



Australian Government

Department of the Environment and Energy

Threat abatement plan for predation, habitat degradation,
competition and disease transmission by feral pigs (*Sus scrofa*)
(2017)

Background Document





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Cover photo: A mob of 89 feral pigs (some out of frame) on the Wildman River floodplain, Northern Territory, 2013. Photographer: B. Salau.

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INTRODUCTION

In 2001 the Australian Government listed '**Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*)**' as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

This listing initiated the development of the first *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa)*, which was made in 2005.

The first threat abatement plan was reviewed in 2011. The new threat abatement plan aims to capture scientific research and other developments that have occurred since the first plan was made, and capture changing priorities for feral pig management.

This background document to the *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017)* provides the detailed information that underpins the threat abatement plan, including biological and scientific information. Relevant extracts from the EPBC Act and EPBC Regulations related to threat abatement plans are included at Appendix B of this document.

SPECIES OVERVIEW

1. Origin and current distribution

The wild form of pig (*Sus scrofa*), also known as wild boar, is native to Eurasia. Wild pigs have been domesticated for millennia, leading to various breeds of domestic pig. Wild pigs, feral pigs and domestic pigs all belong to the same species—*Sus scrofa*—hence their ability to readily interbreed. Wild or feral pigs, and domesticated pigs, are sometimes differentiated as sub-species by use of the trinomial scientific names *Sus scrofa scrofa* and *Sus scrofa domestica* respectively. In this document, '*Sus scrofa*' will be used. The species *Sus scrofa* belongs to the Suidae family, which has numerous species in five genera including *Sus*. The *Sus* genus itself is generally considered to have ten species including *Sus scrofa* (Wilson and Reeder, 2015).

Feral pigs in Australia originated as a result of releases and escapes of various breeds of domestic pig dating back to the late 1700s (McIlroy, 1990). The main breeds of domestic pig involved in the evolution of Australia's feral pig population are believed to be the European Berkshire and Tamworth breeds, which had already been heavily modified by cross-breeding with other breeds from China, India, Italy and Portugal (Choquenot et al., 1996). It is also believed that some populations in the Northern Territory and Queensland may have originated from Celebes warty pigs (*Sus celebensis*) imported from the historical Timor region. These animals are thought to have later interbred with pigs of domestic origin (*S. scrofa*) (Choquenot et al., 1996).

In 1990 it was estimated there were between 3.5 million and 23.5 million feral pigs in Australia, inhabiting approximately 38% of mainland Australia (Hone, 1990a). By 2008, it was estimated that feral pigs inhabited 45% (3.43 million square kilometres) of Australia (West, 2008).

Feral pigs occur in all states and territories, and on some large coastal islands (West, 2008). Figure 1 shows that feral pigs:

- are most abundant in New South Wales and Queensland
- are 'widespread' throughout New South Wales and Queensland, and are 'localised' throughout other states and territories
- are abundant in the Fitzroy River area of north-western Western Australia
- occur at low densities throughout other parts of Western Australia, South Australia and Victoria
- are present in the southeast of Tasmania and on Flinders Island
- occur throughout most of their range in Australia at 'occasional' and 'common' abundances
- are largely absent from Australia's arid and semi-arid interior (apart from parts of far-western New South Wales and south-western Queensland)
- are absent from 50% of the country and their occurrence is unknown in 5%.

