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FERAL PIGS

A REVIEW OF MONITORING AND CONTROL TECHNIQUES

PRODUCED BY

Bionet.NZ

National Pest Control Agencies

ABOUT NPCA AND BIONET

This document was published by NPCA (National Pest Control Agencies) which, until part way through 2018, provided a co-ordinating forum for agencies and stakeholders to address vertebrate animal pest control in New Zealand. In 2018 its role was transferred to the Ministry for Primary Industries under its Bionet brand.

PUBLICATIONS

Most of NPCA's publications on animal pest control were partially updated in April 2018 and transferred to the library section of the Ministry for Primary Industries' 'Bionet' online portal. The updates reflect the transfer and also acknowledge the change in the regulatory regime during 2017 and 2018, while not fully incorporating these changes in the interim, pending further reviews of the publications. Written by experienced practitioners, the main titles cover:

- best practice guidelines on controlling and monitoring vertebrate pests; and
- information about relevant regulations.

The transferred publications can be found at www.bionet.nz/library

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A REVIEW OF MONITORING AND CONTROL TECHNIQUES

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AMENDMENTS IN THIS EDITION

This April 2018 edition has been updated as part of an interim generic review of most NPCA publications. The purpose is twofold.

» Firstly, to reflect the substantial change in the regulatory regime relating to Health and Safety and use of VTAs (Vertebrate Toxic Agents) in the workplace, which now both sit under the Health and Safety at Work Act 2015, and associated regulations.

» Secondly, to change links to other NPCA publications and contact details now that NPCA's publications have been transferred to the BioNet portal, run by the Ministry for Primary Industries.

The full nature of the regulatory changes have NOT been fully captured here, and users are directed to the source legislation and website information provided by the various administering agencies.

This interim review is intended to be followed up more fully in due course.

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PART 1. INTRODUCTION

1.1 Purpose

These guidelines were commissioned by the National Pest Control Agencies (NPCA) so that what is currently known about the practical aspects of feral pig control and monitoring could be made available in a single document. At the outset, it should be noted that there are limitations to current knowledge, as explained in 'Limitations' below.

The primary audience is field staff and contractors responsible for undertaking feral pig control and monitoring. Community groups, land holders and land managers who have a need to manage the environmental and economic impacts of feral pigs will also find the document a useful source of practical guidance.

The document is not intended to direct specialised eradication or research objectives, nor is it intended to be a guide to policy makers.

1.2 Layout

The guidelines are divided into three parts:

1. **Biology and impact as a pest species.** The basic biology and general habits of feral pigs are presented and provide a basis for the nature and timing of control and monitoring. Impacts on primary production and native ecosystems are discussed.
2. **Control and management.** Selecting the appropriate management approach for the situation.
3. **Monitoring**. Selecting the techniques best able to inform management.

1.3 Limitations

In recent decades, comparatively little effort has been expended on the management of feral pigs. However, feral pig management is once again becoming more of an issue, with both Regional Councils and the Department of Conservation giving increasing attention to the impacts feral pigs have on biodiversity values.

These guidelines have been commissioned at a time when little established practice has been documented in New Zealand about the formal control of pigs and almost nothing about their monitoring. Some methods used in the past are no longer available due to regulatory changes. For instance, no toxin is currently registered for use against pigs, and the larger leg-hold traps suited to pigs are banned except with special permit[1]. No monitoring method that might inform good practice is generally in use in New Zealand, nor is any index methodology established which has been formally calibrated against actual pig density.

Most control efforts today rely on encouraging private hunters and their dogs, together with some limited pen trapping and professional hunting (air and ground). Formal monitoring of pig populations is rarely undertaken.

The necessary pest management experience required to establish agreed 'best practice' is therefore lacking, so this document is *preliminary* and intended to be updated as knowledge

[1] Animal Welfare (Leg-hold Traps) Order 2007

improves. Some elements of this document, particularly for monitoring, present methods which are believed to offer a useful starting point towards future good practice.

Practical reference sources are provided for those readers who may wish to find out more.

1.4 Acknowledgements

The contributions of the reviewers of this document are gratefully acknowledged. In particular, the professional input of staff from the Department of Conservation and from various local government agencies.

PART 2. SOME BACKGROUND INFORMATION ABOUT FERAL PIGS

2.1 Biology of the Feral Pig *Sus scrofa*

The feral pig is also called 'Captain Cooker', razorback, te poaka (the porker) or kune kune.

Contrary to popular belief, the Maori did not bring pigs to New Zealand even though pigs were common elsewhere in Polynesia. While feral pigs look similar to the European wild boar, they are, in fact, descended from domestic pigs brought to New Zealand in the eighteenth century, mostly from Europe. The first pigs released in New Zealand were two (sexes unknown) given to the Maori in Doubtless Bay in 1769 by the French explorer de Surville. During his last two voyages to New Zealand, between 1773 and 1777, James Cook released nine pigs and gave another seven to the Maori. From 1790 onwards, sealers, whalers and traders brought more pigs, mainly for barter. Pigs were introduced as a source of food for settlers, Maori and castaways, or used for bartering purposes.

Local feral pig populations were established from many different breeds and subsequently crossbred to various extents with other populations of domestic pigs originating from Europe, Asia and Polynesia. Feral pigs remain highly prized by many New Zealanders today, with public sentiment balanced between viewing feral pigs as a resource as well as a pest.

Figure 1: Feral pig

Feral pigs were well established around human settlements by 1840. Typical of other introduced species, range expansion was rapid and numbers soared. Since the Second World War, numbers have been much reduced as a consequence of hunting pressure, land use change, and habitat changes. In particular, large areas of bracken fern, highly favoured by pigs, are now much rarer than they were.

Feral pigs are smaller and more robust than domestic pigs. Their snouts are longer and larger, and they have powerfully built shoulders, with smaller hindquarters. Their hair is coarse and their tails are usually straight with a bushy tip. Boars have gristly shields up to 90mm thick on their shoulders to protect them during fights. Tusks, used for fighting, are

characteristic in males; these continue to grow, curving outwards and backwards, from the lower jaw. Matching “grinders” in the upper jaws are used to sharpen the tusks.

While there is a wide variation in colour pattern, the predominant colour is black. Although their eyesight is rather poor, feral pigs’ hearing and, particularly smell, are acute. Pigs characteristically have a powerful snout, hinged on a prenasal bone. This, powered by well developed shoulder and neck muscles, is a formidable digging tool, allowing them to access food even from firm soil and partly rotten logs.

Pig rooting results in areas of disturbed soil, turned over pasture, uprooted vegetation, and rotten logs pulled apart. It is the most obvious field sign of pigs. Other field sign might include the remains of lambs, of which pigs tend to leave the skin and lower legs uneaten. Wallows and distinctively crunched *Powelliphanta* shells (native snails) are further field sign of pigs. Size and shape of pig faeces depends on the diet but they are, most commonly, flattened oval pellets joined in a cylinder. Other sign of feral pig activity includes distinctive ‘pad runs’, similar to but larger than possum pad runs. Such runs are particularly noticeable exiting dense cover onto pasture, for instance, and may be worn down to bare dirt.

