are completed prior to the program.

Approvals are usually sent directly to the applicant, in most cases, either the LHPA or NPWS Regional Manager.

Written approval usually specifies that NSW DPI is sent the flight log from the GPS in the aircraft within three weeks of the aerial baiting operation.

Participating land holders and managers must abide by all the conditions for use of 1080 wild dog baits in the current PCO for 1080 liquid concentrate.

On the baiting day, the LHPA must ensure that all indemnity forms are signed and delete from the maps any areas that are not covered by indemnity forms.

It is the responsibility of the aircraft pilot to ensure that the digitised bait flight paths are uploaded to the GPS, navigation system prior to each bait drop and that bait is placed as accurately as practical along these pre-approved bait flight paths.

It is the responsibility of the applicant to ensure that relevant distance restrictions for the placement of baits are followed, the bait does not exceed the quantities specified in the current PCO for 1080 liquid concentrate and other conditions in the PCO are adhered to.

Where possible, Wild Dog Control Associations should arrange aerial baiting programs to coordinate with neighbouring Associations.



TRAPPING

Trapping wild dogs is best conducted by experienced or trained operators. Only soft-jawed or padded jawed spring traps may be used for the control of wild dogs in NSW.



Figure 32. Victor soft-jawed trap. (Photo David Croft)

Traps are best used in conjunction with other control techniques and may be very effective after a coordinated baiting program to control wild dogs that did not pick up a bait. Trapping is often the only means of removing some problem dogs.

Wild dogs often use well known paths to travel around their territory so the best place to set a trap is either on or near a regular dog path. Wild dogs scent mark these paths with urine, so trappers may use trained dogs to identify fresh wild dog sign and place their traps. Wild dogs may be attracted to the trap location by using a lure. Research has shown that the most attractive lures for wild dogs contain dog urine. Manufactured lures, including FeralMone™ SFE have been developed to attract wild dogs and foxes.

Trappers also set traps on scratchings known as 'rakes'. Setting traps around old animal carcasses or with food lures is not recommended because it tends to attract other non-target species such as quolls, goannas or birds.

Wild dog traps should only be anchored to stakes or fixed objects if there is a shock absorbing device such as an in-line spring fitted to the short anchor chain, approximately 50 cm and a swivel attaching the chain to the trap. Alternatively the trap may be tied to logs or objects, known as 'drags,' with approximately 2 m of chain that will move when the dog pulls against the trap. These techniques are designed to prevent unnecessary injuries.

Traps should be visited at least once each day. It is preferable to set traps at the end of each day and check them in the morning. Where daily checking is impracticable strychnine cloths available from LHPA's, may be wrapped around the jaws so that wild dogs die quickly, rather than from exposure or thirst.

Trapped wild dogs should be euthanased as quickly as possible by a single shot to the brain.





Figure 33. Trapped wild dog. (Photo David Croft)



Figure 34. Trapped dog that died from a strychnine cloth. (Photo unknown)

SHOOTING

Shooting may be effective in situations where wild dogs are known to be in the area. A shooter may be able to 'howl up' the wild dog or dispatch an animal that has established a regular pattern of visiting a particular paddock.

Electronic callers, predator calls and trail/game cameras can be used to increase the numbers of dogs shot.

Most shooting however is opportunistic. Shooting can play an important role in controlling wild dogs, but usually does not have as significant an impact on a regional basis as poisoning.



FENCING

Barrier fencing may include conventional and electric fencing, Figure 35, or electrified outriggering of conventional fences. Barrier fencing may only provide an effective barrier to wild dogs providing it is adequately maintained.

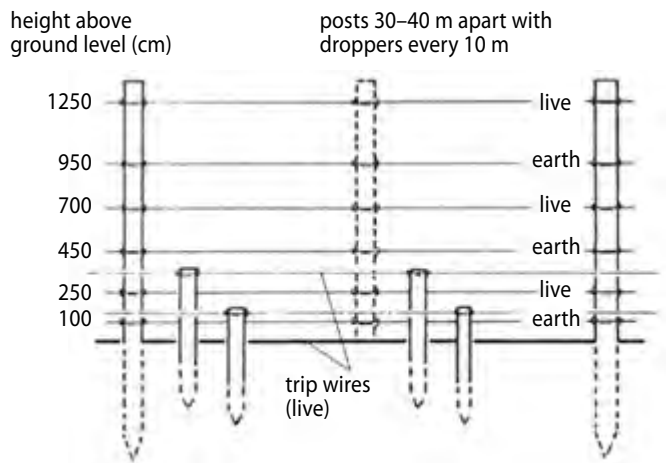


Figure 35. Recommended electric fence for feral animal and wildlife control.

Conventional fences are generally not as effective a barrier as kangaroos, wombats and feral pigs quickly create holes in the fence, leaving an opening for a wild dog. Two electrified outriggers on fences can be a more effective barrier. When designing electric fences it is important to consider the behaviour of wild dogs. As a general rule, wild dogs prefer to push through, push under or dig under the fence.

Most land managers upgrade existing old fences with electric outriggers or construct a much cheaper all-electric fence. Electric barrier fences are of particular help when a property adjoins wild dog habitat or when neighbours neglect control.

Regular maintenance and the incorporation of a monitoring system into the fence will assist supervision.



Figure 36. A well constructed and maintained dog fence. (Photo Peter Fleming)



LIVESTOCK GUARDING ANIMALS

Guard dogs have been used for centuries in Europe to protect sheep and goats from wolves and, more recently, in America against coyotes. Guard dogs take many forms and the Maremma is the most common breed. They have certainly proved successful against foxes and increases in lambing rates of 10%–20% have been cited.

Recent research indicates when properly trained and maintained, guard dogs have a high fidelity to the fields where they are placed. Poor training and inadequate feeding of guard dogs however may contribute to predation problems instead of lessening them.

Guardian dogs are susceptible to 1080.

Other animals such as llamas and donkeys have been used to protect livestock on some properties.

Dog control in town areas

Individual dogs or dog packs, wild or domestic creating a nuisance within a town or village are the responsibility of the local government.

FURTHER READING

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Further information is also available on the internet at www.feral.org.au



Fox biology & control

FOX BIOLOGY

The red fox is a small to medium sized, burnished rusty red coloured canid. Closely related to domestic dogs, the adult European red fox (*Vulpes vulpes*) weighs about 5 to 9 kg with males generally heavier than females and from 700 mm to 1000 mm in length including 300 mm to 350 mm of bushy red tail. The red fox is an athletic animal that can run, leap fences and with partly retractable claws, climb fences and some trees.

Origin and distribution

There are 11 species of fox worldwide, occurring naturally in North America, Europe, Asia and North Africa. The European red fox is the most widely distributed species and was introduced into many countries including Australia in 1845. In Australia, other successful releases followed in southern Victoria in the 1870's and within 20 years, the red fox had achieved pest status. The expansion of the red fox population across mainland Australia followed the spread of its favourite prey, the rabbit. Their distribution on mainland Australia may be still expanding northwards into the tropics, having reached the Tanami desert in late 1970's and now common around Tennant Creek in the Northern Territory. Foxes are limited by the heat and humidity of the tropics and the northern boundary probably fluctuates with the seasons.

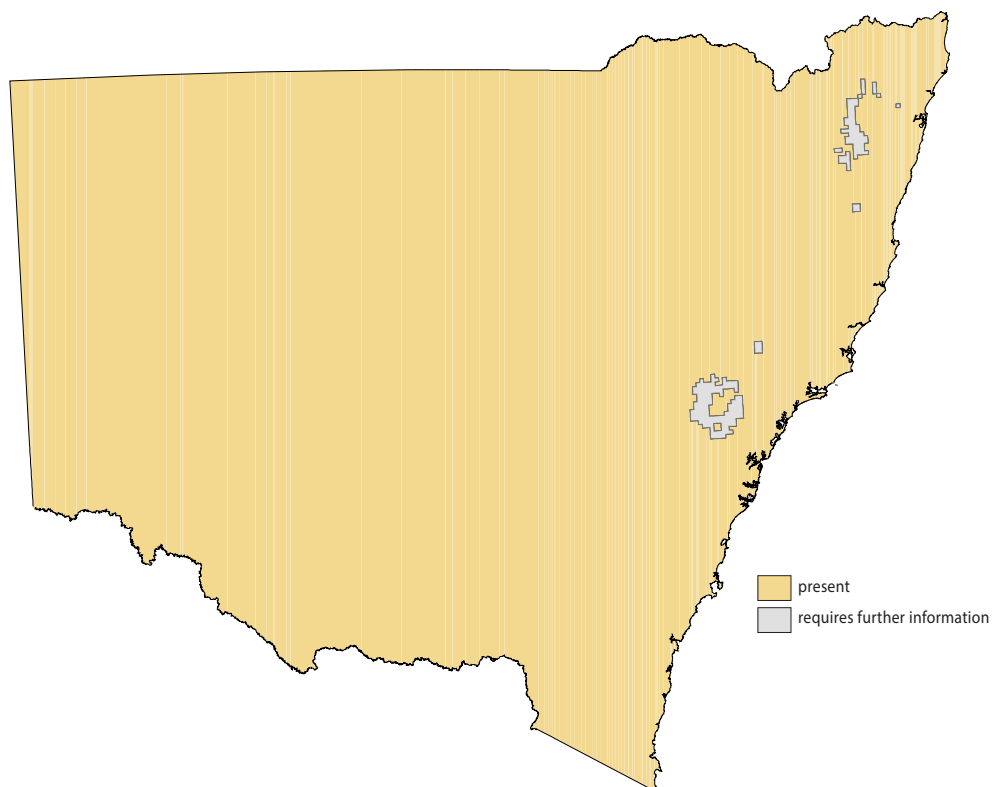


Figure 37. Historical spread and distribution of the red fox. Saunders et al 1995.



Tasmania was the only state where foxes were not introduced or were unsuccessful possibly due to the more aggressive Tasmanian devil. There have been sporadic reported sightings and the odd carcase of the red fox found in Tasmania over the years particularly around ports. With the decline in Tasmanian devil numbers due to disease there is concern that they may be able to successfully breed and colonise.

In NSW, the red fox is favoured by the fragmented landscapes common in all districts that provide shelter, food and den sites. Densities vary from around 1/km² in the coastal forests, 2 to 5/km² in the semi-arid and subalpine regions and 6 to 8/km² in the temperate grazing lands that cover most of NSW. Populations of the red fox are well established in peri-urban and urban areas where food is abundant and densities may range from 16 to 60/km².

Behaviour

The red fox is territorial and continuously mark their home range with urine, faeces and anal scent to warn off other intruding foxes. Scent marking is used to indicate to other foxes the sex and breeding status of the fox. Fox territories range from 2 to 5 km² and vary with type of habitat, population density of foxes and availability of food. Foxes form family groups comprising a male or dog and vixen with helper vixens from the previous litter. They usually move within their own territories but may travel up to 25 km when food is scarce. Fox territories may overlap at times during the year, however, most family groups defend the territory against other foxes.

Breeding

Females come into oestrus for 2 to 3 days over 2 to 3 weeks in winter. Males are fertile throughout winter and early spring. Gestation lasts 51 to 53 days and a litter of 3 to 5, bluey grey cubs is born in the den. Weaning occurs at 4 to 6 weeks by which time most of the grey colouring has gone.



Figure 38. The red fox cub is grey



The young appear from the den in late spring, at about 6 weeks of age. During this time daytime activity by adults feeding cubs is common. The cubs leave the den at about 10 to 12 weeks and by 6 months of age, are independent. Both sexes reach sexual maturity in their first year. Where there is low mortality in the family group, a proportion of the female population may not breed. These helper vixens may assist to raise the cubs. Once foxes are independent they begin to move or disperse out of the family group to find, establish and mark new territories. Most dispersal is within about 30 km, however, long distance dispersal of over 300 km is known to occur. The inherent ability of the red fox to rapidly establish new territories over short or long distances ensures they are perfectly adapted to compensate for any population decline due to control programs.

Food

By day, the red fox usually rests in a hide, this may be a hollow log, tree, an enlarged rabbit burrow or dense undergrowth. By night they hunt and patrol their territory. The red fox is best described as an opportunistic predator and scavenger. Largely carnivorous, foxes eat a diet of 300 g to 450 g/day of small prey in the weight range of 5 to 15 kg, including native animals, birds, rabbits, house mice and carrion. They readily eat fruits such as wild blackberry and insects such as scarab or 'Christmas' beetles. Fox scats may be identified by the amount of beetle residue present at different times of the year. When food is abundant, foxes will often bury or 'cache' excess food. When food is limited in winter, cached food may be recovered.

Impacts

Fox predation is recognised as having a serious impact on many native animals, and is considered to be a major contributor to extinction of some species. Species impacted include: brush tailed and yellow footed rock wallabies, bettongs, numbats, mallee fowl, pied oyster catcher, little tern, plains wanderer, bush stone curlew and the Murray river tortoise. There is also little doubt that foxes have an economic impact on sheep, goat, poultry and cattle enterprises.

Fox predation is listed as a KTP in NSW and a threat abatement plan has been prepared see www.environment.nsw.gov.au/threatenedspecies

Mortality

Diseases such as distemper, parvo virus, sarcoptic mange and predators such as wild dogs, eagles and snakes have an influence in controlling the fox population, however, the greatest single mortality occurs with targeted control programs. Rabbit control programs may reduce fox impact by reducing food supply.

CONTROL

Reducing the impact of the red fox relies on a mixture of control techniques comprising poison baiting, shooting, trapping, fencing and guard animals. All these techniques have a short term effect on local fox numbers. No single control method will be successful on its own and when foxes are removed from an area, reinvasion or immigration from existing untreated areas generally occurs within 2 to 6 weeks.

The most efficient way to reduce the impact of foxes is to conduct a strategic coordinated program over a number of land holdings.



Poison baiting

The poison, 1080 is used for fox baiting programs and is regulated by the 1080 PCO.

Note: Domestic, working and pet dogs are the most likely non-target animals to be affected by fox baiting and they must be restrained for the duration of the program. If showing any symptoms of poisoning they must receive urgent and immediate veterinary attention.

The fox baiting program

Most fox control programs are coordinated in association with the local LHPA and may involve local landholder groups, Landcare, Catchment Management Authority coordinators or other organisations.

The aim should be to have a large group of land managers reduce the impact of the red fox over as much of the landscape as possible in autumn and spring, the period of time most critical for the survival of offspring of sheep, goat or threatened species.

The groups need to decide when to bait, how long and how often. Once that is decided, the coordinator organises the number of baits, type of bait, the distribution and the signing of forms.

Baits should be placed near fences and tracks in the target area and throughout the paddocks. Foxes have an exceptional sense of smell and will locate baits over a wide area.

