FERAL PIGS

Feral pigs (*Sus scrofa*) in Queensland

PEST STATUS REVIEW SERIES - LAND PROTECTION

by
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Queensland Government
Natural Resources and Mines

Acknowledgements
This assessment has drawn heavily from information contained within the Bureau of Resource Sciences publication "Managing Vertebrate Pests - Feral Pigs" (Choquenot, McIlroy and Korn 1996). Additional information and data have been included to provide the assessment with a Queensland emphasis.

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1.0 Summary

Feral pigs are one of the most widespread and damaging pest animals in Queensland and they are difficult to control in some situations. Feral pigs are widely distributed and inflict damage on the environment, lower agricultural production and the general amenity of Queensland.

Feral pigs also pose a disease risk to humans and the native and domestic animals of the State. They are found across most of the State and are susceptible to many exotic and endemic diseases.

Benefits also accrue from feral pigs as they provide income to many professional and amateur hunters, and the revenue gained from the export of 'wild boar' products increase export income and injects money into many small rural communities.

There are few control methods available: baiting, trapping, shooting, hunting and exclusion. The control method used varies with the habitat, safety of people and animals, and the size and location of the area to be treated.

2.0 History

Feral pigs have been part of the Queensland landscape since about 1865. The theory that feral pigs, sometimes known as 'Captain Cookers' were derived from deliberate releases or escapes from Cook's time at Cooktown in north Queensland has been discounted. The only pigs landed by Cook were killed by a fire deliberately lit by Aborigines (Pullar 1953). There has also been some speculation that pigs were introduced from New Guinea by travellers to Cape York. This too has been shown to only be the case for the later part of last century (Pullar 1953), as there are no words in the local Aboriginal language for 'pig' before this time (Pullar 1950; Pavlov *et al.* 1992).

Feral pigs were derived from stock that were let loose or wandered away from where they were being kept, often under semi-feral conditions as settlement progressed across the State. To this day, pigs are still being introduced, both accidentally (escapes from piggeries or truck accidents) and deliberately (usually by recreational hunters), to many parts of the State.

These pigs were probably descendants of Berkshire and Tamworth pigs that were introduced to Australia, including pigs transported as part of the First Fleet (Choquenot *et al.* 1996). These pigs probably then crossed with various breeds from Europe and Asia that were brought into Australia by early settlers from these regions.

3.0 Current and Predicted Distribution

Feral pigs are distributed across much of the State (Fig.1). The distribution of feral pigs is related to their strict requirements of daily water and dense foliage for protection from weather extremes, particularly heat to which they have a poor tolerance. Even so, pigs have become established within a wide variety of habitat types from the Arid Zone to the Wet Tropics. In the more arid areas, the distribution of pigs is quite seasonal and their distribution is restricted to watercourses, associated floodplains and man-made water supplies.

Fig. 1. Relative distribution of feral pigs in Australia.
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Because feral pigs usually have quite definite home ranges, and only disperse during times of major disturbance or limitations on food resources, they have been slow dispersers across much of Queensland. Because of this, feral pigs are still colonising new areas. Some coastal areas and areas around Cunnamulla and within the Wet Tropics World Heritage Area, have only been colonised by feral pigs within the last 30 years. Many cases of feral pigs establishing in new areas are because of deliberate introduction by recreational hunters, particularly in State Forests and on other State lands.

It is estimated that there are some 4 to 6 million feral pigs in Queensland (Mitchell, *pers. comm*.). No detailed survey has been conducted to accurately estimate the size of the population, however some research has been conducted on densities in different habitat types. About 75% of the estimated population is thought to inhabit tropical north Queensland (J. Mitchell, pers comm).

There is great difficulty in accurately estimating the numbers of feral pigs because of their secretive behaviour and the dense vegetation that forms their preferred habitat. Pig numbers also vary quite considerably from season to season, and from habitat to habitat. Table 1 illustrates some of the different densities of feral pigs for a variety of habitats.

Table 1. Reported densities of feral pigs for various districts and habitats.

DISTRICT	HABITAT	DENSITY	REFERENCE
Goondiwindi	pasture woodland, forests and wheat crops	0.1-3.9 pigs/sq km	Wilson *et al* 1987
Aurukun	floodplain, swamp and woodland	1>20 pigs/sq km	Dexter 1990
Aurukun	floodplain, swamp and woodland	1-40 pigs/sq km	J.Mitchell, pers comm.
Lilyvale	floodplain, swamp and woodland	4.2 pigs/sq km	J.Mitchell, pers comm.
Lakefield National Park	floodplain, swamp and woodland	4 pigs/sq km	Mitchell 1998

4.0 Estimates of Current and Potential Impact

4.1 Impact on Primary Production

The impact of feral pigs on agriculture takes three forms (Choquenot *et al* 1996):

- value of the direct losses to agricultural production;
- value of the continuing expenditure on pig control; and
- value of lost opportunities to take profit from alternative investment of this expenditure.

It is difficult to accurately provide a dollar figure to the economic damage caused by pigs as some localities will suffer less damage because of naturally low pig numbers or adequate control methods that reduce their impacts. Despite these problems, some estimates have been made of the magnitude of costs of feral pigs.