Feral pigs range over about one third of New Zealand in suitable habitat up to 1200m asl, as shown in the map below. Key habitat requirements are adequate supplies of water, food and cover. Preferred habitats are native and exotic forest and large areas of bracken, gorse or scrubland next to rough pastoral farmland. Conversion of farmland to exotic forest favours pigs, while scrub clearance and hunting pressure does not. Translocation efforts by hunters maintaining their resource are common.

Figure 2: The approximate feral range of pigs in New Zealand in 1996[2].

[2] From *The Handbook of New Zealand Mammals*, courtesy of C King.

Feral pigs are omnivorous and opportunistic feeders. Plant food includes fruits, grasses, the base of nikau fronds and the roots of many species including nettles, supplejack, thistles and palms. A preferred and staple item is the root and base of bracken. Near the coast, seaweed may be eaten. Animal foods include any soil invertebrates encountered in soil and rotten logs during rooting activities, as well as eggs or such animals as ground nesting birds, young rabbits, new-born lambs, frogs, lizards, native land snails, eels, rodents and any carrion such as dead stock or possums.

Pigs can be active at any time of the day or night, with the period of least activity being mid-afternoon and most activity around dawn and dusk. Pigs respond to hot weather and hunting pressure by becoming more nocturnal in their activities.

While adult boars are generally solitary, pigs are otherwise sociable. Sows will group together with other sows and their piglets. Young pigs also form groups of both sexes up to one year old or bachelor groups of young males.

Home ranges are highly variable, ranging from less than 1 km^2 to about 12 km^2. The area that pigs use is determined mainly by the availability of food, and boars tend to range further than sows.

Sows can begin breeding at 5-8 months old and breed two litters per year, with an average litter size of about 6 piglets. Gestation is 112-114 days. Successful breeding is enhanced by access to protein-rich food sources such as possum carcasses and worms. If protein intake becomes too limited, sows can terminate pregnancy by re-absorbing the foetuses. Piglets stay near the nest for the first 2-3 weeks and then remain with their mother until the next litter is due. Survival rates of piglets are highly variable and up to 90% of piglets die when conditions are poor. However, when conditions are favourable, it is easy to see why pig populations will recover quickly from hunting or control.

2.1.1 Key Resource

For more detailed information on the biology of feral pigs in New Zealand, the following authoritative text is recommended and that text is acknowledged, with thanks, as the primary source for the preceding information. McIlroy, J.C. (2005), 'Feral Pig'. In King, C.M. (Ed.), *The Handbook of New Zealand Mammals,* 2nd edition, Oxford University Press, Melbourne, Australia, pp 334-345.

2.2 Impacts as a Pest Species

Feral pigs impact native ecosystems, pastoral production and contribute to the bovine tuberculosis (Tb) problem.

2.2.1 Impacts on primary production

Pigs can damage pasture and crops, and kill newborn lambs and cast sheep. However, the extent of such damage is limited in New Zealand. Pig hunters and their dogs are normally successfully engaged by farmers to deal with any localised problems of this nature.

Young trees can be dug up and their roots eaten, affecting new plantings of exotic forestry. In some cases, larger trees may be ring-barked. Once again, such problems are localised and uncommon.

Of significance to primary production is the role of feral pigs in the Tb cycle, although the exact role pigs play remains unclear. Unlike possums, pigs are not thought to be 'reservoir' hosts of the disease. That means that where tuberculosis is not present in cattle or possums, it will soon disappear from the pig population. However, where it is present in other animals, especially possums, pigs have a high incidence of the disease, probably from eating Tb-infected possum carcasses. The main pig-related risk to effective Tb management is when they are illegally transported from a Tb-endemic area to a Tb-clear area. Unfortunately, such translocations of feral pigs are quite common.

Pigs are used as a 'sentinel species' to survey the distribution of Tb because they are so susceptible to catching Tb from other infected wildlife. Uninfected pigs are radio-collared, released into the survey area and subsequently recaptured. If Tb is present in other feral animals in the area, then the recaptured pigs are highly likely to show Tb infection.

2.2.2 Impacts on biodiversity values

Ecological impacts of pigs are difficult to separate from the effects of other species introduced around the same time.

Pigs prey upon ground dwelling animals and this can impact populations of birds, their eggs, native land snails, frogs and lizards. The overall effect of pigs on native fauna is believed to be less than the combined effects of possums, rats and mustelids, in that the pig is more an opportunistic predator, or carrion feeder, than an aggressive hunter. Impacts of pigs on native plants are also more localised than the widespread damage caused by deer, goats and possums.

However, no other species systematically roots up the soil like pigs do. This disturbance of the substrate, caused by pigs actively seeking out food sources, could affect ecosystem processes in the long term. Soil-feeding native species, such as the kiwi, may be adversely affected by the severe disturbance of their soil resource. The localised effects of pigs may be significant where a threatened species has a limited range or in vulnerable ecosystems such as wetlands. The extent of pig impacts has not been extensively quantified by formal research, so understanding of the effects of feral pigs remains rather limited.

Some examples of the effects of feral pigs are outlined below[3].

Birds

- Some species, such as populations of ground nesting seabirds, can be seriously compromised by pig predation of eggs and chicks and by burrow destruction. For example, in the Poor Knights Islands, many seabirds re-colonised only after the successful eradication of pigs from Aorangi Island in 1938.
- The loss of 8 Hutton's shearwater colonies in the previous few decades has been attributed to feral pigs and they are regarded as the major short-term threat, at least, for the colony at Kowhai in the Nelson-Marlborough Conservancy.

[3] Most of this list is in the experience of DOC staff from Nelson & Marlborough, M. Hawes, pers. comm.

Invertebrates

- Destruction of *Powelliphanta* land snail habitat and predation of individuals.
- On Arapawa Island in the Marlborough Sounds it is believed that pigs have a major impact on limited distribution ground/soil-dwelling species such as the protected carabid beetle *Megadromus speciosus*. While this species still holds its own in rocky sites, extensive pig rooting elsewhere has almost certainly made large tracts of forest land uninhabitable for it, both through predation of the soil-dwelling larvae and rendering the ground surface un-navigable for the adults.

Plants

- Pigs specifically target Astelia bases, thereby killing whole populations within certain areas. For example, in Nelson *Astelia grandis* is very rare and had its stronghold in the Hope River headwaters until pigs systematically decimated the population there.
- Pigs ploughed up Mutton Cove beach in Abel Tasman National Park about 10 years ago and all but wiped out 300 plants of the nationally critical coastal peppercress, *Lepidium banksii*. The population was by far the largest known for the species. It never recovered and is now gone from that beach.

Habitats

- On the Auckland Islands, pigs are thought to be able to destroy low altitude tussock habitat completely, even after the eradication of goats in 1992.
- Destruction/ploughing of wetlands - wetlands are a nationally threatened ecosystem.
- In areas of alpine tussock land, opening up the ground cover has allowed the establishment of weeds.