Buried baits are less likely to be removed by birds, attacked by ants, taken by other species such as feral cats or quolls, keeps fresher for longer periods, especially during summer in central and western NSW and more likely to rapidly degrade if left on site.

Bury baits at 200 to 500 m intervals. Placing too close together only encourages foxes to eat more and waste baits, use about 50 baits per 400 ha. Dig a small hole using a spade or mattock, insert spade into the soil and lever back about 50 mm, drop in the bait and lever the hole shut. Baits may also be tied to a fence. To reduce non-target impact, such as quolls, bury bait about 10 cm deep. Dragging carcasses along a trail only encourages foxes to follow the trail and eat multiple baits. One bait is sufficient to kill a fox.

Foxes are not frightened by human scent.

Bait at least a week before the period of highest impact, be that lambing, kidding or the presence of young of a threatened species. Continue poisoning at weekly intervals until bait uptake is minimal. Repeat baiting again if foxes migrate into the area.

Bait sites should be marked. Bait take may give an idea of fox activity, however, results can be misleading if one fox is eating multiple baits. All baits not taken should be collected and buried according to the current 1080 PCO.

Bait stations without poison may be set up in sensitive areas to monitor the activity of non-target animals.

Spotlight counts using the method described in *Monitoring Techniques* section of this Manual before and shortly after baiting may determine if there was a reduction in fox numbers. The impact of fox predation may still be high if one fox is causing most of the damage.

Rabbits are the main prey of most foxes. A coordinated rabbit control program should assist to suppress the red fox population.



M-44 ejectors

M-44 ejectors are used with cyanide in the USA where conventional meat and manufactured baits containing 1080 pesticide are banned. The M-44 ejector is a spring loaded pesticide delivery device buried in the ground with an attractant attached. An animal pulls up on the attractant triggering a spring loaded plunger that punctures a capsule of 1080 pesticide and propels it into the animals mouth. These devices have been trialled with some reasonable results, however, comparisons between conventional baiting techniques are scant. The only advantage of this method over others is that baits deteriorate within 2–3 weeks and provided nothing pulls the trigger, the M-44 is probably available for longer.

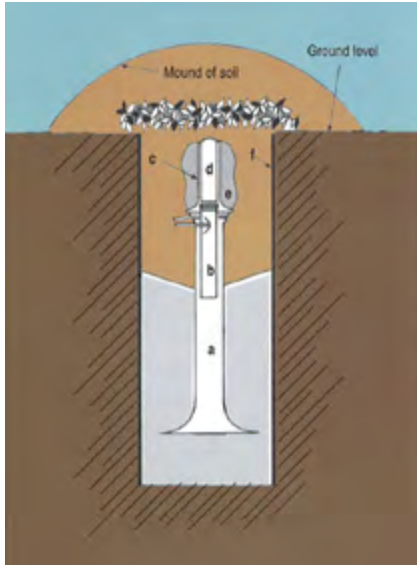


Figure 39. M-44 ejector: (a) hollow metal stake, (b) M-44 ejector, (c) bait holder, (d) 1080 capsule, (e) bait, (f) plastic tube. Copyright CSIRO 2004

Electric fencing

The red fox may be dissuaded from accessing some fields by use of electric fencing. Existing conventional fences may be upgraded by two offset live wires. One about 200 mm from the ground and about 200 mm offset from the fence and another near the top of and offset a similar distance. These wires should prevent foxes going under or over the fence. Any conventional 6 or 7 wire electric fence is effective provided the wire spacing prevents foxes from running through or crawling underneath. Foxes may go over a fence at ramps, stays, posts and under or over gates. Effective fox proof exclusion fencing for threatened species colonies is very expensive. A typical example from Western Australia consists of rabbit netting 2500 mm tall with 600 mm curved overhang supported by wires and 600 mm of foot netting on the predator approach side and offset electric fencing to keep both foxes and other animals such as wombats and kangaroos from damaging the fence. Unfortunately, some burrowing threatened species want to dig out of the enclosed area.



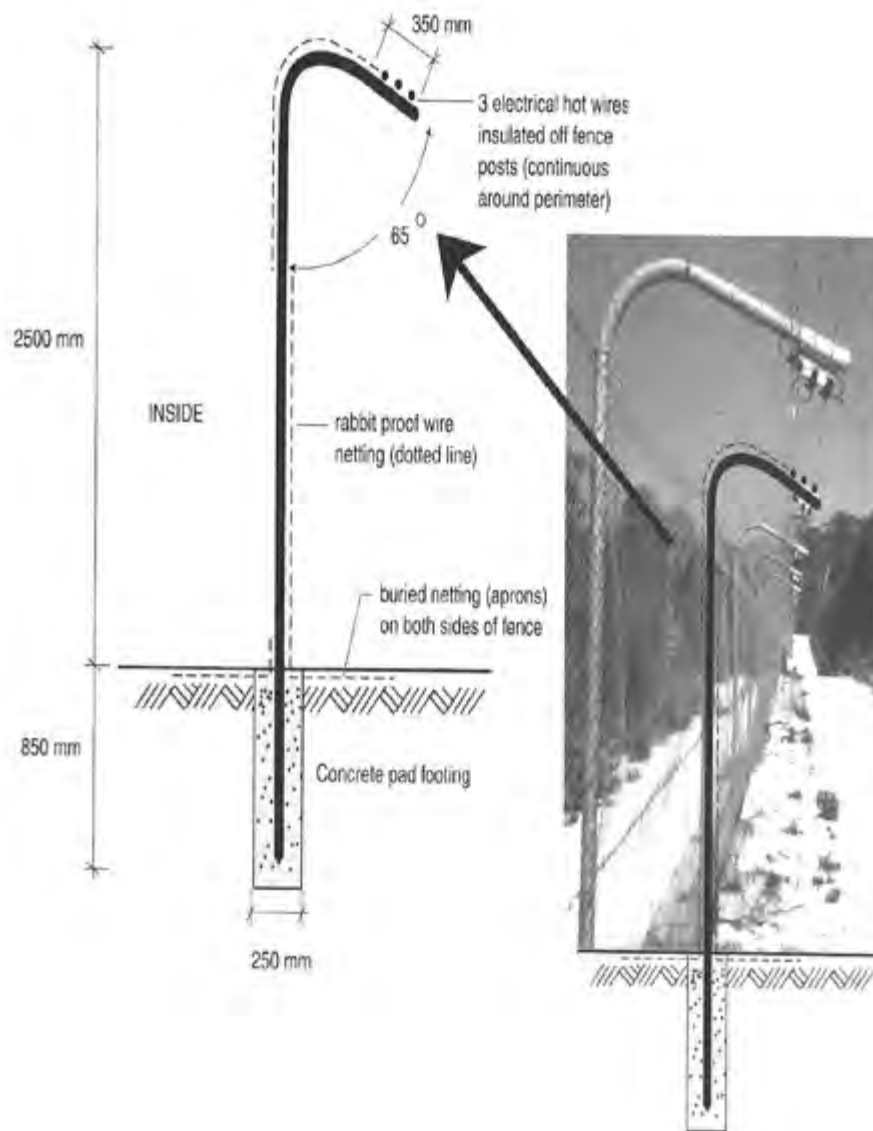


Figure 40. Fox exclusion fence Western Australian Department of Environment and Conservation in Narrogin District. Source: Brian MacMahon, WA DEC

Shooting

About 13% of respondents to a survey in NSW used shooting as the main technique for fox control. The next highest rated technique was baiting at 77%. Group shooting programs and fox drives or battues can be effective. Shooting provides a viable alternative in areas where foxes will not eat baits, baiting is not feasible or not a preferred option. Artificial distress calls may be used to call up foxes to within shooting range. To reduce welfare issues with injured animals a high velocity rifle fitted with a telescopic sight is recommended during both day and night. At night a spotlight of at least 100 W is necessary.



Trapping

The use of both cage traps and leghold traps for capture of the red fox is successful if time consuming. Both leghold traps and cage traps are suitable for use around dwellings and built up areas where poison baits cannot be used.

Foxes use scent trails to mark their territory. Leghold traps may be set where domestic dogs locate these scent marks. Leghold traps with padded jaws must be used and an attractant scent placed on an object nearby.

Cage traps are most successful in towns and around houses where foxes are stealing pet food or poultry and where landholders object to poisons and shooting. Cage traps should be relatively large, 1200 mm x 500 mm x 500 mm to reduce the impression of entering a confined space. The trap must be pegged down to prevent the fox rolling it over and releasing the door and the wire floor should be covered with soil. It may be necessary to try different bait types in an area to determine the most attractive. One of the more successful baits for cage traps is chicken fast food or rabbit. One advantage of cage traps is that domestic pets and non target animals captured in the trap can be released unharmed. All traps should be well concealed and well away from public gaze.



Figure 41. Fox caught in a cage trap. Source: CRESTVIC

Guard animals

A number of species of animals including llamas, alpacas, donkeys and dogs have been used to protect animals from fox predation. Guard dogs have been used very successfully to protect cattle, sheep, goats, poultry and fairy penguins from foxes.

Habitat manipulation

Non-lethal strategies suggested to deter fox presence include the destruction of dens and harbour such as weed infestations, fallen timber and rubbish sites. The destruction of other food sources, particularly carcasses and management of food for domestic working dogs and pets should further reduce fox activity.



FURTHER READING

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Further information is also available on the internet at www.feral.org.au



Mouse biology & control

MOUSE BIOLOGY

Origin

The house mouse, *Mus domesticus*, originated near the present border of Iran and the former USSR. Mice quickly spread to Europe and subsequently throughout the world. They were probably introduced into Australia by the early settlers and, like most introduced animals, took an immediate liking to the country. With an ability to live on a wide range of foodstuffs, mice were able to accompany people as they explored and colonised.

Distribution

The house mouse is not restricted to houses or buildings. They are found throughout NSW in almost all habitats and have adapted to a wide range of environmental conditions. More importantly, they are common on all agricultural lands and particularly cereal and summer cropping areas.

Characteristics

Mice are normally light brown to dark grey on the body, with a light cream belly. Adults have a body length of about 75 mm and weigh up to 30 g. The tail is about as long as the body and is almost hairless. In relation to their body, the ears are large and the eyes and feet are small. The long whiskers or vibrissae are very sensitive and are used as sensors when moving about in the dark.

Mice have prominent incisor teeth that grow continuously: the length of the teeth is controlled by gnawing. Material may be gnawed yet not tasted or swallowed, so it is difficult to devise a repellent coating against mice. The house mouse is distinguished from Australian native mice by:

- its teeth. The house mouse has a well-marked notch or ledge behind the tip of the upper incisors into which the lower teeth fit. Native species have smooth chisel edges
- the number of nipples on the female. Native species have only four teats whereas the house mouse has at least one additional pair of thoracic or chest nipples.





Figure 42. From very few, mouse numbers can build up rapidly. (Photos David Croft)

Food

Mice consume a wide range of foods, eating 3 to 5 g daily. In a field situation, mice survive on the seeds of native grasses and thrive on introduced cereal grains. In food storage areas their diet can include cereals, other grains, vegetables, meat, fish, nuts, cheese and non-rancid animal products. They are attracted to foods such as rolled oats, peanut butter, vegetable oils, pumpkin seeds and molasses. When selecting a bait type, it is important to know that mice will sample all foodstuffs within their range, but may not return to a particular feed type for many days.

Water

Mice can successfully live and breed without free water if the moisture content of the food is at least 15%. Where mice live in sheds and areas where the food supply has a low moisture content, they need 1 to 2 g of water daily to survive. In these situations their activity can be limited by cutting off their access to water.

Reproduction

Mice can start breeding at 6 to 10 weeks of age and produce 10 to 12 litters per year. The gestation period is 19 to 21 days, with the female re-mating almost immediately after giving birth. Young mice begin eating solid food at 11 days and are weaned at 21 days of age. They have a life span of 1 to 2 years.





Figure 43. A mouse nest. (Photo David Croft)

Litter size is generally five or six but can be up to 10. The young are born hairless and blind in a nest of collected materials such as grass, paper, hair, cloth remnants or anything soft that is available.

If there is no infant mortality, one breeding pair of mice could theoretically produce 500 mice within 21 weeks.

In Australia, mice living under field conditions have a seasonal pattern of breeding. This generally begins in early spring and continues until cold or wet conditions develop in late autumn. Mice living in unfavourable seasonal conditions may have a shorter breeding period, while those with nests in the warmth of buildings or haystacks are likely to have an extended breeding period.

Plagues

Mouse plagues tend to occur when there is plenty of food and water available, environmental temperatures are not extreme, soil is moist and easy to dig, nesting conditions are favourable and diseases, parasites and predation are at a low level.

Mouse plagues seem to be increasing in frequency, possibly because of changes in agricultural practice. There has been a marked increase in the number of crops grown under irrigation, as well as a change to follow-on summer/winter cropping. In some of the areas with available irrigation, it is not unusual to grow two summer crops that mature at different times and then follow with a winter cereal crop.





Figure 44. Mouse climbing to a nest in a brick wall. (Photo David Croft)

Behaviour

Mice are most active at night but can also be seen during the day, particularly around buildings or areas with adequate cover. Their home range is limited to an area of about 5 m² in closed buildings, but in crop situations, with available food and water, the home range may be even less. Young mice are forced to seek new areas during periods of high breeding and this is one of the factors associated with the development of a plague. When mice move, they tend to follow the same path from refuge to feeding area. Paths are often confined to walls, pipes or natural barriers, so the tell-tale smear marks can be an indication of mouse activity. In the field, distinct tracks through the vegetation become obvious.

Mice can swim and remain under water for lengthy periods. They can dig, jump upwards at least 30 cm, jump downwards at least 2.5 m without injury and squeeze through openings as small as 8 mm in width. In addition they can climb almost any rough surface, climb upside down and run down ropes and coated electric wires.

Predators

As with all pest species, predation may play a role until there is a rapid population build-up. Predators are unlikely to have any effect on numbers when there is a mouse plague. A noticeable increase in the number of predators in an area may indicate a large increase in the mouse population.

In south-eastern Australia the main predators of mice are foxes, feral cats, snakes, falcons, owls, kites, kestrels, hawks and kookaburras. The presence of itinerant bird species such as the black-shouldered kite is a good indicator that mouse populations may be increasing. Domestic cats have no impact on mouse populations, contrary to popular myth.



Disease

Although disease can cause a sudden decline in mouse numbers, marking the end of a mouse plague, declines in numbers occur mainly when mice are stressed from restricted food and shelter. It is more likely that overcrowding will allow parasite infestations to develop and contribute to the spread of disease. A CSIRO research project is still trying to identify any disease or parasite occurring in mice that could be enhanced as a biological control agent.