The national loss to agriculture by feral pigs has been estimated to be in the order of $100 million, but this may be a conservative estimate (Choquenot *et al* 1996).

Pigs are responsible for damage to a variety of industries. They reduce the yields of grain crops (Benson 1980, Caley 1993), damage and consume pastures (Hone 1980), reduce yields of sugar cane and some tropical fruits such as bananas, mangoes, pawpaw and lychees (McIlroy 1993), damage netting fences, damage and pollute water sources (Tisdell 1982; O'Brien 1987) and prey upon newborn lambs (Plant *et al* 1978; Pavlov *et al* 1981; Hone 1983; Choquenot 1993).

Lamb predation by feral pigs is estimated to range from 18.7% to 32% for the semi arid rangelands (Pavlov *et al* 1981; Plant *et al* 1978). Estimates for losses to grain crops in Queensland are shown in Table 2.

Table 2. Estimated value of lost crop production for Queensland 1996

CROP	% REDUCTION IN YIELD*	VALUE#
Wheat	3	$ 1.9m
Sorghum	5	$ 9.1m
Barley	1	$ 0.3m
Maize	3	$ 0.6m
Total		$ 11.9m

* Based on Tisdell 1982

This figure is for the end of a severe drought and the winter crop figures are significantly lower than average, with the sorghum crop being inflated due to a breaking of the drought allowing large areas to be planted to summer crops.

In 1991 it was estimated that the cost of feral pig damage to sugar cane crops was in the vicinity of $628 000, which equated to a reduction in yield of 25510 tonnes of sugar cane (McIlroy 1993). The value of other crop losses has not been accurately assessed, but pigs are known to cause severe, but often

localised, damage to crops such as potatoes, melons, mandarins, strawberries, pumpkins and tropical fruits (bananas, mangoes, lychees, pawpaws and pineapples). One farmer in the Tully area reported losses of up to 140 bunches of bananas per month (valued at between $4,200 and $12,600) for a twenty hectare plantation, but average losses in the area are about 20 bunches ($600 - $1800) per month (Noble 1996).

The damage caused to pasture and competition with domestic stock is difficult to estimate, as there is considerable variation across pasture types and their biomass. It has been shown that pig activity reduces pasture availability and can lead to the establishment of less desirable pasture species, including weeds (Hone 1980). Most work to date on the impacts of pigs on grazing industries has been concentrated on the predation of lambs and the effects on the sheep grazing lands of semi-arid New South Wales, which is similar in some respects to the southern sheep grazing areas of Queensland.

It has been estimated that Queensland spent approximately $1.1 million in 1984 on feral pig control, which equates to about $2.2 million in today's dollar values (Choquenot *et al* 1996). This amount includes both government and private expenditure on control by various means. It does not include amounts spent by recreational hunters who also contribute to control. This estimate of expenditure is based upon estimates of landholder and government expenditure on control, and so should only be used as a guide to current control costs.

4.2 Impact on the Environment

The impacts of feral pigs on the environment takes one of two forms: damage to habitats or direct damage to animal species.

Degradation of habitats is probably the most obvious form of environmental damage caused by pigs. This damage can be because of rooting, trampling, tusking or rubbing trees and consumption of plants and soil organisms.

The rooting behaviour of pigs has been linked to areas of high soil moisture such as drainage lines and swampy areas (Hone 1988, 1995; Mitchell 1993). This rooting behaviour can severely disrupt the composition of the soil's microorganisms, and subsequently nutrient cycling. Rooting can also disrupt the regeneration of plants, change the composition of the plant community, and allow water erosion to occur in drainage areas where the soil has been severely disturbed.

Pigs can physically destroy vegetation by trampling it along their paths or in the areas where they wallow. Pigs will often have a favourite rubbing tree, but this has not been linked to territory marking. This behaviour is to remove parasites and to relieve irritations. They also tusk trees as part of their normal behaviour. Undermining and rooting during feeding can lead to trees being uprooted.

Although pigs are known to feed on most parts of a wide variety of native and exotic plants, they usually prefer the softer higher energy parts, tubers and fruits. Their negative impact on plant communities is partially balanced by the positive impact of their aiding in the spread of some plants by passing their seeds in dung. This spread of plants also includes weed species.

The feral pig has also been implicated in the transmission of plant diseases such as rootrot fungus (*Phytophthora cinnamomi*) and other plant pathogens. Introduction is usually via contaminated mud and soil carried by pigs and by the physical damage to plants that allows diseases to enter through the wounds.

Feral pigs are known to consume numerous native animals including earthworms, amphipods, centipedes, beetles and other arthropods, snails, frogs, lizards, snakes, the eggs of freshwater crocodiles (C*rocodylus johnstoni*), turtles and their eggs and small ground nesting birds and their eggs (Pullar 1950; Tisdell 1984; McIlroy 1990; Mitchell 1993; Roberts *et al* 1996).

Without definitive information on the prey eaten, rates of predation, density and status of prey and whether predation is density dependent (Choquenot *et al* 1996) it is impossible to accurately determine what effect pigs have on native fauna, apart from the observable damage to individual animals.