Figure 3: Pig Rooting

2.2.3 Key Resources

Parkes, J. 2006. Economic and environmental risks from feral pigs in Northland. **[Envirolink Project for Northland Regional Council.]** **http://envirolink.govt.nz/assets/Envirolink/217-NIrc27EconomicAndEnvironmentalRisksFromFeral.pdf**

Coleman, M. Parkes, J, Walker, K; Impacts of Feral Pigs on D'Urville Island's Invertebrates. In Kararehe Kino, Vertebrate Pest Research, Issue 4, 2004 **[a popular article]** http://www.landcareresearch.co.nz/publications/newsletters/possnews/KarareheKino4.pdf

PART 3. CONTROL

3.1 Management Options

Toxins

One recently registered toxin, Bait-Rite, is available for the control of feral pigs. Refer label and SDS (Safety Data Sheet) instructions and, for further advice on regulatory controls on use of this substance, refer www.worksafe.govt.nz .

Trapping

Trapping is rarely used in New Zealand as a formal feral pig management technique but does have potential application, particularly pen trapping, which might usefully be more widely adopted. The larger leg-hold traps suited to pigs are now banned and snares are a method unlikely to meet reasonable animal welfare expectations.

Night shooting

Night shooting is also rarely used in New Zealand for formal feral pig management but, again, has potential for being more widely implemented.

Day hunting

Day hunting is the most common method used to control feral pigs in New Zealand, including:

- Ground hunting with dogs;
- Ground hunting without dogs;
- Aerial (helicopter) shooting (which can be enhanced with the use of 'Judas pigs').

Of these methods, hunting with dogs is by far the most popular and is much more effective than hunting without dogs. A 1988 survey showed that hunters with dogs accounted for 87% of around 100,000 pigs taken that year. While hunting with dogs has historically been the domain of recreational hunters, the technique is being used to good effect by non-recreational professional hunters also. One example is the eradication of about 5,000 pigs from Santa Cruz Island by ProHunt NZ[4] ().

Aerial shooting has been cost effectively undertaken in relatively open habitat, such as the grasslands of central Otago. However, much typical pig habitat in New Zealand is too densely vegetated for efficient use of aerial hunting. Helicopter shooting in areas with readily accessible cover for the pigs can be enhanced in combination with dogs. The helicopter shooter targets the bulk of a mob of pigs and this is followed by despatching a ground hunter and dogs to target survivors that would have sought cover.

Judas Pigs

Both ground and aerial hunting methods can be enhanced by the use of 'Judas pigs', meaning a pig which has been captured, fitted with a radio collar and released to find and mob up with other feral pigs. Its radio collar will then lead the hunters to the other pigs. The 'Judas' name refers to the betrayal of Jesus by Judas Iscariot, one of Jesus' own disciples.

[4] While this document is not intended to promote any one company over another, the Santa Cruz case study presents a large and successful pig eradication project achieved in a short 22-month timeframe. The short time frame compares favourably with the 30-year period it took to successfully eradicate pigs from the larger Santiago Island (580 km^2) in the Galapagos group.

Exclusion fencing

Exclusion fencing is a final control option, often used in 'Mainland Island' projects. Pig-specific fences can be constructed at less cost than a true multi-species fence and may be usefully applied to protect high value areas from pigs.

3.2 Choosing Control Techniques

Terrain and management objectives are the two key considerations when deciding which combination of control techniques to use. The two-way table below gives general guidance on the suitability of various control techniques or combination of techniques.

Having determined broadly which techniques are suitable, additional consideration will need to be given to factors of specific relevance to the operation. For example, issues of land tenure, relationships with local people, budget and so forth.

Objective/Terrain	Accessible area with plenty of open space	Densely vegetated terrain
Reduce pigs in localised area, with short term impact	In most instances, recreational pig hunters with dogs are effective. Alternatively, pen traps can be set up or hunt by ground without dogs or by helicopter shooting.	In most instances, recreational pig hunters with dogs are effective. Alternatively, paid hunters with dogs may be deployed, particularly where access is difficult.
Keep pigs to moderate numbers over large areas in the long term	In most instances, recreational pig hunters with dogs are effective. Alternatively, hunt by ground without dogs or by helicopter shooting.	In most instances, recreational pig hunters with dogs are effective. Alternatively, professional hunters with dogs may be deployed, particularly where access is difficult. The recently registered toxin, 'Bait-Rite', may also be used.
Reduce pigs to low numbers over large areas in the long term	This will require ongoing active management, using paid hunters with dogs in combination with helicopter shooting. Trapping and Judas pigs may be used in combination with hunting efforts.	This will require ongoing active management, using professional hunting with dogs. Trapping and Judas pigs may be used in combination with hunting efforts but probably to lesser effect. The recently registered toxin, 'Bait-Rite', may also be used.
Eradicate and exclude pigs	In the first instance, this will require that no immigrant pigs can re-enter the area in future. This can be achieved geographically (islands) or with exclusion fencing. Then removing all pigs will rely on a range of techniques, as demonstrated in the Santa Cruz case study below, including fencing the area into manageable units, trapping, helicopter and ground hunting, and finally hunting with dogs. The recently registered toxin, 'Bait-Rite', may also be used.	As for areas with open space. However, the use of trapping and helicopter hunting will be constrained and, hence, there will be greater reliance on professional hunting with dogs. The recently registered toxin, 'Bait-Rite', may also be used. Use of Judas pigs is an option when trying to locate the last few animals but the Santa Cruz experience indicates that this can create problems where pigs lose their collars. Such 'educated' animals are most difficult to recapture.

3.3 Case study - Santa Cruz pig eradication

The largest of the eight Channel Islands off the Californian coast, the 250 km^2 Santa Cruz Island is graced with a 120 km stretch of coastline. The island group is often referred to as 'the Galapagos of North America' and Santa Cruz Island supports more than a thousand species of plants and animals, including 12 found nowhere else on Earth.

A feral pig eradication programme was successfully completed in 2007 after a period of 22 months. Around 5,000 pigs were removed during this time. This achievement relied on meticulous planning and observance of the fundamental tenet of professional pest control: "*do not educate the target species*".

The first step saw the island fenced into five manageable eradication zones, with over 40 km of fence erected. Pigs were then removed using trapping, aerial hunting and ground hunting, in that order. No toxins were used.

3.3.1 Key Resources

Prohunt Incorporated have written a comprehensive Santa Cruz case study. This very useful and highly recommended document, "*A new approach for ungulate eradication*", available at https://www.pestsmart.org.au/wp-content/uploads/2010/03/UngulateEradication2008.pdf .

A further interesting case study, in comparison, is the eradication of pigs from Santiago Island, Galapagos. Cruz, F. Donlan, J. Campbell, K. Carrion, V. (2005). Conservation action in the Galapagos: feral pig (*Sus scrofa*) eradication from Santiago Island. *Biological Conservation 121* (2005) 473–478 online at http://www.galapagos.org/pdf/Cruzetal2005.pdf

3.4 Toxins

The recently registered toxin, 'Bait-Rite', is available for the control of feral pigs. The manufacturer's best practice guidelines are available at www.connovation.co.nz/vdb/document/86 This product may be quite effective; time will tell.