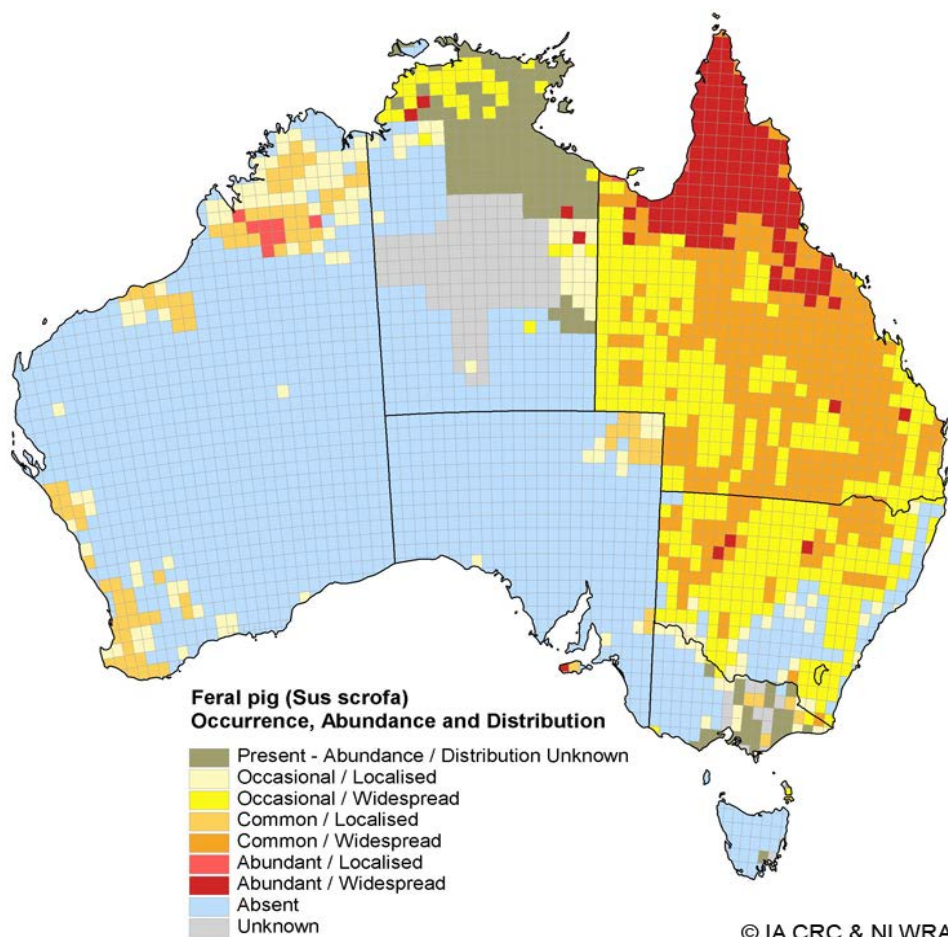


Figure 1. Map showing the occurrence, abundance and distribution of feral pigs (*Sus scrofa*) in Australia in 2006/2007 (from West, 2008). Information available for this distribution map varies in quality. A number of areas have high-quality data that are supported by expert opinion, while other areas have moderate levels of supporting information. See West (2008) for details on data quality.

The range of estimates for the feral pig population in Australia varies greatly, partly because of the difficulty in estimating their numbers, but also because their populations can fluctuate widely in response to variations in environmental conditions and the availability of food and water. Extended dry periods/droughts and control programs can reduce feral pig densities to

roughly half that found under more productive conditions (Giles, 1980). However, feral pigs can increase their numbers at a rate of up to 86% a year in good seasons—a reproductive potential that is closer to rabbits than to other pests of a similar size (Choquenot et al., 1996).

Feral pigs are relatively intolerant of aridity and heat. Their distribution is therefore limited by a need for freely available water and cover. The tropics of Queensland have the highest feral pig densities in Australia due to a particularly suitable combination of water availability, shelter and food resources (Figure 1). Climate matching indicates that there are extensive areas that feral pigs could occupy, where they are currently absent or in low densities (Braysher, 2000). These include large parts of central and eastern Tasmania, Eyre Peninsula, the south-east of South Australia, and south-western Western Australia.

Cowled et al. (2009) estimated the future distribution of a recently introduced, expanding feral pig population in the remote Kimberley region of north-western Australia. Computer modelling used weather data, remote sensing data and feral pig habitat preferences to identify suitable habitat. The study region was 89,125 km² in area. The modelling indicated that feral pigs could expand their distribution, by natural dispersal alone, to occupy 61,950 km² (approximately 70%) of suitable habitat within the study area.

2. Biology

Drawn from Choquenot et al. (1996).

2.1. Appearance

Feral pigs in Australia are smaller, leaner and more muscular than domestic pigs, with well developed shoulders and necks and smaller, shorter hindquarters. They also have longer, larger snouts and tusks, smaller, mostly pricked ears (not pendant like those of many domestic pigs) and much narrower backs. Their hair is longer and coarser than that of domestic pigs. Some individuals develop a crest or mane of bristles extending from their neck down the middle of their back, hence the nickname 'razorback'. These bristles often stand erect when the feral pig becomes enraged (Giles, 1980). The tails of feral pigs are usually straight with a bushy tip.