MICE AS PESTS

Mice are commensal rodents, they live with humans, adapted to living in houses and buildings. Most farm buildings have a few mice. In the field, mice are always present but mostly in low numbers. Refuge areas such as channel banks and the more densely vegetated pastures are ideal habitat where detection is difficult. Poultry and pig sheds or grain storage facilities are also favoured, particularly if the soil can be excavated easily.



Figure 45. Mouse runways in pasture. (Photo David Croft)

Sown crops

Mice cause damage to almost all sown crops, no matter whether they are winter or summer crops or seeds of cereal, oilseed, maize or pasture. By digging into the loose soil immediately after sowing they are able to establish nests and feed on the seed or newly emerging seedlings.

Most crops suffer damage prior to seedling emergence and when the grain or seed begins to mature. However, in cereal crops such as wheat, mice chew the growing nodes of the plant and can stop the development of the head or cause the stem to collapse.

In recent years there has been major mouse damage to wheat, oats, barley, soybean, maize, sunflower, sorghum, rice, lucerne and other legume seed crops, as well as to horticultural crops like melons, pumpkins and tomatoes.





Figure 46. Mouse damage to corn. (Photo Reg Eade)



Figure 47. Mouse damage to tomatoes. (Photo Reg Eade)

Stored produce, buildings and machinery

Mice will be active in most farm areas where produce is stored. Normally, there may be little pressure put on such storage until there are mice in plague numbers that will test security to the limit. Mice can find the smallest hole and work on it until it is large enough to allow entry. During a plague it is difficult to maintain the mouse-free status of any facility unless there has been a mouse-proof component incorporated into the initial design and construction.



In machinery sheds mice can cause major damage to vehicle electrical wiring, upholstery and electric motors. Damage to plastic and rubber components, can cause machinery failure.

Human and animal health

In Australia mice carry a variety of infectious diseases which may be transmitted to humans and other livestock, including:

- Bacterial infections – Leptospirosis, *Leptospira celledoni*; Lyme disease, *Borrelia burgdorferi*; melioidosis, *Pseudomonas pseudomallei*; salmonellosis, *Salmonella* spp.; *Streptobacillus moniliformis*; *Spirillum minus*; *Campylobacter* spp. and *Leptospira icterohaemorrhagiae*.
- Fungal infections – Ringworm, *Trichophyton* spp.
- Viral infections – Ross River virus
- Rickettsial infections – Queensland tick typhus; scrub typhus (mite transmitted)
- Parasitic infections – Fleas; mites; tapeworms; nematodes, *Physaloptera* spp.
- Protozoan infections – Pneumocystosis; toxoplasmosis, *Toxoplasma gondii*. (Caughley et. al., 1998)

In particular, mice can transmit salmonella to one another, to humans and to domestic animals; encephalomyocarditis virus to pigs; fungal skin diseases (ringworms) to cats and humans; and leptospirosis to humans and domestic pigs.

INTEGRATED MOUSE MANAGEMENT

Integrated pest management is the key to effective mouse control. Control is most likely to be effective if a number of management techniques are combined. A range of options are outlined below.

Strict baiting and safety procedures must be used to minimise the risks and hazards associated with using bait. The rate of application of zinc phosphide is 1 kg/ha to achieve an even coverage of 2-3 grains/m². At this rate there should be sufficient bait to kill about 10,000 mice/ha.

ULTRASONIC

There have been a number of ultrasonic devices promoted to either repel or reduce the number of mice in buildings. There is no scientific evidence to show that ultrasonic sound can prevent or control damage by any vertebrate pests including mice.

The physical properties of ultrasonic sound make this technique unreliable. First, ultrasound diffuses rapidly in open space, what begins as a scream may deteriorate into a whisper in just a few metres. Second, ultrasound is very much 'line of sight', so pillars, building supports or stored produce will block the sound waves. Also, in many situations the cacophony of other noises will mask the distracting ultrasonic sound to be little more than background noise.

In the absence of rigorous scientific testing, it is a case of 'buyer beware' when considering ultrasonic sound repellent devices.



PHYSICAL

Mouse control should be part of an organised and ongoing program aiming to reduce damage caused during a plague. Mouse-proofing facilities, grazing or mowing irrigation channel banks, keeping rubbish around farm buildings to a minimum and general good farm hygiene should reduce the potential for a rapid and unexpected mouse build-up.

Once mice are in plague numbers, farmers can do little to control mouse populations. Mouse numbers explode when food, temperature and nesting conditions are favourable, but there are a number of control options that are available when a plague is imminent.



Figure 48. Mouse cage trap – multiple catch. (Photo David Croft)

Barriers

Unless the building has been constructed with good concrete foundations and sheet metal barriers, the cost of erecting barriers at a later time has to be weighed up against the potential value of any loss. The costing involved at construction of mouse proof barriers would need to include foundations, walls, floors, doors and windows, roof and eaves, sewerage and drains. Details on mouse-proofing are available from the major pest control companies and the Grains Research and Development Council (GRDC).





Figure 49. Shed with galvanised barrier. (Photo David Croft)

Traps and deterrents

Trapping will have little impact on mouse numbers in a mouse plague. The use of snap-back traps, water-filled drums and other ingenious devices may be useful early in a plague to reduce invasion of a home or to monitor the rate of increase during a plague. If using such traps, the most attractive baiting material is a small patch of leather or felt soaked with peanut butter, linseed or any other vegetable oil and secured to the trigger plate. Bacon rind, pumpkin seeds, raisins or cheese securely fixed on to the trigger plate also works well.

Although numerous physical and chemical deterrents have been suggested for repelling mice, none have proved to be successful. Ultrasonic devices and coated or impregnated wires have been extensively tested in Australia and overseas and have not been found to have any value in repelling mice.

Further research on repellents or deterrents may result in the eventual production of an effective rodent repellent in the future.





Figure 50. Mouse in snap-back trap. (Photo David Croft)

Raptor perches

Some of the predatory birds such as the black-shouldered kite, the Australian kestrel, the brown falcon and owls are known to be effective in hunting and catching mice.

The Vertebrate Pest Research group studied the effect of placing perches for raptors in paddocks that were susceptible to mouse damage. Results indicate that these perches significantly increased the number of daytime raptors visiting and hunting over these crops. This reduced the rate at which the mouse population increased and then limited the maximum mouse population density; the use of these perches to attract birds of prey could be another valuable management tool.

Perches were 3 m high and were best placed at 100 m spacing around the crop perimeter.

POISONS

Small-scale

The use of poisonous bait around buildings and storage facilities may be relatively successful for controlling small populations of mice. However, once mice begin to plague and the numbers of dead mice appear to be increasing, there may be little or no effect on the overall population. Most of the poisons available are anticoagulants, which are safer than acute poisons, for use around humans and domestic animals, except pigs, which have very low tolerance to anticoagulants.

There are two broad categories of anticoagulants; the indandiones and the coumarins. Both are registered in Australia for rodent control.

Indandiones include:

- pindone.



Coumarins include:

- bromadiolone (Bromakil®)
- brodifacoum (Talon®)
- coumatetralyl (Racumin®)
- flocoumafen (Storm®)
- warfarin (Ratsak®).

Anticoagulants are marketed as grains, pellets, blocks, powder or liquid. They are used as either a bait, drink or tracking powder. All products are available in small or bulk quantities for immediate use.



Figure 51. Mouse baits. (Photo David Croft)

Large-scale (broad-acre) baiting

There is still much debate about the effectiveness of large-scale baiting to protect crops from mouse damage. Although research has indicated that there is little reduction of damage, most land managers would consider that perimeter and spot baiting does reduce long-term damage.

Bromadiolone

Bromadiolone (Bromakil®) is registered in NSW for mouse baiting, but only as crop perimeter bait (PER11331, expiry 30.6.16).

Zinc phosphide

Zinc phosphide is a registered rodenticide available as MouseOff®, SureFire®, ZP® Mouse, GenFarm Zinc Phosphide Mouse Bait and Oztec Zinc Phosphide Bait and is applied in crops for the control of heavy infestations of mice in agricultural situations. Bait can only be applied by aerial application or accurately calibrated ground application equipment.





Figure 52. Mouse dead from zinc phosphide baiting. (Photo David Croft)

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Further information is also available on the internet at www.feral.org.au



Feral goat biology & control

BIOLOGY

Origin

The goat, *Capra hircus* was one of the first animals to be domesticated, eight to ten thousand years ago. The origins of the wild goats, *Capra aegagrus* extend around the dry hills of the Mediterranean basin, including Turkey, Iran and Pakistan.

Goats arrived in Australia with the First Fleet in 1788. They were a convenient livestock animal for early European settlers, being relatively small, eating a wide range of plants and providing both meat and milk. The present feral goat populations are descendants from animals introduced for a variety of reasons since 1788. During the 19th Century, sailors released many goats onto islands and the mainland for emergency food supplies. Cashmere and Angora goats were imported in an attempt to start a fibre industry in Australia. Goats were spread around Australia by settlers, railway construction gangs and miners who used these domesticated animals as a source of milk and meat. These domestic goats escaped, were abandoned or were deliberately released and established feral herds.

Distribution

Feral goats are found in many areas of NSW, including arid and semi-arid rangelands, as well as higher rainfall and agricultural areas of eastern NSW. They have benefited from sheep grazing practices and the provision of artificial water points throughout the dryer regions of NSW.

Feral goats are widely distributed through the western division, locally abundant in the northern and central slopes and scattered throughout the tablelands and coastal regions of NSW, Figure 53.

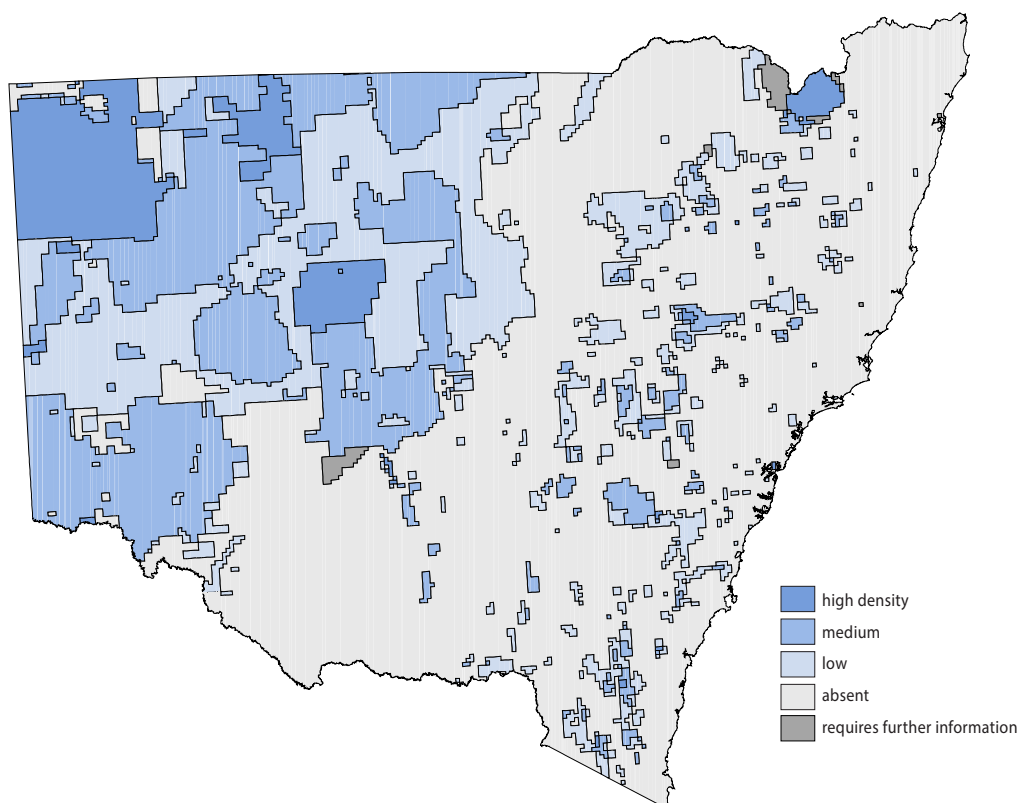


Figure 53. Feral goat distribution and density map (2009).



Habitat

Feral goats are most common on rocky or hilly country in the semi-arid rangelands. These areas provide security from predators and disturbance by humans. Goats are not normally found on flat treeless plains, but can be found on flat country with dense shrub cover. Favourable habitat requires availability of shelter, surface water and an abundance of preferred food species. Large numbers of goats do not occur in areas where dingoes are abundant.

Diet

Goats are generalist herbivores that select the highest quality food available. They eat foliage, twigs, bark, flowers, fruit and roots. They will also eat plant litter, seeds and fungi. Goats can eat the majority of plants in the pastoral zone of Australia, including prickly acacia, many poisonous or bitter plants and species avoided by sheep and cattle.

Though goats will eat just about anything, they are highly selective feeders and specific shrubs, grasses or herbs may comprise the principal part of the goats diet at different times or at different locations.

During dry times goats need to drink water. An average-sized goat will drink between 2 and 4.5 L of water per day, depending upon temperatures, humidity and reproductive status. Some goats, particularly those in temperate or wet climates, can obtain most of their water requirements from their food and can survive in areas with no permanent fresh water.



Figure 54. Goats on a water trough in trap yards. (Photo Peter Fleming)

Breeding

Conception occurs in feral goats in pastoral areas of NSW in all months of the year, but the peak rate occurs from late summer to mid winter. This coincides with the optimum conditions for survival of the mother and young. Breeding rates are influenced by rainfall and, in semi-arid areas, most kids are produced in the cooler times of the year. In the temperate region, kids are born throughout the year.



In drier districts, all sexually mature females in a herd may come into oestrus at the same time and it is thought that this is synchronised by male sexual activity. This can reduce the effects of predation by having a glut of potential victims in the form of young kids all of the same age.

Females can begin breeding at 6 months of age or when they weigh over 15 kg. Males reach sexual maturity at approximately 8 months, but competition for access to oestrus females is fierce and it is unlikely that young males are able to mate until they become large, dominant individuals.

Females may become pregnant in their first year and can become pregnant again soon after giving birth, as lactation does not stop oestrus or pregnancy. Therefore, they can breed twice in a year, as their usual gestation period is only 150 days. Twins and triplets are common, although it is very rare for all three triplets to be raised to independence. At any time in the high rainfall zone, between 16 and 53% of females have kids at foot. The average litter size is 1.3 kids per female.

Females that are about to give birth leave the group and give birth in a protected spot. Kids are fully active soon after birth, but most, although not all, are hidden by their mothers and visited only for feeding. A few days after birth they join the mother on her travels. Females may then remain separate from herds containing adult males for 1 to 2 months.

Mortality

The mortality rate of kids from birth to 6 months is high. Natural mortality rates amongst older goats are unknown but assumed to be about 10%. Adult mortality rates, from all causes including hunting and harvesting are about 26% in temperate regions.