Competition with other animal species has not been proven, but there is some evidence that pigs may compete directly with some specialist feeders such as the Cassowary (C*asuarius casuarius*) (Choquenot *et al* 1996) and other species such as the brolga (*Grus rubicundus*) and magpie geese (*Anseranas semipalmata*) (Tisdell 1984).

4.3 Disease

The feral pig poses a serious threat to Queensland's livestock industries and human health through being a potential carrier, or amplifier, of many endemic and exotic diseases. The diseases that pose the greatest threat are listed in Table 3.

Table 3. List of endemic and exotic diseases carried by feral pigs.

ENDEMIC	**EXOTIC**
Brucellosis (*Brucella suis)*	Foot and Mouth Disease (FMD)
Tuberculosis (*Mycobacterium spp*.)	Classical Swine Fever
Porcine Parvovirus	Aujeszky's Disease
Leptospirosis (*Leptospira spp*)	Japanese Encephalitis
Melioidosis (*Pseudomonas pseudomallei*)	Swine Vesicular Disease
Sparganosis (*Spirometra erinacei*)	African Swine Fever
Murray Valley Encephalitis	Trichinosis
	Rabies
	Screw-worm Fly infestations

Of the exotic diseases, Foot and Mouth Disease (FMD) poses the greatest threat to Queensland's economy. It has been estimated that a FMD outbreak would cost more than $3 billion nationally and if it were to persist in the order of $0.3 - 4 billion annually (Wilson and Choquenot 1996). FMD could have devastating effects on the livestock industries of Queensland, particularly if it were introduced through Cape York, where early detection and eradication

would be difficult. The Department of Primary Industries and the Commonwealth have formulated a national approach to exotic disease management, the Australian Veterinary Emergency Plan (AUSVETPLAN).

4.4 The Pig as a Resource

Many people are of the opinion that the feral pig should be managed as a resource rather than eradicated as a pest. Control programs are usually conducted that do not utilise the feral pig as a resource. These control programs are conducted because of the economic and environmental damage caused by feral pigs and the legislative requirement in all mainland States except the ACT and South Australia.

The feral pig marketed as 'Wild Boar', has been harvested for export since 1980. The main markets for Australian wild boar meat are European Union countries (particularly Germany, France, Italy, Belgium/Luxembourg) and Japan and Sweden. The EU countries have traditionally consumed wild boar meat, and with high human populations and decreasing boar populations in those countries, they have increasingly become dependant on imports for much of their wild boar meats.

Australia now supplies some 20-30 percent of the wild boar consumed, and is now close to overtaking Poland as the worlds largest supplier of wild boar (Ramsay 1994). This market is very volatile, with sales and prices fluctuating from year to year. The market seems to be dependent on the length and severity of the northern winter, which effects the supply of local wild boar.

The Australian Game Meat Producers Association has prepared a Code Of Practice for Humane Shooting, Harvesting and Hygienic Handling of Game Animals. This code of practice provides guidelines to shooters and pig 'chasers' on how to harvest and handle the product so that it is suitable for the export market.

The value of wild boar exports has varied between $10 and $20 million over the last few years because of Australia's drought conditions and the variability of European supply and demand (Ramsay 1994). The number of carcasses processed in Australia is shown in Table 4.

Table 4. Number of wild boar carcasses processed in Australia 1989-1992.

YEAR	CARCASSES
1989	203 837
1990	96 962
1991	101 006
1992	271 133

It has been estimated that there are about 3000 Queensland Meat and Livestock accredited shooters in Queensland and 1200 licensed professional kangaroo shooters who take pigs opportunistically (Dee, pers. comm.). There are also numerous other shooters and hunters who do not sell carcasses. Recreational feral pig hunters across Australia make a significant impact on pig numbers, as well as injecting funds into local economies where they hunt (Tisdell 1982).

In Queensland in 1996 there were about 70 seasonal chiller boxes operating that received approximately 65 000 carcasses, which was about 60% of the national total. Based on this percentage of the national trade, Queensland harvests between $6 and 12 million worth of feral pigs per year (Ramsay 1994). These boxes are located as far north as Lakeland and Doomadgee, but the grain growing areas provided the greatest and most constant supplies of 'wild boar'. The average price paid to 'hunters' in 1996 was 90 cents/kg, but by mid 1997 averaged about 70-75 cents/kg. Preferred carcasses are between 30 and 60 kg with anything below 26 kg being rejected and carcasses over 90 kg being difficult to chill and process. In 1997 there were four export licensed processing works in Queensland, located in Longreach, Roma and two at Eagle Farm in Brisbane. The game meat processing industry in Queensland employs up to 80 people during times of peak production/harvest (Dee, pers. comm.).

4.5 Cost:Benefit Relationship

Whilst the game meat industry and recreational hunters play an important role in controlling feral pigs in some localities, there is an overall net cost to the broader community from feral pigs. The damage done to crops, pastures, fences, water facilities and livestock can be quantified ($100M), and are in excess of the value of the 'wild boar' market ($20M) even without including the costs to the environment and the potential costs from exotic disease.

5.0 Biology and Ecology

5.1 Habitat Requirements

Feral pigs are found in a wide variety of habitats, ranging from dry arid areas, to high mountainous forests and grasslands, to dense tropical rainforest. The two requirements that feral pigs have that restricts their distribution in these habitats are daily water and suitable cover.