Male wild pigs and feral pigs are renowned for their tusks, which project from the sides of the mouth. The lower tusks are triangular in cross section and curve upwards, outwards and backwards, forming an arc. They are generally 5–6 centimetres in length. The upper canines are shorter and oblong in cross section. They curve outwards and back, and remarkably, function as whetstones or grinders to the lower tusks (Pullar, 1953; McIlroy, 1990).

Regional populations of feral pigs vary in physical size, shape and coat colour, differences probably inherited from the breeds which initially escaped or were released. Black is the most common colour (Pullar, 1953; Pavlov, 1983). Other colours include rusty red and a high proportion of lighter or mixed colours, including white, light ginger, brown and white, brown with black spots and agouti patterned (brown or black hair with a lighter tip) (AMRC, 1978). Some feral piglets are marked with dark longitudinal stripes, which disappear as they grow older (Wilson et al., 1992). Such stripes are rarely seen in domestic piglets.

2.2. Size

Male feral pigs tend to be longer, taller and heavier than females (AMRC, 1978; Masters, 1979, 1981; Pavlov, 1980, 1983). While size is highly variable, adults generally range up to 115 kilograms for males and 75 kilograms for females. Feral pigs in the temperate forests of New Zealand may grow to over 200 kilograms and in Namadgi National Park, near Canberra, a 175 kilogram feral pig was caught (McIlroy, 1990). Average body length of adults is 105–155 centimetres for males and 100–130 centimetres for females.

2.3. Longevity and mortality

Feral pigs are relatively short-lived, and individuals older than 5 years are rarely recorded. Adult mortality can vary from 15 to 50% between year classes* (Giles, 1980).

Mortality in young feral pigs during their first year of life is generally high, particularly from the foetal stage to weaning, but it can vary from 10–15% when food supplies and weather are favourable, to 90% where conditions are poor, and even 100% during drought (Masters, 1979; Giles, 1980; Saunders, 1988).

The main causes of mortality in feral pig populations are loss of foetuses, accidental suffocation of piglets by their mothers, loss of contact between piglets and mothers, and starvation at all ages, including in old feral pigs when excessive tooth wear interferes with chewing.

Dingoes (*Canis dingo*) and wild dogs (*Canis familiaris*) prey on piglets and are probably responsible for the frequent high mortality of immature feral pigs and sometimes mature females, but there is conflicting opinion about whether wild dogs limit the size or distribution of feral pig populations (Pavlov, 1983, 1991; Woodall, 1983; Saunders, 1988; Corbett, 1995; Fleming et al., 2001). Indigenous land managers in Gangalidda country in the southern Gulf of Carpentaria protect dingoes as culturally important animals, and suggest a correlation between higher dingo numbers and far fewer feral pigs in their country (Carpentaria Land Council, 2015). Similarly, wild dogs appear to be exerting noticeable control on feral pig numbers on Melville Island (Tiwi Land Council, 2016).

2.4. Reproduction

In Australia, female feral pigs (sows) start breeding at 25–30 kilograms in weight and 7–12 months of age (Masters, 1979; Giles, 1980; Pavlov, 1980). Feral sows have a 21-day oestrus (menstrual) cycle and a gestation period of 112–114 days. There are generally 5 or 6 piglets in each litter, but up to 10 piglets can be born in good conditions. Piglets wean at two to three months of age. The time for a feral sow to return to oestrus (fertility) after parturition (birth) is also variable, being up to 94 days compared with a minimum of 18–22 days for domestic sows (Giles, 1980; Pavlov, 1983).

Feral pigs have relatively high protein requirements, similar to those of domestic pigs, particularly for successful lactation (milk production) and growth of young. If intake of crude protein falls below 15% of the diet, lactation can cease and dependent piglets may die (Giles, 1980). The dietary energy needs of feral pigs are also relatively high, particularly for sows in the last month of pregnancy, which require about twice the digestible energy of non-breeding sows, and lactating sows which require up to three times the non-breeding energy requirements (Giles, 1980).

Breeding is usually seasonal due to variable food quality and availability. In the high country of Kosciuszko National Park, for example, most births occur in summer and autumn, in response to the spring flush of growth (Saunders, 1988). Feral pigs living on the semi-arid floodplain of western New South Wales generally breed continuously, but most pregnancies tend to occur after flooding when more food is available (Giles, 1980). Breeding also occurs throughout the year in feral pigs in the monsoonal tropics of the Northern Territory, with a peak in births during the early dry season (Caley, 1993).