Wild dogs, foxes, wedge-tailed eagles and feral pigs are all predators of feral goats. Wild dogs are the main predators of adult goats and appear to affect feral goat distribution. In northern Australia, goats are rarely present unless wild dogs are absent or controlled to low densities. Foxes are the main predators of feral goat kids in eastern Australia.

Goat populations can rapidly replenish after vigorous control programs. High levels of removal of feral goats from a population may increase survival rates and result in a faster than normal rate of increase. Goats have the potential to double their population every 1.6 years in the absence of mortality caused by human control efforts and predation.





Figure 55. Feral goats as a resource. (Photo David Croft)

Social structure

Feral goats are social animals and are found in herds, the basic social unit being adult females and their recent offspring. The males leave these matriarchal groups to form loose associations with similar aged males or larger mixed-aged groups, which associate with the female's home range during the breeding season but range over larger areas at other times.

Group size within herds of feral goats varies on both a daily and seasonal basis. Much of the seasonal variation seems to be related to the availability of surface water. When water is abundant, groups are generally small and well dispersed. During drier months, groups come together and increase in size, consisting of both males and females of all age classes. During droughts they tend to congregate in large numbers, 500 to 800 goats and remain near water.

Group composition is highly variable. Feral goats are continually forming, breaking and re-amalgamating herds. Many new associations are formed when congregating around water sources.

Movements and home ranges

A good knowledge of the home range of feral goats is a prerequisite to both the effective management of this animal as a resource and the establishment of appropriate strategies for control.

The size of the home ranges of feral goats vary across Australia, being smaller in areas where food, water and shelter are freely available and much larger in semi-arid pastoral regions. The boundaries of these areas are not rigidly defined and are not actively defended to exclude other goats.



Feral goats in higher rainfall areas with ample water and food have small, non-exclusive home ranges generally of about 1.0 to 13.5 km², with males having larger ranges than females. In pastoral regions goat movements are generally much larger, with non-exclusive home ranges. These are usually centred close to, or around, permanent water. Radio tracking of goats on Yerilla Station, in the pastoral area of Western Australia showed the average female home range was 50 km² ranging from 14 to 118 km². Males averaged 271 km², ranging from 102 to 460 km². Data recorded from the Broken Hill region also confirm similar large home ranges.

Long distance movements of goats have been recorded in semi-arid regions. One male in western NSW moved 87 km in a 10-month period. This degree of mobility makes goat control very difficult, as the rate of reinfestation can be very high. It also makes eradication or containment almost impossible in the event of an exotic disease outbreak. However, feral goats in higher rainfall zones are more sedentary, with few goats moving permanently outside their home range.



Figure 56. Feral goat and sheep interaction – a potential spread of disease and parasites. (Photo Peter Fleming)

AGRICULTURAL AND ENVIRONMENTAL IMPACT

Feral goats may compete with both native animals and domestic livestock for food, water and shelter. During droughts, or if feral goat numbers have not been taken into consideration in terms of total grazing pressure, goats can have a major impact on native vegetation. Goats have very destructive grazing habits, as they can completely strip shrubs of bark and leaves. Goats can destroy the vegetation cover, disturb the balance of species in a vegetation community and spread weeds.

Overgrazing and movements of goats can lead to soil erosion. Disturbance of the soil by the sharp hooves of goats and the characteristic pawing of the ground by males leaves the soil open to the erosive forces of the rain and wind. Goats may compete with native animals for shelter; without protection these animals can be exposed to the heat and become easy prey for foxes and wedge-tailed eagles.



Feral goats can carry internal and external parasites, some of which affect sheep and cattle. Feral goats can carry and spread ovine footrot and could also act as a reservoir for, and be a vector of, exotic diseases, including foot and mouth, rabies, bluetongue and rindepest. This makes them a cause for concern to animal health authorities because of the role they may play if an exotic disease outbreak should occur.



Figure 57. Browse damage to young trees from feral goats, Gnalta Nature Reserve. (Photo David Croft)

Other impacts may include damage to infrastructure, such as fences, damage to heritage sites and economic losses associated with controlling feral goats.

Competition and habitat degradation by feral goats are listed as a KTP see www.environment.nsw.gov.au/threatenedspecies

FERAL GOAT CONTROL

Strategic approach

Ideally, land managers need to understand how goats are affecting resources and impacting on their enterprise so that they can determine how to maximise the benefits of control compared with the costs of the chosen management technique.

A strategic approach to feral goat management at a local and regional level is recommended.





Figure 58. A simple goat trap. (Photo David Croft)

It is important that the advantages and disadvantages of each control method be carefully considered before use and the relevant codes of practice followed. Usually no single control method will be suitable or efficient for long-term sustained management operations and so a combination of techniques must be used.

FENCING

Fencing to control goat movements is expensive and difficult to maintain. Goats are intelligent, inquisitive animals and will test fences. Any faults in a fence will soon be detected. Goats will test the lower wires of a fence or look for gaps created by surface irregularities or wash-outs. Goats can also climb, so fallen timber, rocks and strainer posts make easy escape routes. The electrification of wires with standard energisers has been successfully used to modify existing fences to hold goats.

NPWS research in western NSW has demonstrated that goats rarely travel more than 3 km from a water source and are therefore highly dependant on artificial watering points such as earthen tanks and bores, which have been created to water stock. Strategic closure of on-park artificial watering points, and goat-proof fencing on NPWS boundaries near watering points has significantly reduced immigration into parks from surrounding properties and led to a huge decrease in goat numbers on some key national parks.

MUSTERING

Mustering can reduce goat populations and has the advantage that costs can be offset by the sale of captured goats. Goats can be managed as a resource in this way by balancing impacts with economic returns. Many land managers muster opportunistically when they notice a large group of goats on their land. This can be particularly successful during dry periods when goats congregate in large groups near water.



Helicopter or light aircraft are often used to flush goats out of rough country. It has been estimated that an experienced highly skilled pilot can muster 80% of goats in an area of rough hills. In more open flat country, people can easily herd goats into yards on horse or motorbikes, usually with the help of working dogs.

It is important that before the mustered goats are transported from the property that all requirements and documentation are completed to comply with the National Livestock Identification System. For further advice contact your local LHPA.

TRAPPING AT WATER

Feral goats in semi-arid areas must drink during dry times. Therefore, traps at watering points can be effective methods of removing goats. Traps are goat-proof fences surrounding a watering point and incorporating a one-way gate. Such gates will include spear gates, one-way swinging gates or jump-down ramps.

These traps are expensive to build but can be used over a long period of time and are particularly effective during periods of drought. They can be ineffective where extensive permanent bodies of water are present.

Traps must be cleared regularly to avoid starvation and stress in captured goats. The sale of these goats can offset the building and maintenance costs of these traps.

GROUND-BASED SHOOTING

Shooting feral goats from the ground is most successful in the more open pastoral areas, especially when goats are forced to visit water points. However, too much harassment can prompt some goats to find alternative water sites or to drink at night.

Ground-based shooting can be useful when targeting particular goats. Hunting of feral goats is mainly of recreational value.



Figure 59. Goat trap. (Photo David Croft)



SHOOTING FROM HELICOPTERS

Despite its high costs, shooting from helicopters can be an effective means of removal of feral goats, particularly in rugged terrain. Costs will vary with the initial density, habitat, weather and type of helicopter used. This method has been used to manage goats at both high and low densities. An aerial shoot can be particularly successful for removing survivors of mustering or trapping campaigns. It should be noted that survivors of populations that are repeatedly controlled by aerial shooting become wary of helicopters and, while initial cull rates may be high, as few as 21% of known animals may be culled in later shoots.



Figure 60. Goats from the air. (Photo Peter Fleming)

JUDAS GOAT

The Judas goat technique utilises radio-tracking equipment to locate herds of feral goats. A captured, or 'Judas', goat will be fitted with a collar, to which a radio transmitter is attached. Goats are strongly social species and within a few days the Judas goat will join up with a herd of feral goats. This group can be located with the radio-tracking equipment and shot by hunters, either on foot or from helicopters.

If the Judas goat is not shot it will move away and locate other groups of feral goats. If it is shot, the radio transmitter can be recovered and fitted to another goat, which is then released. Male, female and domesticated wether goats have been used successfully as Judas goats. Sterilized female goats that have had prolonged oestrus induced with hormone implants have been used successfully overseas.

This method is used to find groups that are difficult to locate by normal shooting methods. These are usually low-density populations or goats that have survived other control methods have become particularly wary.





Figure 61. A Judas goat. (Photo Peter Fleming)

POISONING

No poison is approved for use in the control of feral goats in NSW. Poisoning has seldom been successful in attempts to control feral goats because of their large-area movements, the hazards the poisoning techniques pose for non-target species and the difficulty of standardising the bait.

ANIMAL WELFARE

- Goats should not be driven to the point of collapse.
- Use of goading devices and dogs for the handling and movement of goats should be kept to a minimum.
- Transport conditions are prescribed, and if goats are to be transported long distances to abattoirs or ports care should be taken to avoid stress to the animals.
- All shooting must be done in a humane manner, preferably by trained shooters with suitable weapons. Goats must be shot only when in range for a lethal shot and clearly visible.
- Shot animals should be checked to ensure that they are dead and every effort should be made to locate and destroy wounded animals.



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Further information is also available on the internet at www.feral.org.au





Pest birds biology & control

INTRODUCTION

There are over 100 bird species in Australia that can cause significant losses to fruit, nut, grain, rice and aquaculture industries, create conflicts in urban areas, damage infrastructure, reduce aesthetic values, and pose risks to the environment and to human health, Table 4, page 104. For example:

- starlings, sparrows, European blackbirds, silvereyes, parrots and lorikeets, cockatoos, honeyeaters, crows and ravens are the main pests of cultivated fruit, nuts, olives and grapes
- sulphur-crested cockatoos, galahs, corellas and cockatiels are the main pests of coarse grains, pulses and oilseeds
- Pacific black duck, Australian wood duck, grey teal and other waterfowl are the main pests of rice
- cormorants, herons and egrets are the main pests of aquaculture.

Introduced pests, including starlings, common mynas, pigeons and sparrows can damage feed storage areas, feedlots and infrastructure, reduce amenity values and impact on native species.



Figure 62. Starlings roosting on a silo. Introduced species such as starlings can defaecate in food storage areas, raising health concerns. (Photo Brian Lukins)



INTEGRATED PEST BIRD MANAGEMENT

There is a diverse range of options for managing pest birds. They have variable effectiveness and no single solution is applicable to all situations. Bird management is often not initiated until after considerable damage has already occurred. Integrated pest management is a concept well understood for insect and disease problems, but birds are rarely managed in the same strategic way.



Figure 63. A starling nest in a eucalypt hollow previously occupied by an eastern rosella. Starlings and common mynas are known to spoil natural nest hollows, reducing breeding opportunities for native species. (Photo Peter West)

Rather than focusing simply on killing as many pest birds as possible, it is now realised that bird management needs to be carefully planned and coordinated. Bird control is just one aspect of an integrated approach to the management of production. Many birds are highly mobile and can readily replace those that are killed in control programs. Unless actions are well planned and coordinated, most control programs are unlikely to have a lasting effect.

When planning bird management, there are some important steps that should be considered.

What is the problem?

Firstly determine if the problem is real or perceived. If it's real then define the impacts the birds are having. It may be that there are reduced crop yields, environmental or infrastructure damage, declining aesthetic amenity, complaints from neighbours, or emotional stress from worrying about the next attack. Several factors have an impact on each of these problems, and the control of birds is often only part of the solution. The following questions will help define the problem:

- Where is the problem?
- How severe is the problem?
- Will the problem change with time?



Identify the birds involved

Implementing an effective bird control program requires a basic understanding of the ecology and biology of the targeted pest species, and in some cases those species affected directly or indirectly, non-targets and prey species by a control program. It is also essential to understand the impact created by the pest.

Control strategies can be targeted for particular birds. For example, some species, such as silveryeyes and many honeyeaters, are highly migratory, moving into crops only during specific periods. Therefore, out-of-season control may be inappropriate for these species.

Native birds need to be identified because most of these species are protected and permits are required for their control. Furthermore, most native birds are beneficial or desirable, so it is important that management does not affect these species. Conversely, some birds can be both beneficial and pests. For example honeyeaters members of the Meliphagidae family can become a more serious problem in orchards during seasons of poor *Eucalyptus* spp. flowering, but also have a benefit by consuming many damaging insects throughout the year.



Figure 64. Red wattlebird in a vineyard. Honeyeaters can cause serious damage in orchards and vineyards when fruit is ripe but also consume large numbers of insects. (Photo John Tracey)

Estimate the impacts

Estimating the amount of damage and calculating the cost will provide a basis for deciding how to best reduce pest bird impact and how much the land manager can afford to invest in any control effort. In agriculture this is simpler. The percentage of crop damaged by birds in an orchard block can be estimated by randomly or systematically sampling rows, plants, and individual fruit or bunches. Bird damage to individual fruit or bunches can be estimated by counting or weighing or by using a visual estimate. However, estimating the other types of damage and social and environmental costs is often more difficult. These impacts need to be quantified to allow an evaluation of the management program.





Figure 65. Measuring damage in a vineyard. Estimating impacts is an essential step in managing pest birds effectively – it provides a basis for deciding how to best reduce impacts and how much to invest in control effort. (Photo Bruce Mitchell)

Identify any key constraints

Consider legal, social and environmental issues. For example, will scare devices be acceptable to the local community, and are the techniques legally and/or environmentally responsible and acceptable? Some devices are extremely noisy and can become offensive close to residential areas.

Decide on most cost-effective time to implement a management plan

Even when good information is available it is often not practicable to be immediately responsive to short-term fluctuations in bird numbers or the damage they cause. When damage becomes significant it is usually too late to implement control. For example, effective use of scaring often requires a 'start early' approach to prevent birds establishing a feeding pattern. Likewise, investment in netting cannot be simply withdrawn for those seasons in which damage is below the cost-benefit threshold. Instead, we may need to look at costs and benefits over a longer time frame and make decisions accordingly. If damage in the area is likely to be high or there is a history of high levels of damage, the manager should be more inclined to invest in continuing management action. Measuring damage this year will help in selecting the optimal management option next year and beyond.



Developing the most appropriate bird management plan

Importantly, a management plan must have details of what will be done, who will do it, when it will be done and how much it will cost. Options can include individual techniques or combinations, and different levels of application. The plan must have long-term, year-to-year strategies to prevent damage and short-term reactive strategies to cope with sudden increases in impacts. For example, in the long term, managers may use netting on a small part of their crop every year. In the short term, when damage is higher, they may also implement a scaring program.