3.5 Shooting

3.5.1 Night shooting

Night shooting is an option in more open and accessible terrain. The technique is most useful in the early stages of control, such as reducing a high population to a medium one. Educated survivors will avoid the light. This is aggravated by the fact that pigs are hard to see, as they do not have eyeshine that strongly reflects in the spotlight. A variation is to get pigs using pre-feed baiting sites for a few weeks before shooting them at the baiting sites.

Remember, night shooting is hazardous and a job for professionals.

Key Resource

Good practice techniques for night shooting pigs and for safe firearm use generally are similar to those for rabbits: see the NPCA publication, *Pest Rabbits: Monitoring and Control* at www.bionet.nz/library/ .

3.5.2 Ground hunting with dogs

Ground shooting by day, with dogs, is the most common and popular approach to feral pig control in New Zealand. But in areas where native ground birds such as kiwi are present, pig dogs can pose a serious risk to the ground-dwelling birds. The risk to kiwi of poorly trained dogs is thought to be greater than the risk posed by feral pigs themselves.

The training of pig dogs, and giving them enough hunting time to keep them effective, is a substantial, specialised and ongoing commitment. That is why this method has always been, and will continue to be, the exclusive domain of committed recreational hunters or specialised professional (paid) teams. Opinions as to the best training methods and breeds are widely divergent and this document does not address the training of effective dog teams.

Minimising potential adverse effects of dogs

However, regardless of how dogs are trained, criteria that the dogs and their masters should meet can be defined. At the time of writing no agreed criteria were established and, while some ideas are presented below, these are very much subject to debate and further development.

- Reduce pig numbers by trapping or other methods first, to minimise the amount of hunting required to eliminate the survivors.
- Restrict each hunter to a maximum of 3 dogs while hunting.
- Require that dogs be kept close by use of 'short finders' and not letting holders free until a pig is bailed.
- Require that all hunters demonstrate control of and basic obedience control of their dogs, and demonstrate that their dogs will only target pigs and not other species such as stock or kiwi.
- Carry out a pig eradication day (or couple of days) once pig numbers have been reduced by trapping, using a number of reliable hunters. If this is done in a coordinated manner, the pigs have less of a chance of leaving the block and escaping as they are more likely to encounter another hunter.
- Require dogs to have telemetry tracking collars so that lost dogs can be recovered5.

Co-ordinated hunting

One technique commonly used by professional hunting teams is the 'Wall of Death'[6] method.

This control method involves teams of experienced hunters with dogs, two-way radios and dog tracking gear. Each hunter in the wall has a team of dogs, which may be either bailers or holders, but each hunter should have good finding dogs. Radio tracking collars are attached to the finders and ideally each hunter has a tracking unit that can track the dogs of all teams. All hunters are in radio communication with each other and should wear high visibility clothing.

[5] Electronic dog tracking equipment can be purchased from CollarTron (www.collartron.co.nz), Kiwi track (www.kiwitrackltd.co.nz) and there may well be others.

[6] This account presented here is written courtesy of E. Kelsall, Greater Wellington, and based on the practices of hunting teams led by Neil Buchanan when engaged to remove pigs from water catchment land.

To begin the drive, the hunter/dog teams position themselves at the head of a valley or spread out down a face in a line. The distance between and location of hunters will vary depending on the scale and nature of the terrain. The hunters aim to maintain a line while they hunt forward and to cover all of the area with their dog teams. The wall should hunt downhill or sidle in steep country where possible, as any pigs chased will normally run downhill. Mapping GPS units can be used to maintain the line or radio contact used to describe when landmarks are reached, such as creeks or ridges. The line must move as slowly as the hunter in the roughest terrain, to ensure all the ground is covered at the same time.

Any pigs they encounter will be pursued by the dogs or driven sideways into the path of the other teams. Hunting in line allows a hunter to reach the bail quickly, which will help to prevent dog injuries and bailed pigs from escaping. The use of dog teams can cause problems with dogs joining other hunter's packs, particularly during the bail, but radio contact will help to sort out any mix-ups. Ideally, a hunter will also be positioned at the ridge above and in the valley below, to prevent any pigs escaping sideways or back into the ground already covered.

Stationary hunters with rifles can be positioned ahead of the team to cover likely game trails or routes of escape and can be alerted of approaching animals by radio. Other animals such as deer or goats can also be targeted as a by-kill in this way.

Hunting must be systematic, ideally with little or no hunting pressure on the area before the organised hunt takes place. Each drive will aim to move any animals not caught into an area yet to be hunted. Natural and artificial features such as steep ridges, bluffs, major rivers, gorges, farmland or purpose-built deer or predator fences should be used as barriers on one side of or at the end of the operational area where possible.

3.5.3 Ground hunting without dogs

Hunting without dogs is usually less effective than hunting with dogs.

This method has some limited application in the initial stages of a control operation, where large numbers of pigs exist in mobs in reasonably open country. In situations like this, initially targeting the mobs with dogs would likely disperse the mob before shooters have an opportunity to despatch a significant number of the pigs. Use of dogs becomes most appropriate when the numbers of pigs likely to be encountered at any one time does not exceed the number of dogs.

Key Resource
PIG003 ground shooting of feral pigs. Prepared by Trudy Sharp & Glen Saunders, NSW Department of Primary Industries.
http://155.187.2.69/biodiversity/invasive/publications/pubs/pig003-ground-shooting-feral-pigs.pdf

3.5.4 Aerial shooting

Aerial shooting of feral pigs from a helicopter may be cost effective in relatively open country and where the density of pigs is high. Helicopter shooting is a specialised technique which is not further covered in this document.

Key Resource
PIG002 aerial shooting of feral pigs. Prepared by Trudy Sharp & Glen Saunders, NSW Department of Primary Industries.
http://155.187.2.69/biodiversity/invasive/publications/pubs/pig002-aerial-shooting-feral-pigs.pdf

3.6 Trapping

Pig trapping is a popular control technique in Australia, where it is considered a useful method for low to medium density populations but ineffective for high density pig populations.

While it is possible to utilise trapping in forest environments, the size and weight of materials to be deployed makes it more ideally suited to areas with vehicle access.

Various different designs of pig trap are available. All are basically an enclosed area with a one-way gate.

Pig traps must be inspected daily and at least within 12 hours of sunrise – a legal requirement under the Animal Welfare Act 1999. Additionally, pig traps set in exposed situations must be inspected and cleared before the heat of day because pigs, having limited sweat glands, require shade and water to assist with body temperature regulation.

Critical factors to successful trapping are:

- pre-feeding is sufficiently long for pigs to overcome their wariness of the trap and the bait;
- the gate mechanism is quiet, opens inwards and allows easy passage of pigs of all ages;
- never put a floor on a pig trap;
- mesh must be seated firmly onto the ground with no gaps underneath;
- do not disturb pigs in the area with hunting activity, as this has been found to make trapping ineffective.