5.2 Diet

The feral pig is considered to be an opportunistic omnivore (Choquenot *et al* 1996), and it has been known to consume the following groups of foods:

fruits and seeds: grains, fruits, rainforest fruits;
foliage and stems: grasses, sugar cane, banana trees;
rhizomes, bulbs and tubers: including tuberous crops such as potatoes;
fungi; and
animal material: carrion, earthworms, lambs, arthropods.

The foods consumed vary from region to region and the potential food sources are limited by availability rather than preference for any one food type.

Pigs have a relatively high-energy requirement, particularly during lactation, and growth of young pigs (Choquenot *et al* 1996). Sows require about 15% of their diet to be crude protein in order to successfully suckle their young. This protein requirement can be met from plant material, but is met more commonly from animal matter such as earthworms, carrion, arthropods, frogs and reptiles. Animal matter rarely exceeds 5-18% of a pigs diet (Giles 1980; Pavlov 1980).

Feral pigs will relocate in response to food availability, particularly seasonal requirements for higher protein and energy associated with reproduction and growth.

5.3 Social Structure and Behaviour

The most common groupings of feral pigs is either a few sows and their young, bachelor groups (individuals less than 18 months of age), or individual boars (usually older than 18 months). After weaning pigs will remain with their mother until the next litter, or in the case of sows, until they mate (Masters 1979; Giles 1980; Pavlov 1980).

Group size varies with age, sex, food and water availability and disturbances (such as hunting or other control measures). Group size can range from solitary boars to groups of 100 or more sharing a locally scarce resource such as a single waterhole during droughts.
Feral pigs habitually make use of trails, shelter areas, feeding and watering areas (subject to availability), rubbing and tusking trees and wallows. Even though they are habitual in their use of such areas, there is no evidence that feral pigs, of either sex, actively defend territories.

The size of a feral pig's home range depends on a number of variables, sex (males have larger home ranges than females) and resources. Food availability and quality is thought to be the main determining factor influencing home range size. Home range size varies from as little as 0.16 sq km for furrowing sows, to greater than 40 sq km for individual boars in the semi arid rangelands (Saunders 1988; Giles 1980).

Feral pigs are most active at night or during times of cooler temperatures (late afternoon, early morning, cooler weather, rainy or overcast conditions. They may become active during periods of disturbance from hunting or other human activities such as stock mustering (Pullar 1950; Giles 1980; Saunders and Kay 1991).

5.4 Reproduction and Population Dynamics

The feral pig is polyoestrus; adult sows have a 21-day oestrus cycle and a gestation period of 112-114 days. Their breeding is limited by food availability and quality (particularly the dietary requirement for about 15% protein). If food quantity and quality is available then feral pigs have the ability to produce two litters every 12-15 months (Giles 1980; Pavlov 1983; Ridpath 1991).

Sexual maturity in feral pig sows is dependent on weight (25-30 kg) rather than age, similar to domestic pigs (Masters 1979; Giles 1980; Pavlov 1980). The litter size of feral pigs generally averages between 4.9 and 6.3 piglets, but may be as high as 10 under favourable conditions (Choquenot *et al* 1996).

Juvenile mortality ranges from 10-15% under favourable conditions to 90 or 100% during periods of drought (Masters 1979; Giles 1980; Saunders 1988). Adult mortality ranges from 15 to 50% depending upon food availability and quality, predators (including hunting pressure) and disease.

The potential for pig populations to grow is estimated by their exponential rate of increase (r). The corresponding (e^r) value provides the approximate multiplication rate. Table 5 gives an indication of the potential rates of increase of a feral pig population starting at 100 (female) pigs without external influences such as harvesting, control, immigrations or emigrations.

Table 5. Potential rates of population increase for a base population of 100 feral breeding sows.

HABITAT	REFERENCE	e^r	After 1 year	After 2 years
Semi-arid rangelands	Choquenot 1994	0.97	197	388
"	Giles 1980	1.82-2.0	282-300	795-900
Tablelands	Saunders et al 1990	1.28	228	519
Wet/Dry Tropics	Caley 1993	0.78 (max)	178	316

6.0 Efficacy of Current Control Methods

6.1 Exclusion and Habitat Modification

Fencing is effective for feral pig control for small high value areas such as cropping and lambing paddocks. Fencing has not been adopted as a large scale control method for several reasons: initial high expense, high maintenance costs, low cost effectiveness for large areas and relocation of the problem rather than overcoming it.

Several trials have been conducted to determine the most effective fence design (Hone and Atkinson 1983; Plant 1980; Tilley 1973). Electrification significantly increases the effectiveness of fencing to exclude or reduce the movements of feral pigs. The most effective fence design features 8/80/15 hinge joint, steel posts at 5m intervals, two top barb wires, and an electrified outrigger wire 25 cm above ground level (Hone and Atkinson 1983). This electrified fence design costs near $2500/km to construct.

Habitat modification, e.g. clearing remnant vegetation or closing water points, is rarely used as a control technique, as it results in the destruction of habitats for native species, is poor soil conservation practice and usually only moves the problem to another location.