Monitor and evaluate

Has the management been successful? Estimating damage is the most direct way to measure the effectiveness of any management program. All costs of implementing control, including labour should also be considered. For example, nets may have significantly reduced bird damage, but if they are repeatedly removed for maintenance or spraying of the crop there will be additional costs to consider.

Evaluating management will enable improved decision-making for future strategies and allows actions to be modified to maximise any economic return. It is advisable to document what worked; what didn't; and what can be improved for next year?

There is no one simple solution for managing birds effectively. However, the following information may help managers decide on the most appropriate actions for their situations.

SCARING

Many visual and sound devices have been used by managers in an attempt to scare birds. These include acetylene and LPG gas guns, electronic devices, radio, flashing or rotating lights, scarecrows, reflective mirrors or tape, helium- or air-filled balloons and predator models or kites. Habituation is the main drawback of all types of scaring. Birds quickly become accustomed to noise or visual cues.

Best results for scaring are achieved when:

- combinations of techniques are used
- scaring starts before birds establish a feeding pattern
- the sound is reinforced by shooting or some form of threat
- the timing and placement of devices are changed frequently, but not at regular intervals.





Figure 66. An acetylene gas gun for deterring birds. Using a combination of techniques, starting early, reinforcement, timing and placement are important considerations for effective scaring. (Photo John Tracey)



Figure 67. Peaceful Pyramid®, a visual reflective deterrent for birds. (Photo John Tracey)



The following suggestions may improve or prolong the effectiveness of scaring:

- Loud sounds are more aversive than quiet sounds.
- Sounds with a wide frequency range are more aversive than pure tones.
- Devices are more effective when used for the shortest time necessary for a response; discontinue their use when birds are not feeding in the crop or the device is no longer effective.
- Adult birds are more easily scared than juveniles.
- All species tested become habituated, accustomed to nearly all sounds tested.
- Ultrasonic devices tested have been found to be ineffective. Most birds cannot hear ultrasound ≥ 20 kHz..
- Broadcast alarm and distress calls can be effective but can result in habituation. As for other sounds, some are species specific and may cause a 'mobbing' rather than an escape response.
- Birds of prey rarely call when hunting; hence pre-recorded raptor calls are likely to represent something novel to birds rather than create an avoidance response from a predator.

BIRDS OF PREY

Attracting birds of prey or the use of falconry is often perceived to be of value in scaring birds or reducing pest numbers. However, although falconry has been used previously in airports to reduce bird strikes, it is impractical in most situations. Falconry is strictly regulated in Australia, requires skilled handlers and considerable training and is labour intensive.

Encouraging raptors to specific areas is difficult, as different species occupy different ecological niches. For example, sparrowhawks and goshawks prefer hunting among trees and tall shrubs to surprise prey; most falcons prefer open country; and Australian hobbies prefer lightly timbered country along watercourses. The most effective predators of adult birds are unlikely to be attracted by carrion or other food sources. Species that may be attracted, e.g. wedge-tailed eagles, little eagles and whistling kites, do not normally hunt birds in flight.

Some studies have shown that providing perches increases the numbers of birds of prey. However, this has not yet demonstrated a reduction in the number of pest birds or the damage they cause. More investigation is required.





Figure 68. Brown goshawk under bird netting. Birds of prey can be effective predators of pest birds but their ability to reduce impacts is not known. (Photo John Tracey)

LETHAL CONTROL

Many attempts to kill birds, despite alleviating frustration, often do not reduce damage. The techniques used are usually labour intensive and may have legal, welfare and social concerns. Permits from NPWS are required for most native species and for some introduced species. Contact NPWS for further information.

Pest birds, particularly introduced species, have high population turnover rates and high rates of natural juvenile mortality. Attempts to reduce populations in the long term need to remove a greater number than those that are being replaced. Therefore, greater effectiveness may be achieved if the breeding population is targeted or when using lethal control as part of a scaring program, see *Shooting*.

Trapping

The use of traps requires considerable labour and is therefore often cost prohibitive. However, trapping may be of benefit in situations where a single resident species is involved and a large proportion of the population can be trapped. A multitude of different trap designs is available, including remotely operated nets, cage and roost traps, funnel-entrance traps, modified Australian crow traps and nest box traps.

The success of trapping varies according to the skill of the operator and the time of year. For example, large numbers of starlings can be captured after the breeding season, between late December and May, when many juveniles are congregating. However, this may have little long-term effect on the population size owing to the high breeding potential of starlings, which can produce an average of two clutches of four chicks each season. Hence, removing birds during the breeding season, August to November may result in the capture of fewer individuals but potentially creates a greater reduction in population size for the following summer and autumn.



Shooting

Shooting is most beneficial when employed as a part of a scaring program. If regarded as a training tool rather than a method of population control, it can educate birds to associate noise with a real threat. To reduce habituation, shooting should be done at the same time scaring devices are used. This establishes a connection between the scarer and danger.

Poisons

Fenthion, alphachloralose and 4-aminopyridine are all RCPs. They can only be used to control pest birds by authorised persons who have successfully completed the EPA approved course. Use is mostly restricted to commercial, industrial and agricultural buildings, and to a limited number of pest birds. Site-specific approval must also be obtained from NPWS to ensure potential non-target birds are not harmed.

Fertility control

The reduction of breeding success by removing eggs or nests or applying oil to eggs has not been adequately investigated. This method may be appropriate for highly fecund species, and it has the advantage of reducing the need to kill large numbers of birds. Permits must be obtained for native species. Various fertility-control chemicals have been reviewed for birds, but none has been sufficiently field tested, nor are any commercially available.



Figure 69. A starling consuming free-feed bait at a waste-water treatment plant. Lethal poisons for birds are strictly regulated and are not available for broad-scale agricultural use in New South Wales. (Photo Brian Lukins)



SITE AND HABITAT CONSIDERATIONS

A range of landscape and habitat factors influences the number of pest birds and the damage they cause. These factors can be considered when the manager is attempting to minimise losses. The varieties grown and timing of maturity can be important. For example, growing varieties that mature simultaneously can help to alleviate the damage to individual growers. Depending on the birds involved, sites with adjacent roosting habitat or powerlines can have higher losses.

The numbers of pest birds and the levels of damage will vary according to the preferred habitat of different species. For example, mynas prefer urban environments; cockatoos and starlings are most abundant in cleared agricultural and peri-urban areas; and most native species prefer native vegetation. These factors can be considered before planting new crops.



*Figure 70. Starlings roosting in blackberry, *Rubus fruticosus*. Impacts can be greater where perching and roosting opportunities are available. (Photo John Tracey)*

ALTERNATIVE FOODS

Providing alternative food sources by decoy or sacrificial planting may be effective for some situations or when used in combination with other techniques. This relies on knowledge of the feeding habits of the main pest birds involved. A decoy planting ideally will produce food of equivalent or enhanced nutritional requirements and attractiveness for birds. It will be available just before and during the time that the crop is susceptible to damage. For honeyeaters and lorikeets, revegetating areas with local native trees and shrubs will increase the availability of their preferred food source. This may offer a long-term solution in reducing damage and has obvious environmental benefits.



Birds such as starlings that prefer insects may be attracted to irrigated areas where large numbers of insects are available. However, supplying alternative foods may also attract more pest birds to the area. Hence, for honeyeaters and lorikeets, a more regional approach to revegetation, rather than localised plantings, may be required. Additionally, a scaring program is likely to be more effective if alternative food sources are available.

NETTING

Exclusion netting using throw-over or permanent nets has high up-front costs but may be appropriate where high-value crops are grown and levels of damage are high. A variety of netting options are available. Machines can be used to install and remove drape-over nets of varying width: one, two or four rows. 'Lock-out' netting provides a continuous cover of netting by joining draped nets without the need for poles and cables. Nets can also be used on infrastructure to prevent birds roosting or nesting. If maintained, netting with ultraviolet stabilisers can provide between 5 and 10 years of protection.

Throw-over netting is more easily damaged than permanent netting and often does not provide as much protection. Permanent netting is easier to maintain and allows easier spraying of vines and trees. Netting overcomes many of the legal, environmental, social and animal welfare concerns associated with other techniques. The decision to net is mainly an economic one. Will the increase in returns from excluding birds be beneficial over the life of the netting? As an example, cost-benefit analyses on vineyard netting suggest that drape-over nets are cost-effective when damage is consistently greater than 10% and permanent nets are cost-effective when damage is over 25%. The value of the crop and the practicalities of netting must be considered.



Figure 71. A permanent netting structure in a vineyard. Netting is likely to be the most effective technique for reducing damage but has significant and often prohibitive up-front costs.
(Photo John Tracey)



ROOSTING DETERRENTS

A variety of spikes, coils and wire products are available to exclude birds from perching on buildings and infrastructure. Electrified wires, which can be attached to the tops of vineyard trellises, are also available. These wires give birds a small electric shock but do not harm them. Monofilament lines have been successful for deterring larger birds from fish farms but are ineffective for deterring smaller species from fruit or nut crops.

CHEMICAL DETERRENTS

There are several chemical deterrent products commercially available in Australia. Check with the APVMA for up-to-date registration information and appropriate applications.

Some deterrents are based on polybutene, which is a tactile roosting repellent; aluminium ammonium sulfate, which acts on a sense of smell and taste; or methiocarb, which is an insecticide that causes conditioned aversion.

- Polybutene is a sticky substance that irritates the bird's feet and can prevent birds from roosting on infrastructure; hence is applicable for buildings and urban areas.
- Aluminium ammonium sulfate may be applied to vegetables, nuts, fruit, orchard trees and vines, provided that the label instructions are adhered to, e.g. thorough washing before consumption.
- Methiocarb is a secondary repellent that causes birds to become ill, creating a learned aversion to the food. This product may be applied only to ornamental plants, and it is not registered for use on edible fruit or nuts.
- Garlic and chilli sprays have been used to deter birds from feeding, but these are unlikely to be effective. As there are no registered products for bird deterrence, their use is also illegal.



SOURCES AND FURTHER READING

This information is based on national guidelines for managing pest birds in horticulture (Tracey *et al.* 2007) developed by the Bureau of Rural Sciences.

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Further information is also available on the internet at www.feral.org.au



Table 4. Impacts by Australian birds

	Fruit	Cherries	Stone fruit	Pome Fruits	Grapes	Tropical Fruit	Berries	Citrus	Nuts	Flowers	Olives	Vegetables	Grain	Legumes	Rice	Sunflower	Sugar Cane	Pasture	Livestock	Stock/Feed	Forestry	Aquaculture	Apiary	Urban	Airport	Infrastructure	Potential Disease	Environmental	
INTRODUCED SPECIES (COMMON NAMES)																													
Starlings																													
Indian mynas																													
European blackbirds																													
Song thrushes																													
Sparrows																													
Pigeons																													
European goldfinches																													
European greenfinches																													
Red-whiskered bulbuls																													
NATIVE SPECIES (COMMON NAMES)																													
Cockatoos, corellas, galahs																													
Cockatiels																													
Parrots, fig-parrots, ring-necks																													
Rosellas																													
Lorikeets																													
Crows and ravens																													
Currawongs																													
Silvereyes																													
Honeyeaters																													
Noisy miners																													
Bowerbirds																													
Orioles, figbirds																													
Cuckoo shrikes																													
Mistletoe birds																													
Ducks, swans, geese																													
Egrets, herons, cormorants																													
Swampphen, native-hen, coots																													
Wedge-tailed eagles																													
Black kites																													
Rainbow bee-eaters																													
Emus																													
Swallows, martins																													
Australian brush turkeys																													
Australian magpies																													



Monitoring techniques

GENERAL MONITORING

Introduction

The purpose of this document is to provide readers with sufficient background information on monitoring and the purpose it serves, to plan for and undertake monitoring in control activities and pest management.

There are many issues to consider with monitoring, and it is recommended that operators do their own research on monitoring techniques, and consider how each technique may suit their specific circumstances. It is also critical for thorough planning to take place before any monitoring activities are undertaken.

This document focuses on some of the commonly used techniques for monitoring pest animal populations, and focuses on species addressed in this Manual. The monitoring techniques presented herein can be used by farmers and land managers to measure the effectiveness of management decisions (and control programs) in reducing pest populations and their adverse impacts.

Why monitor?

Vertebrate pests cause damage estimated at around \$1 billion to primary production, biodiversity, ecosystem services, health and tourism in Australia each year. Governments, land managers, and landholders alike are investing significantly in programs to address these impacts by directly controlling pest populations where they cause unacceptable levels of damage.

Wherever control is undertaken, it is important to know whether there have been benefits from the control effort. Monitoring can be used to identify areas for control, and measure the effectiveness of control activities in reducing pest populations or the damage they cause. Simply assuming that a control program is successful, without actually measuring the outcomes (in terms of benefits) can lead to false conclusions, poor management decisions, and a waste of valuable resources.

The best-practice management approach in pest management recommends detailed monitoring in association with any control program to measure the effectiveness of control in reducing pest numbers and/or the damage they cause. It is important to ask the question: Does your pest control translate into measurable benefits to your farm or the environment? The best-practice management approach recommends you use monitoring to answer that question.



Purpose of monitoring

Monitoring serves many purposes in pest animal management. It is often forgotten but represents a fundamental step in any pest animal management program. It can be used to measure pest populations and identify management priorities, such as areas for control work, and to evaluate previous management decisions or control programs (also referred to as performance monitoring).

Monitoring of pests or their impacts is used to:

1. Identify priorities for immediate and future management (e.g. planning and resourcing). *Where are the areas that need control?*
2. Evaluate previous management activities and control programs (e.g. response to control). *What are the benefits gained from the control program?*
3. Improve knowledge and understanding (e.g. relationship between animal numbers and their impacts). *How does the damage caused by pests change with a reduction in animal numbers?*
4. Raise awareness of issues, opportunities, and limitations, as well as provide information on current and potential problems. *What issues need to be considered in your pest management program?*

Monitoring can also be undertaken to assess the steps in a control program and identify if there are ways of making it more cost-effective (also referred to as operational monitoring) – although this is not described further in this document.

Defining monitoring objectives

Monitoring programs are normally designed to measure pest numbers, the level of damage caused by pest animals (e.g. stock losses), or whether there is a change in the numbers of a pest or the condition of an asset (e.g. crop) associated with a control program. Therefore, monitoring may be one-off (to identify priority areas for control), repeated (to evaluate change in a pest population or damage over time), or ongoing (to measure change in pests or resource condition over longer periods).

Regardless of purpose, it is vital that the objective(s) of monitoring are accurately defined. The objectives(s) of monitoring will determine what is directly measured, what level of monitoring is needed, and how often it is undertaken. By defining the objective(s) clearly, it will also be easier to identify suitable techniques to use in the monitoring program.