While traps are normally used with a food bait, some research has been carried out on using oestrous feral pigs as trapping lures (McIlroy and Gifford 2005). Although the method is not cost-effective as a general technique, it may be useful in specific circumstances, such as eradication campaigns on islands, if the last few pigs are impossible to cull by other methods.

The following case study details a methodology that has been successful.

3.6.1 Case study: a panel trap design and methodology from Marlborough

This example of use of panel traps is taken from written guidelines contributed by Lindsay Grueber of Tasman District Council[7], and is based on the extensive experience of Nigel Young. The re-usable panel trap design breaks down to flat sections which can be readily transported on a standard trailer. The design is simple, cost-effective, portable and catches pigs.

Figure 4: Panel Trap. (Photo courtesy Nigel Young, Blenheim)

1. Trap construction

- **Sides and ends:** made of reinforcing mesh 'black'8 – 50 x 50 mm (4 mm thick) mesh hole size. Sheet size is 2.4 m x 1.2 m. Bigger mesh hole size may result in damage to the pigs' snouts when they charge the sides or provide them with the opportunity to lift the mesh with their snouts.
- **Mesh:** held in place using waratahs wired at each corner and centre on the outside of the mesh.
- **Gate frame and gate**: frame made from angle iron approx. 25 x 25 mm x 5 mm thick. Gate made from flat steel (approx. 25 mm x 5 mm thick) with 50 mm mesh welded to it.
- **Gate dimensions**: approx. 600 mm wide x 900 mm in height and is made to suit the gate frame ensuring the gate will close nicely onto the flat of the angle iron. Remember the gate design is to open inwards.
- **The gate:** is hinged at the top using pipe 'rounds' and neat fitting steel rod welded permanently in place on the frame and gate respectively. Variations to this top-swinging hinge are fine so long as the gate shuts freely and evenly.
- Gate **frame fixing:** On each outside of the gate frame, weld two pieces of steel pipe approx. 75mm in length – one near the top and one near the bottom, with a hole diameter big enough to allow a waratah to easily fit through. This is how the gate frame is held in place and to also wire the mesh sides to.

[7] Tasman District Council report 2003 - 'Controlling Feral Pigs using Panel Traps' with design and methodology by Nigel Young, Blenheim.

[8] One supplier of 50 mm mesh is Fletcher EasySteel.

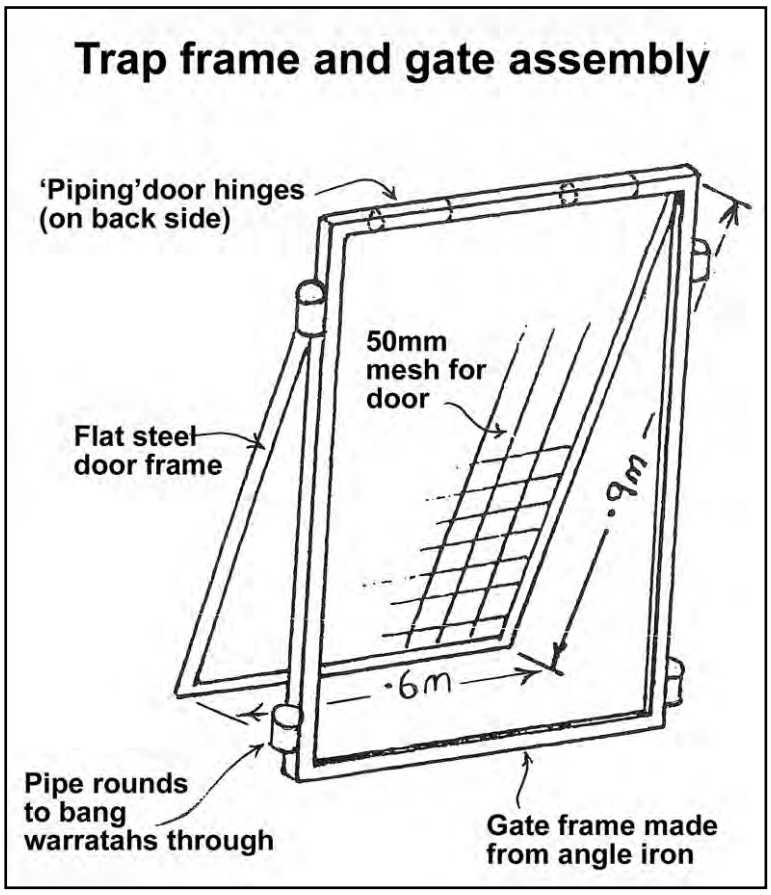

Figure 5: Trap frame and gate assembly

2. Pre-feeding

- This stage of the trapping process is critical to success and no short cuts should be taken, even though you will want the pig damage to stop immediately. It may take several nights before the first feed occurs.
- As soon as fresh sign is seen, start feeding. Do not erect the trap until the pigs are accustomed to feeding.
- Pre-feed with fermented barley. Half-fill a 20L bucket with barley and top up with warm water and some molasses (optional). Leave for 3 – 4 days or until you notice a fermenting smell.
- Pre-feed where there is evidence of pig activity.
- Pour half the contents of the bucket in a pile and shape up by hand to form a cone, then dump a handful of grain every 2 - 3 paces out from the main pile across the area affected by rooting to about 20 - 30 m and repeat in several different directions.
- Coning the main pile allows a 'tentative take' by pigs disturbing the pile to be visually confirmed, as they are extremely wary. Pigs will often test the new food and wait a couple of days until they know it's safe to eat before they start feeding properly,
- Once feeding starts ensure plenty of grain and replenish daily for 2 - 3 nights and then erect the trap near the main pile. Reduce the main pile and add a new pile of grain to the trap interior plus a 'lead-in' grain trail.

3. Erecting the trap

- Once pigs are taking the feed, set up the sides and ends of the trap. Do not set up the gate/frame unit yet but take it with you to use for setting up the mesh spacing.
- On rough or uneven ground grub any high points to allow the mesh to sit flush with the ground and eliminate any gaps that will allow pigs to escape under.
- Use waratahs at each corner and at the centre of the mesh panels. Wire firmly into place (bottom, middle and top) on the outside of the mesh panels. Additional waratahs/wiring may be required depending on terrain. Don't hit the waratahs at the gate gap area too firmly as they will be removed and used when the gate unit is fixed in place. If you have concerns about the solidness of the waratahs or mesh, the waratahs can be wired (at the top) on the diagonal to one another.
- Obviously the gate will create an overhang of one of the panels (by the width of the gate unit) – don't worry about this.
- Maintain feed daily for a couple of nights to accustom pigs to walking into the trap. Then, all going well, erect the gate frame and gate (don't change the entry position), and wire the gate open.
- The frame/gate should be angled slightly inwards at the bottom to allow the gate to swing shut – this angle should allow firm but not hard shutting of the gate. Remember, it has to be able to be accessed easily by pigs of all ages, not just the big ones, and not scare pigs still outside the trap by clanging shut.
- Maintain feed – some just outside the trap, with the bulk inside, for at least another three nights. If pigs are still freely feeding, set the trap.