Prolonged drought can see feral pig numbers decline significantly. Conversely, favourable conditions (i.e. high rainfall and/or flooding) can see feral pig numbers increase rapidly. Under favourable conditions, sows can produce two weaned litters every 12–15 months (Giles, 1980;

* A year class is all the individuals in an animal population that were born in a specific year and are of the same, specific age. Most animal populations are made up of multiple year classes (e.g. age 0+, age 1 year, age 2 years, age 3 years, etc.). Individual animals in the population progress through these year classes until they die.

Pavlov, 1983; Ridpath, 1991). This potentially high reproductive rate gives feral pig populations the capacity to recover quickly from natural setbacks and control programs and is a major factor to be considered in their management. Published maximum reproductive rate (r_{\max}) estimates for feral pigs suggest that ~55–70% of a feral pig population needs to be removed throughout the year to keep the population size stable (Bengsen et al., 2014).

2.5. Habitat

The most critical factors affecting the distribution and habitat use of feral pigs in Australia are their poor heat tolerance and the accompanying need for access to daily water and dense shelter. This largely restricts their distribution to the vicinity of watercourses and associated floodplains in inland or seasonally dry areas of Australia. These factors are less critical in the more forest-covered parts of eastern Australia and south-west Western Australia, where populations are still spreading.

Within these limitations however, feral pigs are habitat generalists and occupy a wide range of habitats in Australia, including the subalpine grasslands and forests of Kosciuszko National Park, the semi-arid floodplains (often dominated by lignum (*Duma florulenta*)) in western New South Wales, the *Typha* and *Phragmites* reed beds of the Macquarie Marshes in central New South Wales, the rainforests in the Wet Tropics of northern Queensland, and the paperbark (*Melaleuca* species) swamps, open floodplains, monsoon forest patches, *Mimosa* thickets and dry woodlands in the Northern Territory (AMRC, 1978; Giles, 1980; Saunders, 1988; Hone, 1990b; Bowman and McDonough, 1991; McIlroy, 1993; Dexter, 1995).

2.6. Diet

Feral pigs are opportunistic omnivores, with strong preferences for succulent green vegetation, a wide variety of animal material, fruit and grain (Giles, 1980). Other foods include a variety of fungi and underground starch-rich plant material, such as roots, bulbs and corms. Pigs have a single stomach, with a poor capacity to digest cellulose, so they cannot feed solely on roughage as ruminants do.

The items eaten by feral pigs in Australia vary from region to region, but include:

(a) Fruits and seeds:

Figs, palms, pandanus and other rainforest trees; cycads (*Macrozamia* species); bush peanuts (*Elaeocarpus* species); sweet briar (*Rosa rubiginosa*); wattles (*Acacia* species); geebung (*Persoonia* species); *Coprosma* species; bananas, mangoes and a wide range of orchard fruit; grasses; and crops such as pumpkins, watermelons, potatoes, peanuts, taro, maize, wheat, oats, sorghum and other cereals.

(b) Foliage and stems:

Small palms, pandanus and other rainforest seedlings; young coconut and banana trees; sugarcane; succulents such as pigweed (*Portulaca oleracea*); semi-aquatic ferns (e.g. nardoo (*Marsilea drummondii*)); the Gondwanan relict wetland species reedia (*Reedia spathacea*); and a range of forbs[†], grasses and legumes, including native medics (*Medicago* species), introduced clovers, lucerne and paspalum, native grasses (e.g. *Poa* species) and young wheat.

(c) Rhizomes, bulbs and tubers:

Lilies (e.g. stream lily and flax lily (*Helmholtzia* species) and vanilla lily (*Arthropodium milleflorum*)); grasses, sedges and rushes such as spike-rushes (*Eleocharis* species), *Cyperus rotundus*, *Setaria sphacelata*, common water-reed (*Phragmites* species), cumbungi or bullrush (*Typha* species), sedges (*Scirpus* species) and rushes (*Juncus* species); bracken (*Pteridium esculentum*); introduced dock (*Rumex* species) and thistles (Family Asteraceae); numerous orchid species; native geranium (*Geranium solanderi*); *Oxalis* species; yams and other tropical

[†] herbaceous flowering plants other than grasses and sedges

rootstocks (*Ipomoea*, *Dioscorea* and *Ampelocissus* species); and cycads (*Macrozamia* species).

(d) Fungi:

Underground and above-ground.