Changes in management practices sometimes occur when pigs are a serious economic problem. The change in management usually revolves around altering the duration of lambing, but this was shown to be ineffective by Hone (1987). A more effective change in management involves lambing in paddocks away from areas of known pig activity, or changing from sheep breeding and wool growing to wool growing alone, or even cattle production in extreme cases of pig predation. The shift in enterprise may involve potential lost income to the landholder.

6.2 Poisoning

Poisoning is the most cost effective and efficient control method currently available for feral pig control (Korn 1986). The use of poisons is restricted, with baits containing 1080 only being able to be prepared by registered operators.

1080 (Sodium monofluroacetate) poison is the one of only two products registered for use in Queensland to control feral pigs, the other being CSSP (see below). 1080 poison has many attributes that make it suitable for general usage; it is found in many native plant species, therefore native animals have a certain inbuilt tolerance to it, and it degrades readily in soil. There are several disadvantages in using 1080; it is highly toxic to dogs, it has no antidote and secondary poisoning, via animals consuming carcasses, can occur.

1080 has been widely used for feral pig control across Queensland and can be used with meat (in western and northern grazing areas), grain, pellets or vegetables, as the bait material. Prefeeding is usually conducted for a period of 2 or 3 days before poisoning to attract as many pigs as possible to the bait station.

Not all pigs within an area will take baits (depending on alternative food availability, density of baits and pigs). The success rates of baiting vary considerably, with population reductions ranging from 58% to 99.4% (Hone and Pederson 1980; Bryant and Hone 1984). The success of baiting also varies with operator experience and incidence of vomiting. Pigs are known to vomit following 1080 ingestion, and males are known to vomit more than females independent of amount of poison ingested (Hone 1987). This vomiting behaviour by feral pigs will reduce the effectiveness of current baiting campaigns and may lead to bait shyness for future campaigns. Anti-emetic compounds have not been shown to reduce the amount of vomiting by feral pigs (O'Brien *et al.* 1986).

Warfarin, an anticoagulant, is another poison that has been trialed for use in feral pig control. It has not however been registered for use by the National Registration Authority for broad scale use. It has several benefits over other poisons, it has an antidote (Vitamin K), can require several doses before causing death, secondary poisoning does not occur, it does not cause vomiting and is cheaper than 1080. It does however have some disadvantages: it is not specific, requires several doses before becoming effective and can take several days before mortality occurs.

Phosphorus based poisons (Sayers Alport Phosphorus-SAP and CSSP) have been used in the past by landholders. They cause a long and painful death, and consequently are not used or recommended by the Department of Natural Resources and Mines. Because they could previously be purchased by landholders without restriction, they have been widely used and stored by landholders. The exact amount of these poisons used in pig control is unknown. These poisons also have serious impacts on non-target species as dose rates vary and there is no control over the use of stocks held by landholders.

6.3 Recreational Hunting

It has been estimated that recreational hunters kill 15-20% of the feral pig population in accessible areas annually (Tisdell 1982). The use of recreational hunters to control pig numbers is seldom effective as recreational hunters only kill a small percentage of the population, disperse pigs through regular disturbance and hunt on relatively small, easily accessible areas.

However the value of recreational hunters to the broader community must not be overlooked, recreational hunting can provide significant revenue to small communities.

Hunters have been known to introduce pigs to 'clean' areas to provide themselves with hunting opportunities in the future. Hunters have also been known not to take small pigs or sows or to castrate males or to cut the ears off pigs to make them more difficult to catch with dogs, thus insuring 'sport' in future seasons. These actions are in direct opposition to effective pig control.

The use of dogs to hunt pigs, either to flush them out of shelter, or to chase and catch them has been criticized by animal welfare groups, but is currently legal throughout Queensland. A review of the animal protection legislation by the Department of Primary Industries may alter this situation. The success of dogs capturing pigs has been studied and results show that solitary pigs are caught on 90% of the occasions when chased (Caley 1993), when groups of

pigs are encountered only one is usually caught and only about 70% of those chased are caught (Oliver *et al.* 1992). Another risk associated with using dogs is them becoming lost and their subsequently becoming 'feral', preying on stock and native animals.

6.4 Trapping

Trapping of feral pigs has gained increasing acceptance as trap designs improve, feeding behaviour is better understood and the restrictions on the use of poisoned baits increases. Trapping is relatively expensive and labour intensive and so not practical for large scale control. Trapping is environmentally friendly, relatively humane and some costs can be defrayed against the sale of pig carcasses. However, the success of trapping has been found to vary from 28% of the population (Saunders *et al* 1993), to 81% (Choquenot 1993).

Some of the other advantages of trapping over other control methods are that (Lukins 1989):

- trapping does not interfere with normal pig behaviour (unlike shooting or dogging);
- the number of pigs is known exactly, and carcasses can be removed safely;
- it is a flexible technique and can be fitted into routine property activities, making it economical in terms of labour, materials and number of operators; and
- properly designed traps can be moved or re-used as necessary. Good trapping makes use of opportunities as they arise.

Hone *et al* (1980) outlined the points that landholders and managers need to consider when trapping:

- type of trap to use;
- number of traps to use;
- where to put traps;
- number of nights each trap is used;
- type and amount of bait to use; and
- amount and duration of pre-feeding.