Figure 6: Trap door wired open. Note feed both inside and outside trap. (Photo courtesy Nigel Young, Blenheim)

4. Setting the trap

- The gate should be set in a roughly horizontal position and propped up at one corner to allow open access. A **trip string** is attached to the top of the prop and then through the mesh side panel near the rear of the trap and across to the other side where it is attached. Position 'trip' up just high enough so hares, possums etc don't set it off.
- Another trigger used in Australia and New Zealand is to place a small rock on the bait (sometimes even an old loaf of bread) and string so that the pigs nose this off when in the trap.
- Maintain the feed pile near the centre of the trap plus a new pile between the trip-string and rear of the trap.

Figure 7: Trap set on extensive pasture damage. Note the angle of the gate. The best result of this type of set is 14 pigs in one night! (Photo courtesy Nigel Young, Blenheim).

Figure 8: Gate propped open with trip string attached. Note additional feed pile between trip and rear of trap. (Photo courtesy Nigel Young, Blenheim)

5. Despatching trapped pigs

- Head shooting with a centre-fire rifle is effective if undertaken by a competent and licensed shooter.
- If lactating sows are caught in a trap without their young, efforts should be made to find dependent piglets and kill them quickly and humanely.
- **Caution:** when shooting, it is advisable to shoot from the trap gate area and be aware that although small pigs will often huddle together in a corner, larger pigs may charge at the shooter.
- Once all pigs in the trap are dead, wire the gate open and pull the carcasses out and away from trap before bleeding. Don't leave dead pigs lying around outside the trap.
- Reset trap and continue until no further pigs are caught.

Figure 9: Shade provided as pigs have difficulty regulating body temperature and will suffer heat stress in exposed conditions. Also make sure traps are checked as early as possible. (Photo courtesy Nigel Young, Blenheim)

Key Resources

Trapping of Feral pigs, Sharp and Saunders 2005 online at hhttps://www.pestsmart.org.au/wp-content/uploads/2018/02/171221_SOP_PIG001_web.pdf

Monitoring Techniques for Vertebrate Pests – Feral Pigs, Mitchell B and Balogh S, 2007. NSW DPA Orange online at http://www.pestsmart.org.au/wp-content/uploads/2010/03/Monitoring-techniques-for-vertebrate-pests---pigs.pdf **[Australian, contains practical advice, and pictures of trap construction]**

3.7 Fencing

Feral pigs can be fenced out of areas. Fencing is a relatively expensive option and once the capital cost of establishing a fence is met, regular checking and maintenance will be necessary to ensure its ongoing effectiveness.

3.7.1 Electric fencing

Effectiveness of existing fences, either mesh or conventional, can be greatly enhanced with an electric outrigger. This should be about 20-30 cm off the ground and 20-30 cm out from the main fence as shown below[9].

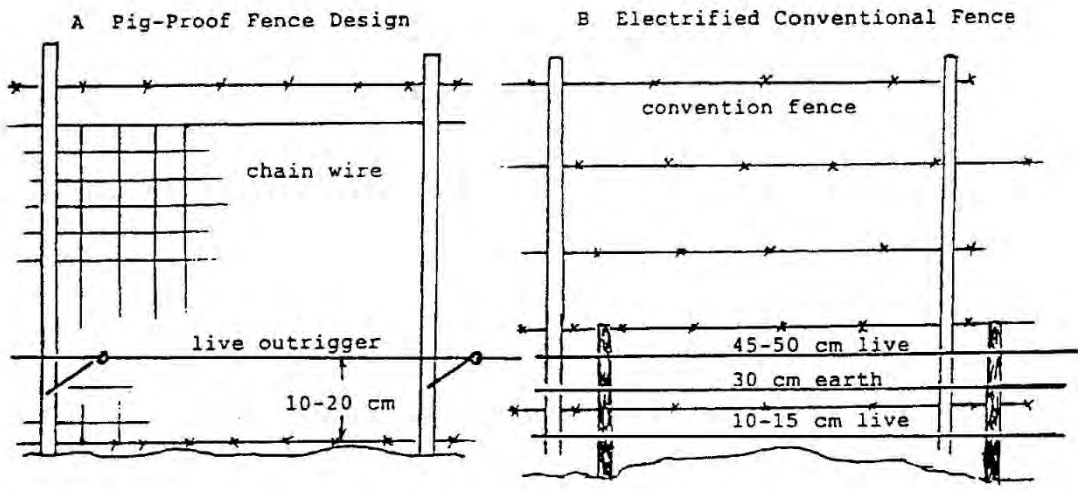

Figure 10: comparative fence designs

3.7.2 Case study: Te Paki pig fence design

A cost effective pig fence can be constructed using readily available pig fencing materials. The Te Paki pig fences in Northland were constructed from posts, standards, pig netting and barbed wire and have proven to be effective at excluding both pigs and farm stock. They have a post about every 4 m (depending on ground contours) with a metal standard every metre. The bottom barbed wire is as close to ground level as possible, following the contours. The pig netting is very close to the barbed wire and also follows all contours. Finally the fence is topped off with a second barbed wire. All wires are tied to every standard and stapled to every post. The fence is approximately 1100 mm high - i.e. it uses standard length posts.

While the Te Paki pig fences in Northland are effective in their location, there is little incentive for pigs to enter those fenced exclosures. Where pigs are more motivated or accustomed to accessing a known food source, more robust fences may be necessary. For instance, in the Santa Cruz eradication project, wire fence mesh was buried into the ground to prevent pigs getting under.

[9] Courtesy Department of Conservation, Northland.

Key Resources
Pest Fences: Notes and Comments. Mike Aviss and Andy Roberts (1994). *DOC Threatened Species Occasional Publication no. 5*. online at; www.doc.govt.nz/upload/documents/science-and-technical/TSOP05.pdf **[describes Te Paki pig fence, with pictures]**

PIG001 trapping of feral pigs. Prepared by Trudy Sharp & Glen Saunders, NSW Department of Primary Industries.
https://www.pestsmart.org.au/wp-content/uploads/2018/02/171221_SOP_PIG001_web.pdf **[Australian]**

Catalogue of Fence Designs – Cost effective feral animal exclusion.
http://www.generalpurposehosting.com/fences/downloads/Getting%20Fencing%20Right.PDF **[practical document with clear pictures and design, courtesy of the Australian Government]**

3.8 Judas Pigs

'Judas pig' refers to a pig which has been captured, is fitted with a radio collar and released to find and mob up with other feral pigs. Its radio collar will then lead the hunters to the other pigs. The 'Judas' name refers to the betrayal of Jesus by one of his own disciples, Judas Iscariot.

Sows and young pigs are most suitable as Judas pigs since older boars are least sociable. This tendency also means that older boars are least likely to be located using Judas pigs.

Use of Judas pigs is a specialised technique, particularly suited where pig population density is very low. For example, the final stages of eradication or to check that no new pig populations are spilling into eradicated areas.

In moderate to high pig populations, use of Judas pigs is unlikely to be cost-effective as pigs can be relatively easily located using dogs, for instance.