(e) Animal material:

Earthworms, snails, arthropods (especially beetles), crustaceans, shellfish, frogs, fish, reptiles (including turtle eggs), eggs of ground-nesting birds, birds, mice, young rabbits, lambs and other small mammals and carrion.

(Sources of information: Pullar, 1950; Masters, 1979, 1981; Giles, 1980; Boreham, 1981; Alexiou, 1983; Hopkins and Graham, 1985; Statham and Middleton, 1987; Bowman and McDonough, 1991; Pavlov, 1991; Ridpath, 1991; Pavlov et al., 1992; Mitchell, 1993; also Jones et al., 2008; TSSC, 2008).

Both the availability and the nutrient levels of the various foods feral pigs consume changes seasonally. For example, in central and western New South Wales, feral pigs feed mainly on green herbaceous material when it becomes available after heavy rain or floods (Giles, 1980). During dry periods they eat roots, carrion and little else. In the Girilambone area in central New South Wales, they mainly eat forbs such as potato bush (*Solanum ellipticum*) and insects in autumn, native medics (*Medicago* species) (with their high protein content) in winter, and wheat in spring and summer. Roots, however, are the most consistent food item in all seasons (Pavlov, 1980). Studies in New South Wales have shown consumption of animal matter varies greatly between seasons but rarely exceeds 5–18% of the diet (Giles, 1980; Pavlov, 1980).

An international literature review reported that feral pigs prey on soil fauna including insect larvae, beetles, snails, centipedes and earthworms, reducing their abundances between 40 and 90%. This review also found animal matter can make up to 30% of feral pig diet (Barrios-Garcia and Ballari, 2012), though this is a higher figure than found in Australian studies.

3. Environmental impacts

3.1. Overview

This overview examines the environmental impacts of feral pigs. However, feral pigs also have significant economic impacts for primary producers (see 'Economic Impacts' section).

The environmental impacts of feral pigs in Australia take many forms. These include predation of animals and consumption of plants and soil organisms; habitat change and degradation due to destruction of plants, reduced plant regeneration, soil erosion and changes in soil structure, and the spreading of weeds. Feral pigs can act as reservoirs for disease, and they are implicated in the spread of the plant pathogen *Phytophthora cinnamomi*, which causes severe and widespread damage to native ecosystems. Feral pig impacts are particularly associated with wetlands and riparian ecosystems, which are preferred habitats. This leads to impacts on water quality (water turbidity and dissolved nutrient levels).

The most significant environmental impact feral pigs have is degradation of habitats and predation of native species. Habitat degradation is mostly a consequence of their digging up of soils, grasslands and forest litter as they forage or 'root' for subterranean food items such as roots and fungi. Moist soils particularly attract digging activities. Feral pig disturbance can be locally extensive, such as in or around swamps and lagoons, and may be associated with sites modified by people, or close to roads, tracks and watercourses. Foraging can result in obvious large expanses of deeply turned over or rooted soil in highly profitable foraging patches. More commonly, damage is distributed discontinuously throughout a broad area, such that a few sites experience high levels of damage while many sites have little (Bengsen et al., 2014).

A combined review/field study of feral animal impacts on native vegetation, and techniques to measure their impacts, concluded that using indicator plant species was not a good measure of feral pig impacts. General pasture impacts (including both introduced and native plants) was a better measure, as feral pigs forage into the soil profile and dig for plant roots, particularly focusing on pasture plants (Lethbridge et al., 2013). The same study stated that vegetative damage caused by feral pig diggings was striking. The amount of bare ground in recent diggings was almost 100% and there was a 78% reduction in total plant biomass compared to nearby 'no-digging' areas. However, it noted that damaged/destroyed vegetation will 'recover' or 'reset' over time—but whether this recovery brings the digging sites back to the 'pre-dug' condition was unclear and required further long-term studies (Lethbridge et al., 2013).

Lethbridge et al. (2013) supported findings in previous studies, finding that the location of feral pig diggings were strongly influenced by the presence of microhabitat variables, especially water. Intense diggings occurred in these small, preferred microhabitats where there is food, cover and water, while larger areas of less favourable microhabitats tended to have low levels of diggings. The association of feral pig density with the extent of diggings was positive.