An example monitoring objective:

Evaluate the success of rabbit control (using suitable monitoring techniques) by measuring whether there is any change in the damage caused by rabbits to a pasture. (asset) before and after a control program.



Best-practice pest animal management

Adopting 'best-practice management' is now considered the most suitable approach for dealing with a pest issue. Rather than simply trying to kill as many pest animals as possible, the best-practice management approach recommends detailed planning, coordination and monitoring. Best-practice management involves 3 stages:

Stage 1: Planning. This stage involves identifying the trigger for action, determining who takes responsibility for the pest issue, describing the area(s) of concern, gathering all necessary information, and reviewing the information to identify suitable land management units for further action.

Stage 2: Determining pest management priorities. This stage involves setting land management areas, ranking land management areas for production and conservation values, ranking land management areas for threat from pest animals, determining the overall rank to identify priorities, and doing a reality check to decide which land management areas require an action.

Stage 3: Developing and implementing local pest management plans. This stage involves defining the management problem in terms of damage to assets/infrastructure/crops/natural resources, developing the management plan, implementing the plan, and monitoring and assessing performance.

The best-practice pest management approach also recognises the principles of strategic pest management – recommending the use of many control techniques, coordination with neighbours, evaluating management options, detailed monitoring, and measurement of the effectiveness of management decisions in reducing a pest problem, pest numbers and/or the damage they cause.

It may seem like a lot of effort to go to, but pest animal management specialists and scientists believe that adopting the best-practice management approach is the best way to deliver long-lasting benefits – 'a bigger bang for your buck'.

For more information see *Vertebrate Pest Control Manual*, under *Introduction*, NSW DPI.

Monitoring of pest animal numbers

Measurements of the number (or abundance) of animals in an area can be very useful in pest management for several reasons.

Information on the presence or range of a species range can be used to:

- detect expansion or contraction in the range of species (including new incursions)
- determine the feasibility of management options and the scale of management required.



Information on the abundance of animals can help to:

- identify priorities, problems and opportunities for management
- evaluate the effectiveness of management in terms of change in the numbers of pest animals in a given area
- assess species whose occurrence or extent changes very little in response to control, but whose relative numbers are a measureable and meaningful indicator of population size
- identify the relationships between pest numbers and damage associated with pests.

Monitoring of the damage caused by pest animals

While information on pest numbers can be very useful, measuring changes in the damage caused by pests (such as crop damage, pasture damage, livestock predation, or soil erosion) is the best means of assessing the effectiveness of control or management decisions. Where possible, it is better to measure change in the damage caused by a pest, rather than to measure the numbers of a pest, because a change in pest numbers does not always directly translate into a reduction in the damage they cause.

In some cases, damage is caused by a select number of individuals. For instance, as is often the case with wild dogs, some individuals are more prone to mauling of sheep than others. Caution is required using reduced animal numbers to imply control effectiveness.

The trigger for control is usually a point in which the level of damage associated with a pest species reached unacceptable levels. Therefore, before any control is undertaken, it is prudent to decide what level of damage is acceptable, and then to aim at reducing damage back to that level.

To determine the level of damage caused by a pest requires direct or indirect measurements of damage before and after control. If damage levels are not reduced to an 'acceptable level' after control, then further control may be required.

The best way to gauge whether control has been successful is to measure the damage caused by a pest before and after control activities. Measuring the damage caused by a pest can help a land manager to:

1. determine the level of control necessary to reduce the damage caused by pest animals to an acceptable level
2. identify any changes needed to a control program to target all individuals in a population, thereby maximising the effectiveness of the program
3. assess the effectiveness of control by comparing pre- and post-control levels of pest related damage
4. gain a thorough understanding of the relationship between numbers of a pest and the damage they cause to a property.

If it is not feasible to directly measure pest damage, information on abundance can be used as a surrogate measure, however, caution is required because pest numbers do not always directly translate to pest damage. Without information on pest numbers and/or measurements of damage, an operator will not be able to accurately determine whether a control program has been successful.

Whether monitoring pest numbers or pest damage, the method used before and after control should be the same, so any changes can be easily identified.



Monitoring for possible adverse impacts to non-target species/communities

Monitoring can also be performed to identify if non-target impacts are likely to occur from a management decision or control activity. In NSW, the *Pesticides Act 1999* requires a review of the environmental factors before a decision to use toxic baits can be made. Monitoring can be used to identify whether any non-target species occur in the area of proposed control, or to determine if non-target species are attracted to a proposed control method.

Prior to poison baiting, non-poisoned baits can be used to check whether non-target animals may be attracted to a bait station, and appropriate changes can be made (such as destocking paddocks or moving bait stations) before commencing poison-baiting. Bait stations can also be checked during a control program to identify whether any non-target species are attracted to the site.

It is the responsibility of the operator to ensure that a pesticide is safe to use and that the proposed control area does not include sensitive areas such as watercourses. It is no longer considered acceptable to undertake control without taking adequate precautions.

In NSW, the *Threatened Species Conservation Act 1995* may require monitoring of the impact of a baiting program to non-target species.

As a rule of thumb, the supervisor or control operator may need to ensure that:

- all species have been identified (via fauna survey)
- all the information necessary to make judgments on baiting is provided
- risk assessments including Conservation Risk Assessments have been completed
- all people handling pesticides are adequately trained
- the baiting program complies with the pesticide label or PCO
- the threat to non-target species is minimal
- isolation distances are maintained
- the farmer or land manager approves of the bait type and quantity to be applied.

Pre-control monitoring of native wildlife to minimal non-target impacts

If there is a risk of non-target impacts to native animals (or domestic livestock), there are a number of strategies you can use to minimise adverse consequences of a control action.

Limit the area of control – By limiting the area of control, such as the distribution of bait in areas where pest animal populations are low, you can reduce the possibility of non-target impacts.

Limit the amount of control applied – By being targeted and only undertaking control where a pest species is known to occur, or limiting the amount of bait used, you can minimise the risk of non-target impacts to native animals, and save valuable funds in the process.



Free feeding – Free-feeding may attract a range of species to a feeding station; where their presence can be recorded. This technique is often used to determine whether native animals (including threatened species) occur in an area or are attracted to the bait station. If this is the case, the station is closed and another location may be chosen. Free feeding can also draw in target species, such as pigs to a feeding trough, helping you to centre your control efforts.

Record keeping – Land managers and landholder alike can play a vital role in recording and reporting information on possible non-target species, such as native animals when detected. If incorporated into a control program, such information can be used to target pests and minimise non-target impacts simultaneously.

Mapping – Recording and mapping information on the locations of pest animals, non-target species such as threatened species/communities, sensitive areas, or historical information on suitable site maps can be very useful in identifying priorities, planning and coordinating control, documenting activities, and to minimise possible adverse consequences from your management decisions. Maps can also be a powerful tool in communicating control outcomes to landholders, neighbours, and collaborators.

Situation reporting – Information obtained before, during, or after a control program can be used to prepare a ‘pest situation report’. These can be used to gain a greater understanding of issues and opportunities, and can be used to communicate the status of a situation to neighbours or local authorities. Situation reports can be used to ensure possible non-target impacts are well identified and appropriately addressed.

Pre- and post-control monitoring of native wildlife

Without adequate precautions, many of the commonly used techniques to control pest animals can adversely impact upon non-target species, such as native wildlife. Appropriate monitoring of wildlife numbers before and after a control program can help to ascertain whether a technique is adversely impacting on non-target species. As with monitoring of damage before and after control, the method used for monitoring native animals should be the same before and after control, so any changes can be easily identified.

Information recorded should include the number and name of each species observed, together with details on the surrounding habitat, and any deaths that may have resulted from the control phase. This monitoring may provide a better understanding of the impacts of control technique(s) and their method of application, which can then be modified in future control programs to reduce non-target impacts.

Types of monitoring

Monitoring serves as a tool for planning and prioritising actions, and as a tool for assessing the effectiveness of management decisions or control. Monitoring techniques can be used to detect the presence of species, estimate animal abundance, record change over time, assess habitat use, measure damage caused by pests, and measure unforeseen consequences from actions.

Monitoring should be performed for a specific purpose, and produce results that are easily understood. When selecting monitoring technique(s) it is fundamental that you clearly define the purpose of your monitoring, what you will measure, and what you will report. Not all monitoring techniques will be suitable for your circumstances.



Interpretation of results

The outputs from monitoring, whether they be measures of damage caused by a pest animal, or change in pest numbers following control, need to be clear and unambiguous. The results should help you to decide on the best and most cost-effective course of action. If the outputs from your monitoring are unclear, uncertainty may surround the next course of action. In these circumstances, additional monitoring may be necessary, or there may be a need to consult a pest animal specialist, such as a LHPA Ranger.

MONITORING TECHNIQUES

There are a wide range of techniques available for monitoring pest animal populations. Some are more suitable than others, and each varies in suitability according to species and circumstances. The section below presents a brief summary of some of the techniques available for monitoring pest animal populations. Care is required when implementing monitoring techniques, and it is recommended that operators become thoroughly familiar with these techniques before field application. Monitoring requires good planning and organisation. A poorly planned monitoring program may provide you with misleading results.

The following techniques will be discussed in this section:

1. Spotlight counts
2. Aerial survey (basic)
3. Scats and tracks
4. Bait uptake
5. Warren counts/active entrance counts
6. Traps (live capture)
7. Traps (lethal)
8. Sand plots
9. Camera Trapping
10. Census cards
11. Observations (sightings, howling etc.)
12. Impact/damage (crop, pasture, predation etc).

Their applicability to different pest species is shown in Table 5.



Table 5. Available techniques that are easy to do, and their suitability for different pest animals.

TECHNIQUE	PEST ANIMAL					FERAL PEST	
	RABBIT	FOX	WILD DOG	FERAL PIG	MICE	GOATS	BIRDS
1. Spotlight counts	✓	✓	✓	✓			
2. Aerial survey (basic)				✓		✓	
3. Scats and tracks	✓	✓	✓	✓	✓	✓	
4. Bait uptake	✓	✓	✓	✓	✓		
5. Warren /active entrance counts	✓				✓		
6. Traps (live capture)	✓	✓	✓	✓	✓	✓	✓
7. Traps (mortal)	✓				✓		
8. Sand plots	✓	✓	✓	✓	✓		
9. Camera trapping	✓	✓	✓	✓	✓	✓	✓
10. Census cards					✓		
11. Observation (sightings, howling etc.)	✓	✓	✓	✓	✓	✓	✓
12. Impact (crop, pasture, predation)	✓	✓	✓	✓	✓	✓	✓

ADVANCED SPOTLIGHT COUNTING TECHNIQUES

Spotlight counts

Spotlight counting is a valuable tool for estimating the density of a species and the areas where that species feeds/forages, as well as for deciding which control technique to use. Spotlight counting is particularly suitable for rabbits, but is appropriate for many other species (see Table 5).

Selecting a route

Prior to the selection of night spotlight count routes, the area must be thoroughly inspected and marked out during the daytime. Hazards or sensitive areas should be identified and adequately marked. In addition, an inspection can be carried out at night to verify and/or assist in highlighting areas that should be included in the spotlight count.

The route selected should cover an area that is typical of the topography, vegetation, density and distribution of the pest being controlled or monitored. The count routes should be placed to cover approximately 5% to 10% of the area involved. Those areas that should have count routes are chosen by:

- selecting areas that have historically had high rabbit numbers or where poisoning has not been carried out
- selecting areas that you or the land manager considers could have the potential to cause problems for various reasons
- covering a variety of land use types, habitat and topography, where possible



- ensuring that there is a reasonable distribution and length of count routes throughout the area selected.

Ideally, a spotlight count route should be from 2 to 5 km in length. The route length is largely dependent on the type of terrain to be traversed and is restricted by what can be easily covered in one session (or in approximately 1 to 1.5 hours). If the count period or route is too long, operator tiredness may result in inaccurate or inconsistent data. If the route is too short, it may not adequately sample the area of interest.

When spotlight count routes are being marked, planning is essential. Care must be taken to avoid instances where your spotlight route may result in counting animals more than once, such as where a route changes direction. You must also ensure that the entire spotlight route is accessible at all times when counts are required (e.g. check that a gully, creek or stream can be crossed after rain).

Spotlight count routes can include sections of vehicle tracks or roads, although counting along busy roads can bias results and can present safety issues.

The spotlight count route should be permanently marked, either in sections between gates or every kilometre. Where the route deviates, landmarks such as gates, fences, trees, rocky outcrops etc. should also be marked so the spotlight route is well defined. This will ensure that the same route is taken each night. Either mark the route with reflectors, reflective tape or brightly coloured ribbon.

Routes can also be marked with short lengths of metal posts or treated wooden pegs driven into the ground beside the route. The pegs can be painted white and have adhesive reflector tape or metal reflectors attached.

In areas where cattle or horses are present, it is advisable to avoid using adhesive reflectors, as these animals have the tendency to lick them off.

Conducting a spotlight count

Each spotlight count should be conducted as consistently as possible. It is recommended that counts are carried out following the same route, by the same observer, using the same vehicle (or vehicle type), using the same spotlight wattage, driven at the same speed (approximately 10 to 15 km/hr); and thus ensuring the same amount of time is spent covering the count route on each occasion. Where possible, counts should be commenced at a similar time each night.





Figure 72. Vehicle set up for a spotlight count. Note the light on the roof so the observer can remain in the passenger seat. This removes any OHS issues of travelling in the back of a vehicle. (Photo David Croft)

Adverse weather conditions, such as rain, wind or extremes of temperature can influence animal behaviour. This is more noticeable with species like rabbits.

Cold temperatures can reduce the activity of many animals. Rain, particularly if heavy or persistent, can cause significant change to the emergence of rabbits. Similarly, wind may also deter animals from foraging (as they cannot hear approaching predators). In windy or rainy conditions, rabbits tend to concentrate on sheltered areas, avoiding ridges where spotlight routes are often placed.

Ideal conditions for a spotlight count are a cool to mild evening with no rain, and calm or with a slight breeze. As moonlight can influence animal activity, many spotlight counts are conducted in the dark phase of the moon.

The most suitable time to conduct spotlight counts is just after sunset. Many nocturnal animals are active between 7 pm and midnight, including rabbits, foxes and other pest species.

Spotlight counts should involve a minimum of three counts on consecutive nights or as close as practicable under similar weather conditions. If the difference in the nightly number is more than 10% between the first, second and/or third nights, then up to five night counts should be conducted.

The person conducting the spotlight survey should count animals only within a set 90 to 180 degree arc and a set distance from the vehicle and this must remain constant. A maximum distance of 50 m to 100 m from the vehicle is sufficient. Counts should include the number of target species, and also the number of other species such as predators, native animals, etc. Either progressively or at the end of each kilometre (or section), the data needs to be recorded on an appropriate standardised recording form/data sheet (see Table 6) to ensure that an accurate record is kept.