Several trap types are successful. The relative success and design of trap to use depends on the local environment, materials, number of pigs to be trapped and presence of non-target species such as cassowaries (Figure 2.).

Some of the other factors that may influence the decision to trap include: it is time consuming and expensive to initially build and maintain traps.

The Department of Natural Resources and Mines advises landholders to consider trapping when poisoning is impractical, or as a follow up to poisoning. The Department also advises landholders to reduce disturbance to pigs from shooting or dogs before and during the trapping period.

Hone (1984) has described the important steps in trapping:

- feeding sites should be placed where feral pigs are active, for example, water points and pop-holes in fences;
- initially, feed the pigs with bait such as grain and pellets (fermented material is often attractive), vegetables or fruit, meat or carrion;
- build the trap where feed is being taken, and leave it open and baited, but not set, for one or two nights;
- then set the trap each night;
- if the feed is being taken, continue to trap until no more pigs are caught;
- leave the trap unset and feed a different bait from that used initially;
- if feral pigs start taking the bait, set the trap for several nights; and
- once no bait is taken, start feeding elsewhere before moving the trap.

6.5 Biological Control

Pathogens and immunocontraception via a vector have been suggested as possible biological control methods for feral pigs.

These methods have not been pursued, as it would be difficult if not impossible to stop the spread of any disease or disease borne immunocontraception to domestic pigs. The feral pig industry, and the associated export and flow on revenue would also be significantly affected by any such disease.

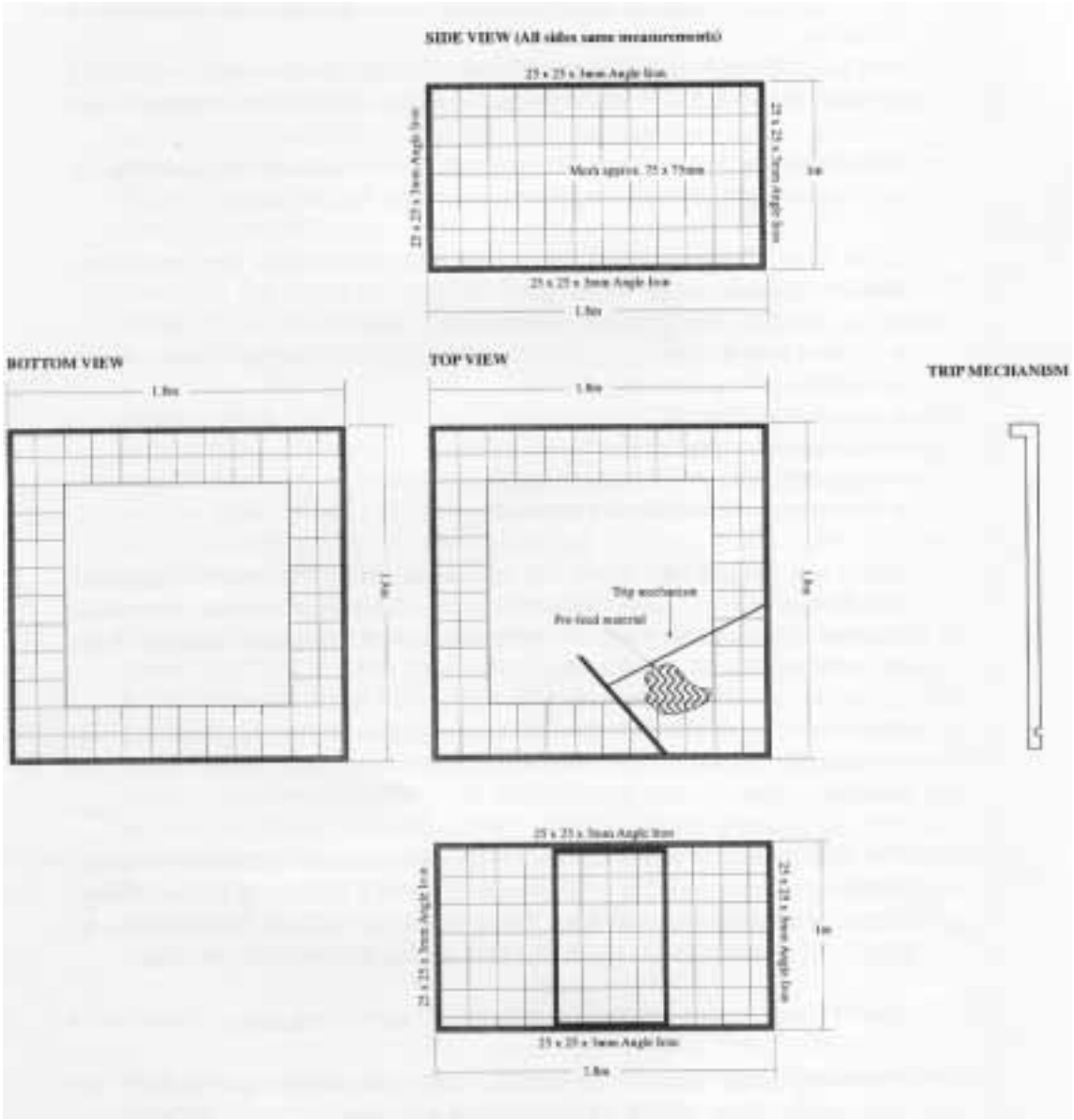

Fig.2 Cassowary Safe Feral Pig - Box Trap (Mitchell and Dorrington)