Key Resources
Sharp, T. and Saunders, G. PIG004 – Use of Judas Pigs. NSW Department of Primary Industry. http://155.187.2.69/biodiversity/invasive/publications/pubs/pig004-use-judas-pigs.pdf

DOC (2002). Judas Workshop. Proceedings of a workshop on the use of radio telemetry for animal pest control. Department of Conservation, Otago Conservancy, Dunedin, NZ.

McIlroy, J.C.; Gifford, E.J. 1997: The 'Judas' pig technique: a method that could enhance control programmes against feral pigs, *Sus scrofa*. *Wildlife Research 24*: 483–491.

PART 4. MONITORING

4.1 Monitoring Overview

No well established and nationally consistent monitoring techniques are recognised for measuring the actual or relative abundance of feral pigs.

A nationally standardised methodology may arise as feral pig management efforts increase. Presented here are four relative abundance (index) methodologies, which may prove useful to the New Zealand situation. None have been confirmed by formal calibration against known population density in New Zealand.

Monitoring can be of two types; **operational monitoring**, which usually measures changes in the population of the pest species, and **performance monitoring**, also known as outcome monitoring, which measures the response of the resource being protected from pigs. Both types of monitoring range from informal or anecdotal evidence, through simple quantitative methods and finally to fully randomised and replicated experimental designs, which provide the most conclusive evidence.

Ideally, both pest density and the resource being protected will be monitored, and monitored well, according to established principles of experimental design. However, the quality of evidence required is also subject to cost benefit principles. For example, the success of pig control can be visually confirmed where pasture damage (rooting) or lamb predation stops or is significantly reduced. No monitoring of the pig population nor any formal effort quantifying the extent of pasture damage, is necessary. In this example, only anecdotal performance monitoring is undertaken.

However, where conservation values are being protected it is more challenging to determine the outcomes. The relationship between pig population density and viability of native snail populations, for instance, is not well established by science and that is true of most relationships where pigs impact conservation values. This is of significant consequence because even if monitoring techniques for feral pigs (either actual or relative abundance methods) were well established, it remains unknown what population density should be targeted to provide the necessary protection for a given resource.

While **performance monitoring** is important, the methods vary widely and generally need to be designed for the specific resource to be protected. Such monitoring is not considered further in this document. Instead, monitoring of feral pig populations (**operational monitoring**) is considered.

Key Resource

A useful and practical reference for monitoring of feral pigs comes from Australia. It should be remembered that most New Zealand pig habitat is not typical of the open savannah type terrain widely used by pigs in Australia.

Monitoring Techniques for Vertebrate Pests – Feral Pigs. (2007). Mitchell and Balogh. online at https://www.pestsmart.org.au/wp-content/uploads/2010/03/Monitoring-techniques-for-vertebrate-pests---pigs2.pdf

4.2 Monitoring Techniques

Four methods of feral pig monitoring are described,[10] which are most likely to be useful for management of feral pigs. Remember that these index methods have not been widely used in New Zealand. Nor have the indices been formally calibrated against known pig densities. *With collective experience and further research, therefore, these methods are likely to be subject to change and further development.*

1. Day inspections – Field Sign
2. Day Inspections – Soil Disturbance
3. Faecal counts
4. Catch per Unit Effort (CPUE)

Some advantages and disadvantages of these monitoring methods are tabulated below.

Technique	Advantages	Disadvantages
Day inspections – Field Sign	• Inexpensive • Able to detect pig presence at low population densities • Suited to mapping distribution of pig populations over large areas	• Relatively coarse measure • Not suited to monitoring short term changes (e.g. pre and post control)
Day Inspections – Soil Disturbance	• Inexpensive • Provides index of population density as well as a direct measure of habitat disturbance	• Relatively coarse measure • Not suited to monitoring short term changes (e.g. pre and post control)
Faecal counts	• Able to quantify pre and post control population indices • Faecal count indices well correlated to population density	• Likely to be an insensitive measure at low population densities • Relatively labour intensive
Catch per Unit Effort (CPUE)	• Can be incorporated into control program, therefore inexpensive monitoring method • Removes feral pigs	• Hunters may not report captures accurately • Probability of detection is likely to vary as the population is reduced

[10] These methods are all based on the techniques described in 'Monitoring Techniques for Vertebrate Pests – Feral https://www.pestsmart.org.au/wp-content/uploads/2010/03/Monitoring-techniques-for-vertebrate-pests---pigs.pdf

4.2.1 Day inspections – field sign

Pigs are large animals and their rooting behaviour heralds their presence even to the relatively untrained eye. This allows us to develop a simple presence/absence index based on a walk-through survey. The methodology can be:

- on a map, systematically place a suitable number of 1 km transects over the management area, spaced at least 1 km apart (minimum of 10 transects if space allows);
- walk the transects, stopping every 100m (using GPS) to record the presence or absence of sign (actual sighting or dung or pig wallow or rooting) over the previous 100 m;
- the index is the average percentage of 100 m sections which record the presence of pig sign.

This simple index, based on presence/absence, is useful for mapping the distribution of feral pigs and provides a coarse index of the relative abundance of the pig population density. It is suitable for cost effective regional-scale trend monitoring but is unlikely to be accurate enough for operational purposes.

4.2.2 Day inspections – soil disturbance

This method provides both an index of pig population density and a direct estimate of the proportion of the substrate which is being affected by pig activity. The advantage of the method is that it provides some insight into the proportion of substrate habitat which is being modified by pigs at any one time, which in turn casts some illumination on the scale of likely impact on species dependant on the substrate ecosystem. The method is challenged by the difficulty of determining a consistent cut-off point to distinguish old rooting from fresh rooting. For the purpose of this index, old rooting is defined as any rooting which shows new emergence of any species of seedling. This means some quite old rooting may be classified 'fresh' and, therefore, this method will not be sensitive to short-term changes in the pig population.

- On a map, systematically place a suitable number of 1 km transects over the management area, spaced at least 1 km apart (minimum of 10 transects if space allows).
- Every 50 m along the line establish a 10 m x 2 m plot, marked at each end with a peg (i.e. 20 plots per line). Capture the GPS position for each plot.
- For each plot, estimate to the nearest 20% the percentage of substrate disturbed by pig 'fresh' activity (rooting or wallowing) and categorise as closest to; 0% disturbance, 20%, 40%, 60%, 80%, or 100%.
- The index is the average of percentage substrate disturbance per plot for all transects.

4.2.3 Faecal counts

This index is more precise than simple day inspections. It is also more labour intensive. Faecal counts have been shown in Australia to be significantly correlated with population density of feral pigs. For operational purposes, this index is likely to provide the most useful measure of ***change*** in population density.

- On a map, systematically place a suitable number of 1 km transects over the management area, spaced at least 1 km apart (minimum of 10 transects if space allows).
- Every 50 m along the line establish a 10 m x 2 m plot, marked at each end with a peg (i.e. 20 plots per line). Capture the GPS position for each plot.

- Clear each plot of any pig dung.
- Return after 1 month and count the occurrences of pig dung in each plot (string a line between the 2 pegs, and count 1m either side of the line).
- The index is the average number of dung occurrences per plot for all transects.