All spotlight count routes should be marked on individual property maps. This ensures that routes can be undertaken by someone else if the need arises, and that counts can be continued if the original counting team is no longer available.

If during a spotlight count, you find that some sections of the route are not able to be counted owing to changes in landscape (e.g. cropping, heavy stocking, fog, etc.), record 'not counted' (NC) on the data sheet in the appropriate columns of the recording form and a reason in that row of the count sheet. If, on the other hand, part of a section was unable to be counted, record pest numbers, etc. and note in the comments column that the entire section was not counted, and a reason. If less than 60% of the spotlight route is counted, then you will need to recount the whole section.

Data can be recorded either using a tape recorder, using one person to observe and another to record data, or using a hand-held tally counter (when animal numbers are high).

Recording data

Filling in the spotlight count record

The spotlight record sheet (see Table 6) can be photocopied and put in a folder, notebook or small plastic sleeve. Fill in the details at the top of the count sheet before starting. Print and ensure that figures are legible.

Count route

Correct identification of property and route (attached to a map).

Start and finish times

If possible, use the 24-hour clock: e.g. start 1930, finish 2100, and always record start and finish times, and any stops necessary during a count.

Odometer start/finish

Record in kilometres to the nearest 100 metres.

Spotlight

Voltage – 12-volt system (avoid 6-volt systems).

Wattage – 100 W narrow beam is ideal for spotlighting. A variation in the bulb's wattage affects numbers visible, and if changed it will affect the comparison between different counts.



Table 6. Spotlight count sheet

Property/block			Date
Spotlight volts	Watts	Odometer start	Finish
Wind force	Direction		
Temperature	Moon	Cloud	Rainfall
Time start	Finish	Counter	

[illegible]

Counter/observer

Name of the person doing the count (counter/observer) is important, as a change in counter can affect the number of animals observed. Use the same person where possible.

Temperature

Record temperature as Very cold (VC), Cold (C), Mild (M), Warm (W), Hot (H).

Cloud

Cloud cover is generally recorded in octals (0 clear – 8 total coverage). Alternatively record cloud cover as clear (B for bright and open), part cloudy (PC), overcast (O), gloomy/dull (G), ugly/threatening (U).

Rainfall

Record any significant recent rainfall in the previous days (as current, today, yesterday, this week, last week).

Wind force

Record as a value from 0 to 7:

Calm (0) – *smoke rises vertically.*

Light air (1) – *smoke indicates direction.*

Slight breeze (2) – *leaves rustle, breeze felt on face.*

Gentle breeze (3) – *leaves, twigs in constant motion.*

Moderate breeze (4) – *causes dust and paper to be blown around.*

Fresh breeze (5) – *small trees sway.*

Strong breeze (6) – *large branches in motion.*

Near gale (7) – *whole trees in motion (too strong to count rabbits).*

Wind direction

Record direction as N, NE, E, SE, S, SW, W, NW.

Leave blank if force is zero.

Amount of moon visible

Record 0, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1.

Sector

Identify each section. For example, each sector might be 1 km long, or a distance between gates etc. that have been marked on the route map.



Animals seen

Record actual number seen in each sector and use the code letter for each species to save space on the recording form. e.g. rabbits (R), foxes (F), feral pigs (FP), hares (H), possums (P), kangaroos (K) etc.

Predators

Record using a letter to identify the species e.g. one cat – 1C, two foxes – 2F [cat (C), fox (F), dog (D)].

Stock

Record if stock are present on sector of route, or if they have affected the count (Y=yes). A blank indicates no stock disturbance.

Visibility

The visibility of animals is determined by many factors, including weather and pasture height.

Visibility can be recorded as:

Excellent (E), Good (G), Poor (P), Uncountable (U)

Vegetation type and condition

Pasture (P), Crop (C), Cultivated (W), Trees (T), Green (G), Dry (D), Sparse (S)

Surface/ground conditions

Dry (DR), Wet (WE), Slushy (SL), Dew on dry ground (DD), Frost (FR)

Rainfall

Any changes in rainfall in each count. Leave blank if no rainfall.

Trace (T), Showers (S), Drizzle (D), Mist (M), Rain (R)

Example – wet with mist is recorded as (WE M).



AERIAL SURVEY

An aerial survey is a visual count of a species seen from the air. It is best if the aircraft is either a high-fixed-wing plane such as a small Cessna or a helicopter.

Marks applied to either the strut or wing support allows observers to determine the distance that animals are seen from the aircraft's flight line. These distances are usually grouped into zones (such as colour zones) that correspond with distances. This method assists with rapid counting and distance sampling during an aerial survey. An alternative method is to attach a marked rod to aircraft (see photo below).

Flying height is usually determined by agreed standards, and would normally be around 150 feet for helicopters and 250 feet for fixed-wing aircraft. Flying height must conform with regulations.

There are many issues to consider with aerial surveys, but information gained from aerial surveys can be very useful. Unlike many other methods, aerial surveys are also useful for surveying large areas quickly. However, aerial surveys can be expensive and require good planning and coordination. They should not be performed without training and consultation with scientific expertise.



Figure 73. Helicopter fitted with a marked bar doing aerial survey. (Photo David Croft)



SCATS, TRACKS AND DUNG COUNTS

Identification of scats

Animal scats and tracks are sometimes all that can be used to identify whether a species is present in an area. Some animal scats are easy to identify, others are more difficult. It is easy to distinguish between the scats of feral pigs and rabbits. However, to differentiate between rabbits and sheep may need a little more experience. Similarly, to distinguish between macropod species would require a level of expertise that most people would not have.

Where scat identification is difficult, consult an expert.

Identification of tracks

In a similar way, some tracks are also easy to identify if only a few different species are present. But to differentiate between wild dogs and foxes or between feral pigs and other cloven-hoofed animals may require more skill and knowledge. In many cases, there are a few distinguishing features to look for.



Figure 74. Footprints in sand tray. (Photo David Croft)

There are a number of reference books on tracks and scats that will assist in the identification process (see Further Reading). If the use of scats and tracks is a valuable tool for a particular monitoring program, then it might be worth engaging someone with the skills to identify those animals of concern.



Dung counts

One method of assessing animal density in an area is to undertake dung counts. This usually involves removal of dung from a site, and returning at a later date to measure the accumulation of new dung. Like many monitoring techniques, there are a range of issues to consider with this technique. If planning a detailed monitoring program with dung counts, consult a research specialist.

BAIT STATIONS/BAIT UPTAKE

A bait station is a device/location that contains food that attracts animals. It can be as simple as a pile of grain on a roadside, or an elaborate device attached to a tree above the ground that excludes all animals except the target species (e.g. possums in New Zealand).

Baits stations

Bait stations usually consist of a measured amount of food placed in a location that can be examined to measure visitation by an animal. For some species, bait uptake can be a false measure of the success of control (e.g. foxes cache baits), but it is a good method to determine the presence of a species in an area for the purposes of monitoring.

Bait stations are particularly useful if animals follow set movement patterns or feed in an area that is easily accessible. The benefits of this technique are the flexible timing of sampling and that sampling can be done during the day, while the animal may move around by night. The drawbacks of this technique include; the risk that bait stations may be destroyed by rain or human activity; they are not an accurate measure of abundance, and they take considerable time to set up, especially if putting in a number of sampling sites.

A bait station will not provide an accurate estimate of the density of animals in an area but can provide an indication of an animals 'presence'. Sand pads can be used to measure activity at or around a bait station. Select a number of sites to be monitored, such as roads, between refuge areas or known feeding areas. If possible, physically mark each bait station with a numbered post so that future surveys can use the same location.





Figure 75. Pig traps used as bait stations to monitor activity without disturbing the group. (Photo David Croft)

A bait station can be a simple raked area on the ground, a dish, tray, length of poly pipe or a cage. The choice of bait is crucial and needs to attract the target species. For example, if you are using a bait station for rabbits, then oats or carrots would be used. Similarly, for mice a grain or pellet type bait would be suitable. For foxes and dogs, cubes of meat that are tethered or buried might be suitable. The bait station may also need to be fenced to keep non-target or larger animals out of it.

How to do the assessment

Select sites to be monitored and record their location by using a map or GPS if possible. Set up the bait stations as a separate plot or set a number in a large sand pad. Count and record all baits removed or measure uptake the following day and if necessary, reset the station.

The best time to check bait stations is early in the morning, before other animals have had a chance to feed on any residual food.

For some species a simple calculation can help to identify how many animals have visited a station. For mice monitoring, the amount (weight) of food remaining can be used to estimate the number of mice that have visited the bait, as mice will consume approximately 3 g of food a night. If there has been 30 g of food removed (with no obvious sign of non-target species being present) then potentially 10 mice may have visited that particular bait station. Table 7 is an example of a simple count sheet.



Table 7. Simple count sheet.

DATE	BAIT TYPE	PUT OUT (g)	PICKED UP (g)	DIFFERENCE (g)	NOTES	LIKELY NO. OF PESTS
e.g. 2.2.2007	wheat	100	34	66	crumbs would indicate house mouse	

Other indicators

Baits can be dyed with food dye or using bits of coloured plastic in the food to act as markers. A search for scats around a bait station and examination of these scats may give an idea of the species consuming bait, or it may indicate where the animals have travelled from that particular feeding area.

WARREN/ACTIVE ENTRANCE COUNTS

The number of active burrow entrances counted per unit area (e.g. hectare) can provide an estimate of the density of rabbits or mice in that area. Where a high proportion of entrances in a warren are active, showing regular animal movement in and out of the entrance and lack of cob-webs, leaves and debris, this would indicate a very active warren.

A simple technique to count active versus inactive burrow entrances in a large warren is to walk around and work towards the centre, placing a marker (such as strips of coloured cardboard or plastic) in each hole until all holes have been identified. Then walk back and pick up the strips with the 'active' strips in the right hand and the 'inactive' strips in the left hand. A bit of simple maths will give you a percentage of active to inactive holes.

Similarly, counting holes during a walk through a crop, along contour banks, along grass verges or fencelines can give an indication of mouse activity. Freshly dug soil at the entrance to a burrow indicates that the burrow is active.

Another simple observation technique for mouse activity is to walk along a crop row or a set path and collapse all mouse holes encountered in 100 m (or some other pre-determined distance). Then count all the re-openings each day for 2 or 3 days.

TRAPS

There are many ways in which traps can be used for monitoring of pest species. Most traps can be easily moved to where pest activity is current, and can be used repeatedly.

Whenever traps are used, operators need to pay significant attention to prevent injury or harm to any target or non-target animals, including humans and livestock.



Live capture traps

There are many live capture traps (such as Elliott, Victor and cage traps) that can be used for rodents, wild dogs, foxes, feral pigs, feral cats, etc.



Figure 76. Elliott live capture mouse trap. (Photo David Croft)

A range of live capture traps is available commercially, or traps can be built fairly cheaply. Elliott, Victor and cage traps for rodents are probably more likely to be used by research or field staff rather than pest control operators or farmers. However, there are a few small cage traps available commercially that are more suitable for use by pest control operators and farmers.

For Canids such as foxes or wild dogs, the use of a soft jawed leg-hold trap is possible. These may be traps such as the Victor Soft Catch® or a modified steel jawed trap that has no metal contact with an animal's limb and rubber-wrapped jaws. Details on modifying steel traps to rubber-jawed traps are available through NSW DPI.

For the smaller carnivores, the use of cage traps is an option. These require a little bit of skill to set up, particularly if feral cats or foxes are the target animals. The placement, attractant and checking of traps on a regular basis need to be considered carefully before using live capture traps. It is advisable to always check with an experienced trapper before using live capture traps.





Figure 77. A cage trap used for foxes and feral cats. (Photo David Croft)

Feral pigs are relatively easy to trap if they are in an area. Trap designs range from a heart-shaped trap made from silo mesh to mesh panels with a swinging one-way gate. Descriptions of feral pig traps are included in the *Feral pig* section of this Manual or on the internet.

There are a number of effective trap designs. The construction of the entrance door to a trap is the most important part of the design. The door must work effectively to allow pigs to enter the trap but not allow them to back out/escape.

Traps should be set up where feral pig activity is current. It is normal to set up traps near water holes, on regularly walked pig trails, or at other sites where pigs are moving regularly, such as near a hole in a fence. Traps can be baited with grain, fermented grain, pellets, vegetables or fruit.

The term 'free-feeding' is often used to describe feeding of animals to allow them to become familiar with a food type before setting a trap. With feral pigs, once they are readily consuming bait, construct a trap around the bait site with a trail of bait leading through the trap entrance. Initially, leave the trap door tied open for a number of nights until pigs are readily entering the trap to feed. The trap can then be set. Check the trap daily, preferably in the morning, and humanely destroy any pigs caught. No animals should be left in traps for excessive periods.



Figure 78. Feral pig trap. (Photo David Croft)



Mortality traps

Mortality traps are those that result in the death of the animal, usually when the trap is activated. The most well known mortality trap is the snap-back or wooden mouse trap. When used as monitoring tools, the traps need to be inspected regularly and before any scavenging animals arrive. Carefully inspect traps to identify if the traps are attracting non-target animals.



Figure 79. Mouse in a snap-back trap. (Photo David Croft)

SAND PADS OR SAND PLOTS (PARTICULARLY FOR WILD DOGS AND FOXES)

A sand pad is simply a patch of raked sand or soil that can be used to show a foot or pad imprint when an animal walks over it. Sand pads are particularly useful where animals follow set paths or there is a road or track that is easily accessible. The benefits of this technique include the flexible timing of sampling (that can be done during the day), and that once set-up, this technique has minimal maintenance requirements.

The drawbacks of this technique include that animal tracks may be destroyed by weather or humans, their usefulness can vary seasonally, they are not an accurate measure of abundance, and they take time to set up if you are putting in a number of sampling sites.

A sand pad does not provide an accurate density of animals in an area but can provide an indication of the 'presence' and activity of a species, or many species simultaneously. If there are many prints from a species on a sand pad, sometimes you can identify individuals by print shape and size, irregularities, or gait length. Alternatively, many footprints may mean that one individual was very active at that site.



Figure 80. Sand pads can be small trays or a larger area of raked sand. (Photo David Croft)



Sand pads are easy to prepare with limited materials required. Select a number of sites to be monitored (e.g. roads or between refuge areas and known feeding areas). Sand pads should be spaced at 1 km intervals for approximately 25 km for wild dogs and 500 m spacing for foxes, and 10 km for cats. Smaller animals tend to move shorter distance so these distances may be modified for foxes and cats.

If possible physically mark the locations of sand pads with posts with reflectors so that future surveys can use the same site. Once set out, sand pads should be used repeatedly, and not moved in future surveys, so that valid comparisons can be made.