6.6 Fertility Control

Currently there is no work being carried out on producing an immunocontraceptive bait for feral pigs. There is research being conducted on finding an immunocontraceptive for control of rabbits, foxes and rodents. As with these other species, there are problems involved in possibly developing such a control method (Bomford 1990):

- lack of long-acting contraceptive compounds (making repeat dosing necessary);
- high costs of delivery by baits (particularly when repeat dosing is needed);
- less effect on population size than when an equivalent number of pigs are killed, due to repeat dosing requirements; and
- potential effects on non-target species.

Because delivery methods are the same it would be far more efficient to provide a poisoned bait than an immunocontraceptive bait.

6.7 Shooting (helicopter and ground shooting)

Shooting has been used as a control method ever since feral pigs first became a problem in Queensland. Shooting, particularly from the ground is a very labour and resource intensive method, and cannot be used to control pigs over large areas, particularly when pigs are at low densities. Shooting, both ground and air, can cause pigs to disperse and requires a great deal of skill for it to be cost effective.

The use of helicopters in recent times has made shooting a more economic option, particularly in inaccessible areas. Helicopter shooting still has some shortcomings. Some habitat types can conceal pigs from the air making them difficult to shoot and shooting cannot be used as a stand alone control measure, as it will only reduce the population by a limited amount.

It has been proposed to use 'Judas' pigs in a similar way as 'Judas' goats are used in feral goat control. This method involves the use of a radio collared individual to locate other animals after it is released and rejoins a group. Because pigs are not as gregarious as goats, this method has limited application and is seldom used.

6.8 Control During Exotic Disease Outbreaks

In the event of an exotic disease outbreak, financial and legal control constraints take on less importance and the amount of control required is increased. The procedure for an exotic disease outbreak, as set out in the AUSVETPLAN, requires that containment of the disease within a geographic area occurs first, and secondly that vector population reduction is carried out as quickly as possible. Monitoring of the adjoining vector population for disease incidence must also be carried out to assess the rate of spread of the disease.

To successfully plan an eradication campaign for containment of an outbreak of exotic disease within a feral pig population several factors, including the delay in first detecting infected animals, the prevalence of infection and the size and location of the area to be decontaminated must be determined (Pech and McIlroy 1990). In order to eradicate an exotic disease, it is necessary to reduce the vector population to the threshold at which the disease will not spread. This varies for different areas but has been estimated to be in the order of 95%. However, in simulated exercises reductions in the order of 40-80% have been achieved. This result indicates that current planning and control measures for pigs will need to be modified to achieve successful reduction of populations to required levels.

7.0 Animal Welfare Considerations

In Queensland the *Animals Protection Act* 1925, gives no protection to any feral animal but does provide, in broad terms, that procedures to destroy declared animals must not constitute 'unreasonable, unnecessary or unjustifiable ill-treatment'. Ill-treat is defined as : ill-treat, wound, mutilate, overdrive, override, overwork, abuse, worry, torment, torture and cause any animal unnecessary pain or suffering; also overload or overdrive when loaded, and overcrowd, and unreasonably beat or kick.

This legislation is currently being reviewed. Once the legislation review is complete, a new Act is expected to be tabled in 1998. This new legislation will be prepared by the Department of Primary Industries in consultation with animal welfare groups, the pet industry, environmental groups, primary producers and the Department of Natural Resources and Mines and will have broad community input.

As mentioned above, the use of dogs in chasing and capturing pigs has been condemned by animal welfare groups, but remains legal in Queensland. There have been suggestions that the practice has been withdrawn from the recommended methods list in NSW, and penalties of up to $10 000 being applicable for using this method of pest control.

8.0 Management and Control Practices

8.1 Legislative Status in Queensland

The feral pig is a declared animal under Section 69 of the *Rural Lands Protection Act* 1985. It is categorized as an A1, A2 and A6 animal for the whole State, which means that:

> *A1 in respect of an area if the introduction of those animals into that area should, in the opinion of the Governor in Council be prohibited;*
>
> *A2 in respect of an area if those animals-*
> *(i) are not vertebrate animals native to that area; and*
> *(ii) should, in the opinion of the Governor in Council, be destroyed in that area;*
>
> *A6 in respect of an area if the keeping and selling of those animals in that area should, in the opinion of the Governor in Council, be subject to prescribed conditions and restrictions.*

Penalties applicable to landholders for noncompliance with the provisions of the Act, are shown in Table 6.

Table 6. Offences and penalties applicable to feral pigs in Queensland.

OFFENCE	MAX. FIRST OFFENCE	MAX. SECOND OFFENCE
Failure to control	$375	$1,500
Failure to comply with direction	$1,500	$3,750
Introduction of Category A1 animals	$7,500	
Restrictions on keeping and selling A6 animals	$3,750	
Liberating declared animals	$7,500	

Section 80 of the *Rural Lands Protection Act 1985* places the responsibility for control of declared animals with the landholder, and there is a penalty of $375 for failure to control. As can be seen from the list of penalties, people releasing feral pigs into areas for hunting purposes are liable to a $7,500 fine, and persons who keep feral pigs are liable to fines up to $3,750.