Key Resource
Faecal counts are a well established methodology used for many species. The principles are well established, as for example in the protocol for deer.

Forsyth D. 2005; Protocol for estimating changes in the relative abundance of deer in New Zealand forests using the Faecal Pellet Index (FPI). *Landcare Research Contract Report: LC0506/027*. http://www.doc.govt.nz/documents/conservation/threats-and-impacts/animal-pests/fpi-protocol.pdf

4.2.4 CPUE – catch per unit effort

This index may be useful for trend monitoring and also (perhaps marginally) as a measure of control efficacy. There are two variations.

The first is the recreational hunter CPUE. This is a measure of the number of pigs reported killed per hunter day effort in a given area. This method only applies to areas of public land where hunting permits are required. This method suffers from misreporting or data gaps where hunters either do not get a permit in the first place or, if they do, submit an inaccurate report or no report at all. However, as a trend-monitoring tool and for mapping presence/absence, it has value if hunters submit reliable information on kills and the days hunted.

The second measure of CPUE is derived from professional control operators engaged to reduce a pig population. The number of pigs killed per hunter or trapping day or helicopter shooting hour will reduce as pigs are removed from the population and this can be extrapolated graphically to approximate the percentage of the population still remaining. This method works well enough where reliable information from control operators is assured and the objective of management is to reduce the pig population only. However, as very low or zero pig densities are targeted, this method fails as the few, educated survivors are much more difficult to capture or kill than that of the naive pigs that got killed early in the control program. It is therefore an insufficient technique for confirming eradication.

4.2.5 Other methods

A number of other potential monitoring methodologies exist, a few of which are briefly identified below. These methods are less likely to be relevant as they either lend themselves to more open terrain or are expensive and specialised methods, suited to specialised research or eradication programmes.

Night counting

Most New Zealand feral pig habitat has too much cover to enable this method to be used. Where open terrain allows this method, the reader is referred to the sister publication *Pest*

Rabbits: Monitoring and Control at www.bionet.nz/library/ as the night counting methodology presented there can be applied for pigs also.

Aerial survey by day or by night using FLIR (forward looking infra red)
This is useful over large and reasonably open terrain not typical of New Zealand pig habitat. There is evidence from experiences with FLIR of staff at the Department of Conservation at Ben Ohau that it is quite ineffective, even in more open tussock country, with no pigs detected where they were known to be present.

Judas pig/radio tracking and DNA sampling
This is useful for research purposes or confirming the success of an eradication programme.

Trap catch
The lack of vehicle access to most pig habitat and the weight of pig traps make this method impractical.

Motion sensing camera
This method has potential but is untried in New Zealand.

Tracking
Fresh dirt or sand can be spread over known runs to confirm (from footprints) whether they are still being used. Widely used in Australia but not particularly suited to the New Zealand environment.

Distance sampling (ground)
The great advantage of distance sampling methods is that they give a true density estimate rather than an index. However, the Achilles heel of distance sampling is 'sightability' of the target; a factor that is compromised by the dense cover of typical New Zealand pig habitat and by the behavioural response of feral pigs avoiding the people who are trying to find (and often kill) them.

Bait take
Bait take has potential, as a simple index of the proportion of sites where bait is taken by pigs. Bait take methods can be confounded where individual animals take bait from more than one monitoring site.

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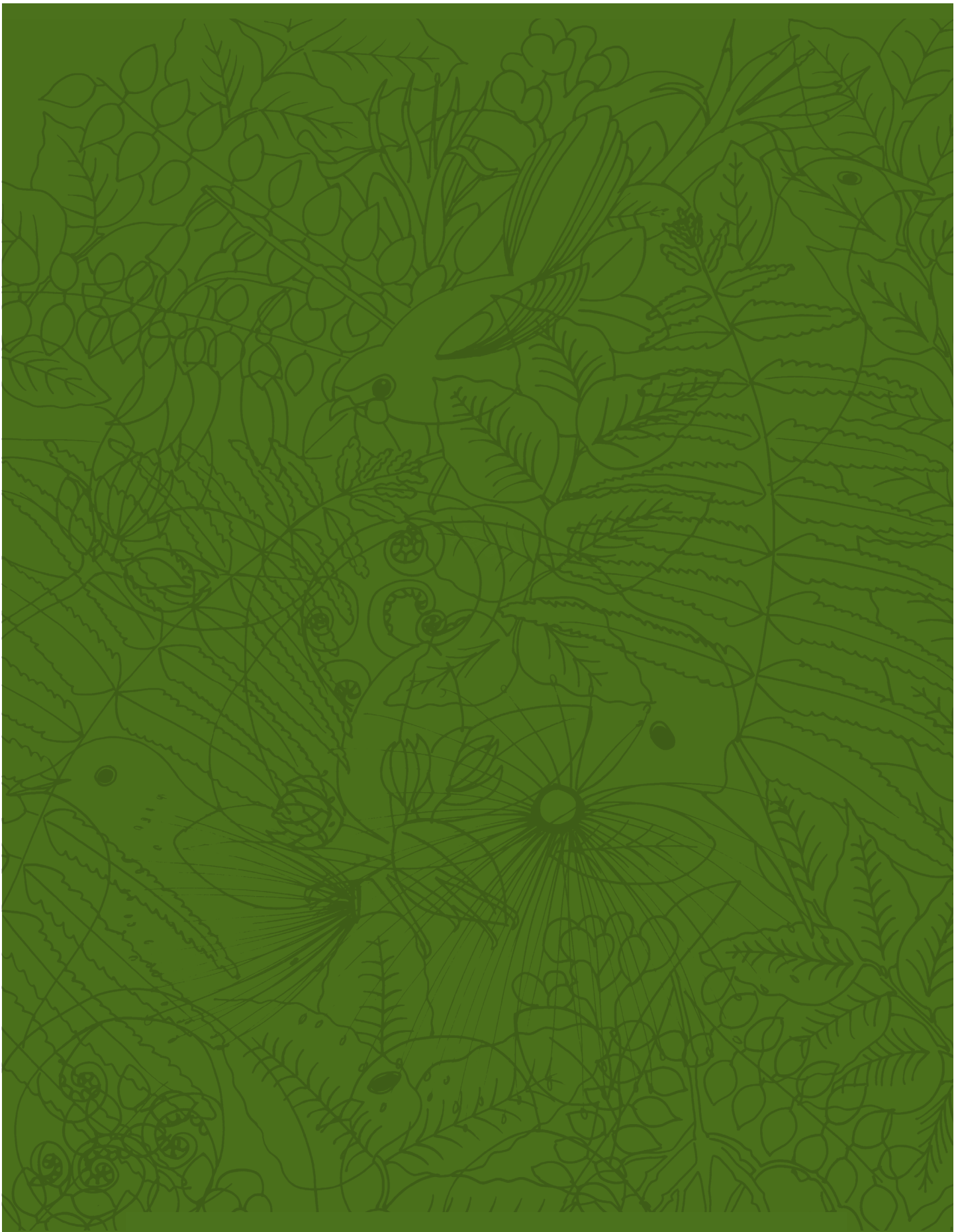

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