Put down a thin layer of sand or fine soil (1 to 3 cm deep) approximately 1 m long across the entire width of the road or counting area. If the pad is not naturally sandy or dusty, then sand may have to be brought in. However, local soils are less likely to be a deterrent to animals. Sweep smooth with a rake, broom or concrete rake to minimise ridges and allow for better prints. Mark or number each site and GPS the location where possible.

How to do the count

Count and record all animal tracks the following day and then sweep the sand pad area clean again. The best time to check is early in the morning when the sun is still low in the sky as this provides a better shadow across the tracks. If this is not possible, then the use of a strong torch shone at an angle tends to highlight the ridges and depressions of the print and allows for better recognition. Record all tracks seen on a count sheet, not forgetting those that might not be easily identified. Repeat the count for 3 consecutive days. Table 8 is a suitable simple count sheet.

Table 8: Simple count sheet

Sand plot monitoring data sheet

DATE			OBSERVER'S NAME				LOCATION	
GPS DATUM:			PLOT INTERVAL: 200 M / 500 M / 1 KM				TRANSECT NAME	
PLOT NO	OK?	NIL	DOG	FOX	CAT PIG	BANDICOOT	OTHER	COMMENT
1								
2								
3								
4								
5								
6								
7								



CAMERA TRAPPING

The use of camera traps for studying pest animal populations is a relatively recent technique being used in Australia to measure pests such as rodents, foxes, feral cats, feral pigs, feral camels and wild dogs. There are a variety of camera trap types and models and choosing the right model that is fit for purpose is critical to the success of your monitoring program. Camera sites can be passive, for example, no attractant and often along tracks or active, where a bait or lure is used to attract and hold animals at a chosen point. Similar to other technique where animal detection is critical to the measurement of the population, many camera traps are required to cover an appropriate area and sample the population adequately. When using camera trapping in monitoring it is essential that users are completely familiar with how the camera trap works and how to maximise its detection capabilities. The correct settings and placement is integral to data collection. The techniques used will vary between survey objectives, species targeted, habitat and camera models. A detailed guide on camera trapping is available from www.feral.org.au

MONITORING RODENTS WITH CENSUS CARDS

Perimeter and in-crop monitoring

This type of monitoring could use census cards (see over) and would provide a guide as to where baiting would be the most effective. The grid could give an estimate of the mouse population.

Past research using in-crop trap lines to monitor mouse populations has been able to determine a level whereby the impact of the mice present would cause extreme losses. As mice are found in most agricultural enterprises constantly, there is always a need to maintain some form of monitoring or observation that can relate to changing population densities.

Growers should be aware that any increase in mouse populations shown during monitoring, whether by using census cards or bait stations, should be passed on to their district agronomist or LHPA.

Census cards

These cards are simple and can be used by any operator. They are squares of gridded paper soaked in linseed or canola oil and placed at suitable intervals, either in or around the susceptible crop. Sample census cards and instructions for use are shown in Appendix A.

Note. If census cards have been chewed then there is a high probability that mice will take bait. However, the use of census cards to monitor mouse populations after baiting may have limited success.





Figure 81. A census card that has been chewed. (Photo David Croft)

Other monitoring techniques for rodents

There are many simple monitoring techniques to identify whether there are changes in rodent populations. Some techniques are easy and cost-effective to use, such as walk through a crop, placing sheets of galvanised iron or a hessian bag at strategic locations and monitoring animals underneath at regular occasions. Other techniques are labour intensive, such as creating and monitoring a grid of traps to estimate animal abundance. Although this technique is probably the most reliable, it is not necessarily suited for farmers. Snap-back traps and bait stations can also be used to provide an indication of mouse abundance.

Bait stations

Apart from census cards, a measured amount of grain in a set bait station can be used as a crude monitoring device. Bait stations need to be checked frequently, such as once a week during quieter periods or every morning as mice become more noticeable.





*Figure 82. A simple bait station for mice can be made from an upturned ice cream container.
(Photo David Croft)*

In all cases where the monitoring technique uses a food base (grain, oil, bacon rind, etc), that particular technique is only as reliable as the acceptance of that food type at that time. As the crops mature and protein or sugar levels change, so does the food preference of mice.

Mouse signs: simple monitoring

One of the first places mice are observed is around buildings and sheds. The signs of an increasing presence of mice are:

- increased droppings
- gnawing
- burrows
- smudges on walls or rafters
- dark runways along skirtings or rafters
- tracks and worn pathways
- smell, sight and sounds
- mounds of soil and/or seed.

Apart from those monitoring techniques already covered, there are other methods that can be used in selected circumstances. In protected areas, talcum powder or flour can be used to note tracks and to identify mouse activity.



Trapping around the farm

While there are only few techniques to trap and monitor rodents, snap-back traps are an effective means of monitoring rodent populations, and are suitable for removing low numbers of mice in homes, buildings, or where poisons pose a risk to people or animals.

All traps provide a means of monitoring mouse numbers over time. Keep a record in a notebook or on a calendar of the number caught.

Visible sightings in the field

There are a number of visual sighting techniques available to farmers. The presence of burrows or of worn paths between cracks of soil are good indicators that mice are present.

Crop damage

Crop damage from mice is often unnoticed until it is severe. Signs of mouse activity include chewed stems or damage to seed heads. Debris such as seed husks at the base of plants suggests the damage to seed heads has been caused by mice rather than by insects or birds. However, bird and insect damage should not be dismissed until the real cause is determined.

A regular walk through a maturing crop or stubble paddock can provide valuable information on mouse activity. It is important to record all your observations, particularly the evidence of active burrows, and compare the current results with those of the past.

Hole counts

The number of burrow entrances counted per unit area in crops, contour banks and along grass verges and fence lines give an indication of mouse activity. Freshly dug soil at the entrance to a burrow indicates that the burrow is active.



Figure 83. Holes can be counted, filled in and checked for reopening. (Photo Reg Eade)



A simple technique is to walk along a crop row or set path and collapse all mouse holes encountered in a 100 m (or some other pre-determined distance). For the next 2 or 3 days, count all the re-openings each day.

Monitoring nest sites

In addition to holes and burrows, mice will nest under any shelter such as field bins, sheets of iron, timber or in pipes. These nesting sites should be checked regularly to see whether mouse numbers are increasing. If young mice are found in nests during summer and autumn, then there is potential for a rapid increase even to plague proportions.

Syphons

In irrigation areas, farmers have relied on sight and smell when using syphons. Syphons that have not been used for a while will quite often have a very 'mousy' smell if mice are active, or there may be mice running out of the ends of the syphons that can be counted and recorded.

Night counts

Counting numbers of mice seen on a road regularly travelled at night or the number of mice seen in a 1-minute period after switching on a light in a shed can also provide evidence of their increasing presence. This should encourage a greater pro-active approach for paddock monitoring.

Increasing numbers of predators

There are a number of indicators of an increase in rodent numbers. In some cases, as rodent numbers rise, there is an increase in the number of raptors such as hawks, kites and falcons, as well as owls and foxes. Owls often leave 'pellets' on posts containing rodent fur, and watch for increased fox activity and footprints in sandy areas.

While predators usually respond to an increase in rodent numbers, it is usually towards the end of a rodent population boom, where a control program is often too late or ineffective.

OBSERVATIONS (SIGHTINGS, HOWLING)

Keeping records of incidental animal sightings or records of the calls of animals (such as howling behaviour in wild dogs or barking foxes) is another useful technique that anyone can use. Such information, particularly if collected over time, can be used to identify areas where pest animals are common, and may help to identify areas where control could be a future management option.

It is also important to recognise that keeping a record of observations can also be used to identify movement behaviour – where pest animals may cross roads to forage or hunt. This information, particularly if used in combination with records of damage (such as stock losses), and information gathered from other monitoring techniques, can be used in the design of control programs, or used to measure the effectiveness of management decisions.

For documenting observations, record the time, date, locations of sightings/howling, weather conditions, observer details, and any other relevant information.



IMPACTS (CROP, PASTURE, PREDATION)

While the purpose of monitoring the impacts/damage caused by pest animals is largely the same as monitoring animal numbers (see General Monitoring section above), measurements of the damage caused by a pest provides more useful information for management.

The extent of a pest problem should really be evaluated in terms of the adverse impacts/damage they cause, not their numbers. However, there are sometimes limitations on how damage can be assessed, and it is often more difficult to measure damage than monitor animal numbers/sign. Thus, pest numbers are often used to measure the effectiveness of management decisions, or identify priorities for control.

However, the emphasis should be on measuring pest-related damage, not pest numbers. Measuring the damage caused by pest animals is the best way of identifying whether a control action is required, and is the best way of evaluating the effectiveness of previous management decisions/actions. The focus of landholders and land managers should be on reducing damage until it reaches an 'acceptable' level. Is the damage caused by a pest species considered acceptable, or unacceptable? How much control is required to reduce damage to an 'acceptable' level?

Given that it is often impractical to totally eradicate a pest from an area, as the resources required for such a task often exceed the benefits of doing so, the goal should be to reduce animal numbers to where damage is no longer 'unacceptable' rather than to simply aim at eliminating every individual animal.

Pest animals are responsible for a wide variety of damage throughout Australia to social, economic and environmental values/assets. The damage caused by a pest animal also varies substantially throughout their range, and across different locations and at different times. Damage also varies with the asset/crop/resource being damaged, the condition of the asset, pest species, other species present, the duration the pest has been present, local circumstances, and other many factors. For these reasons, measuring damage is also complex, and it is difficult to recommend techniques that can be used to monitoring/measure damage in all circumstances. Most techniques are also limited in what they measure, and are suitable for a few different impact types.





Figure 84. Evidence of mice in a crop – note the crumbs. (Photo Reg Eade)

There are numerous ways in which impact monitoring can be performed, and the direct and indirect techniques that should be used will be different with every circumstance. Below is a short illustration of the range of techniques available to make measures of pest animal damage.

For pest birds, some techniques used for measuring damage include: weighing, counting or visual assessment of damage to fruit, grains or horticultural crops; economic valuations of damage associated with aircraft strikes; clean up costs where birds may roost in public venues; estimates of economic losses to aquaculture from pest birds, and repair costs where birds damage infrastructure.

For herbivores, commonly used techniques measure changes in pasture biomass, vegetation cover, plant species richness, crop damage, soil erosion, competition with livestock, spread of weeds, disease and parasites.

For introduced predators, common ways of measuring damage include counts of stock losses and the number of stock mauled, and estimates of lamb predation.

For rodents, damage to crops can be measured with observations/counts of seed heads or chewed stems, or husks at the base of plants (see image). Other direct measures include using bait cards (as described above). Rodent damage can also be caused by grain contamination rather than grain consumption, so losses associated with crop disposal can also be measured and recorded.

In almost all cases, to gain a truly accurate understanding of the impacts of a pest species, pre- and -post control damage assessments need to be performed, and the differences compared. The techniques and methods by which this can be done are varied and dependent on site-specific circumstances.



There are usually a broad range of indirect costs associated with pest animal damage, and many techniques to measure those costs. Wherever possible, costs should be recorded and monitored over time, such as the cost of control, as well as the costs of lost earnings associated with repairing damage, controlling pests, and the time required to address a pest problem.

FURTHER READING

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Further information is also available on the internet at www.dpi.nsw.gov.au and www.feral.org.au



APPENDIX A. CENSUS CARDS FOR ASSESSING THE PRESENCE OF MICE IN THE FIELD

Mice are present all the time in the field living in holes and under cover from predators. They tend to be more active at night and so it is not always easy to determine how many mice are present at any one time.

There is no really accurate way to count mice, except for extensive trapping (which is very labour intensive) over a number of nights. However, the use of census cards can provide an indication of mice and whether they are increasing or declining.

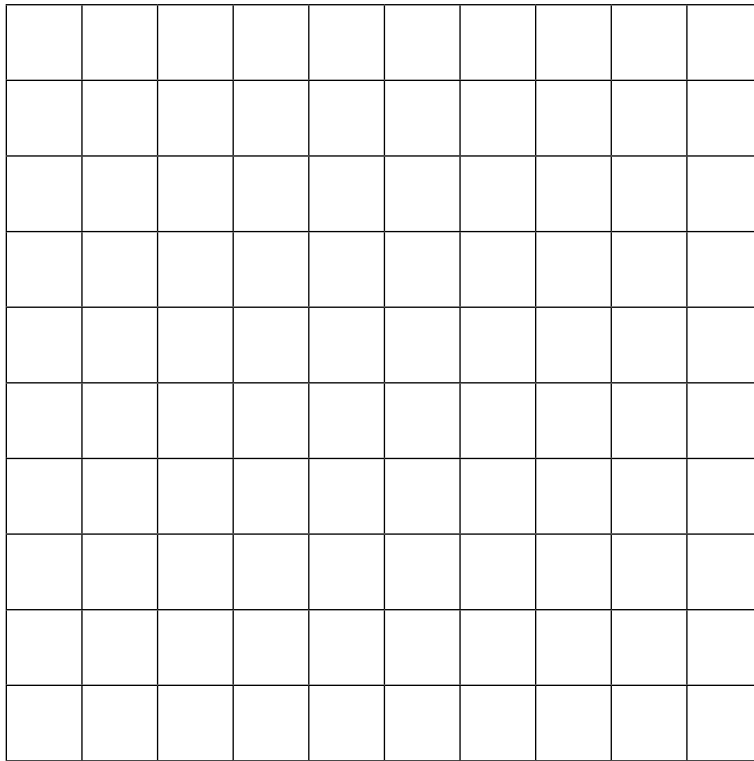
Preparing and using census cards

1. Cut sufficient cards to do each night's count. You need 10 cards per monitoring line (fewer cards is not a reliable indicator).
2. Each card is 10 cm × 10 cm cut from white bond (e.g. photocopy) paper.
3. Soak cards in canola oil for at least 1 hour.
4. When ready for dispensing, drain cards for 10 minutes.
5. Cards are put out in the afternoon (the later the better).
6. Each monitoring line should be marked and noted (recording the type of vegetation).
7. Place 10 cards in a row in the paddock at 10 m (12 paces) intervals.
8. Fix cards to the ground with wire spikes (not clods of dirt) to prevent cards being carried off or blown away.
9. Retrieve cards the following morning.
10. Mouse presence and damage potential can be assessed by determining the percentage of each card eaten.
11. Counting the number of squares eaten will give a percentage. Greater than 10% to 15% of the card eaten indicates there could be a potential mouse problem.
12. Assessment using this technique can be done any time monitoring is required.

These grids can be cut out, put in a plastic bag or laminated and used as a template.

The census cards should be 10 × 10 cm which is the same dimensions as the outside edge of the template shown here.





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