The Department of Natural Resources and Mines policy is to 'reduce the impact of feral pigs through coordinated and sustained control programs in strategic areas of Queensland where feral pigs constitute a high risk to agricultural production and/or the environment.'

The policy states that A2 animals shall be subject to 'sustained control in strategic areas in concert with commercial utilisation where appropriate for established pests.' This has been further explained by defining:

Sustained control as ' the implementation of control on a regular basis to keep population at or below a threshold density at which the benefit of control is equal to or greater than the cost of control. Sustained control requires the development of pest animal management plans that include regular and integrated control options. (Integrated control is the use and combination of multiple control techniques).'

Commercial utilisation (harvesting and hunting) as ' utilising animal pests as a resource is particularly appropriate for some species such as the feral horse, feral pig, feral goat and rabbit. Commercial utilisation can be integrated with other control methods to regulate pest animal numbers and should be incorporated in management plans.'

8.2 Management Strategies in Queensland

8.2.1 Pastoral Zone

In the pastoral zone, the main management strategy is baiting, including aerial bait dispersal. This strategy is used because any program needs to cover large areas, but should be concentrated around areas where pig activity is greatest such as around, but not too close to, drainage lines and watering points. The actual impact of feral pigs in these extensive grazing areas, particularly the cattle grazing areas, is limited. Commercial utilisation by professional and recreational hunters also forms part of the overall control strategy, as it is control at a low cost to the landholder. Because this zone takes in arid and semi arid regions, feral pig numbers are subject to wide variations due to climatic extremes that lead to food and water shortages, but also occasional large numbers.

8.2.2 Wet Tropics

The Wet Tropics presents unique problems due to the inaccessible nature of the terrain, high conservation value, plentiful food and water, and proximity to urban settlement. Control is mainly by using traps (cassowary and wallaby safe) with limited baiting in some areas. Trapping is conducted at accessible sites that border or are in close proximity to agricultural enterprises and urban settlement. Broadscale baiting is not possible because of the presence of endangered fauna and tourists. A project to determine the impacts of feral pigs on the natural environment in this region, and a successful community based trapping program has been running in this area for several years. Shooting and 'dogging' are considered to be ineffective control methods because of the thick vegetation and the potential for dogs to escape or become lost, and become problems themselves.

8.2.3 Agricultural Zone

Feral pigs cause a great deal of damage to agricultural crops, particularly grain crops (as shown in Table 2) and considerable resources are allocated to control in this zone. The main means of control is capturing either with dogs or in traps, or hunting. The feral pig or 'wild boar' industry provides a significant input into local economies, and also controls a significant number of pigs. Baiting is carried out to a lesser extent depending on landholder

perceptions of hunting, the extent of the problem, proximity to chiller boxes, prices paid for carcasses and availability of alternate food sources.

8.2.4 Near Urban Situations

Feral pigs are reasonably common in these situations, and are sometimes found in surprising numbers: approximately 100 feral pigs were found along a creek line in the Redland Bay area, south of Brisbane in 1996. Feral pigs in these situations cause damage to parklands, for example Mt Glorious National Park, and to gardens and hobby farms. Control options in these situations are limited. Baiting can only be used in areas where it is considered to be safe by the local Land Protection Officer. Trapping is considered to be the safest and most effective control option. Hunting is of limited value because of firearms restrictions and the problems of using dogs. Exclusion fencing is practiced and is effective for high value areas.

8.3 Property Management Strategies

The Bureau of Resource Sciences (BRS) (Choquenot *et al.* 1996) has outlined four stages of a strategic management program at both the local and regional level:

Problem definition - The problem, if it is real or perceived, needs to be defined. This process will compare the dollar or conservation value of the damage caused by feral pigs, with the benefits received from controlling them. The estimation of environmental costs and benefits is difficult and requires the costing of intangible factors.

Developing a management plan - The main components of developing a management plan is to establish: a set of objectives (interim and long-term goals), a time frame to achieve goals, and indicators for measuring performance. There are several options for the level of control, these range from local eradication, strategic management, commercial management, crisis management or no management, depending on the particular situation. Strategic management offers the most flexible option, as it allows for changes in economic, environmental and pest circumstances. Control techniques need to be included in the preparation of the plan.

Implementing the plan - In order to effectively implement the plan, it is essential to gain broad support for the plan. Stakeholders should be identified and their involvement and 'ownership' of the plan should be encouraged.

Monitoring and evaluating progress - Monitoring of both the operational (cost effectiveness) and performance (effectiveness of the management plan) components of the plan is essential if changes are to be made, and mistakes rectified.

This approach to preparing an effective management plan will allow for the preparation of a dynamic plan that can be adapted for a variety of situations and changing circumstances.

9.0 Acknowledgments

This assessment has drawn heavily from information contained within the Bureau of Resource Sciences publication “Managing Vertebrate Pests - Feral Pigs” (Choquenot, McIlroy and Korn 1996). Additional information and data has been include so as to give the assessment a Queensland emphasis.

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