The presence of feral pigs often results in increases in weed abundance, although whether this is through passing seeds in faeces, spreading seeds attached to fur, creating localised nutrient enrichment through urine and faeces, or simply by creating ground disturbance in which weeds can take root, is not certain. Evidence indicates feral pigs can spread many Weeds of National Significance in Australia including pond apple (*Annona glabra*) (McIlroy, 1993; Fensham, 1996; Grice, 1996; Lynes and Campbell, 2000; Setter et al., 2002), and field evidence from Queensland shows viable mesquite seedlings can sprout from feral pig faeces (Queensland DPI&F, 2008). However, an international literature review found feral pigs damage most or all seeds that they consume, so the primary means of weed dispersal may be through fur attachment (Barrios-Garcia and Ballari, 2012).

Indigenous people in the Reef Catchments Natural Resource Management (NRM) region (Mackay/Eungella region, central coastal Queensland) have observed feral pigs digging up native plants along the Elliot River and rubber vine—an invasive weed—subsequently colonising those areas.

There is increasing evidence that feral pigs spread the plant pathogen *Phytophthora cinnamomi*. Three of four feral pigs examined in Hawaii were found to be carrying the organism in soil on their hooves (Kliejunas and Ko, 1976). Similarly, a New Zealand study detected 19 plant pathogens on the trotters and snouts of 457 feral pigs in New Zealand, including *P. cinnamomi* (Krull et al., 2013b). Feeding trials with *Phytophthora*-inoculated plant materials have demonstrated that *P. cinnamomi* spores can survive passage through the guts of pigs and that viable spores are excreted up to seven days post-ingestion (Li et al., 2013).

Native fauna preyed upon by feral pigs include earthworms, amphipods, centipedes, beetles and other arthropods, crustaceans, snails, frogs, lizards, snakes, the eggs of the freshwater crocodile (*Crocodylus johnstoni*), freshwater turtles and their eggs, marine turtle eggs and hatchlings, and small ground-nesting birds and their eggs (Tisdell, 1984; McIlroy, 1990; Mitchell, 1993; Roberts et. al., 1996).

3.2. Impacts by region

The following sections describe some of the known impacts from feral pigs in particular regions and/or ecosystems:

3.2.1. Tropical savannahs

In tropical savannah areas, feral pigs have the greatest impacts on biodiversity in ephemeral lagoons and wetlands. Most of the reported damage comprises rooting and consumption of riparian and aquatic vegetation, and predation on freshwater aquatic species such as

freshwater turtles and frogs. In coastal areas, feral pigs are major predators of eggs and hatchlings from marine turtle nests.



Figure 2. Aerial photo of feral pig damage on the East Alligator River floodplain, Northern Territory. (Photo: Buck Salau, 2005.)

3.2.1.1. Predation

Feral pigs are a major predator of freshwater aquatic species in northern Australia. Frogs, freshwater crayfish and freshwater turtles are all preyed upon (Mitchell, 2010). For example, over 150 frogs were found in a single feral pig stomach in the Cape York region (Mitchell, 2010). Indigenous communities in northern Australia report predation on freshwater turtles, frogs and freshwater mussels. Feral pigs are also known to prey on freshwater mussels in the Channel Country (e.g. Coopers Creek, etc.) of far western Queensland (Bunn, pers. comm., 2016).

In northern Cape York Peninsula (Queensland), feral pig diggings and disturbance are implicated in the drastic decline of the Jardine River painted turtle (*Emydura subglobosa*), which was not found during an extensive 2008 survey of the Jardine River (Schaffer et al., 2009). In fact, this survey failed to catch any freshwater turtles at all, despite four freshwater turtle species being known from that area.

In discussing this result, the researchers comment that:

“... the usual threats ... like river regulation and industrial or agricultural pollution can be ruled out. What we did notice, however, were the ubiquitous diggings by foraging feral pigs ... In the early 1980s, one of us hunted wild pigs in the Jardine River area and saw no sign of pigs or their foraging activities near the river ... In 2008 pig disruption of the river banks was extensive, suggesting that their numbers and impacts are increasing. It is hard

to conceive this level of disturbance not having some effect on turtle populations, for example, through ... predation, disruption of nesting activities, or impeding movement between the river and adjacent habitats.” (Schaffer et al., 2009)

In 2014, a small population of Jardine River painted turtles was rediscovered (ABC News, 2014a). Further surveys have found the species still survives in small numbers at several sites on the Jardine River, however feral pigs are still considered a major threat to the species (Freeman et al., 2014).

Feral pigs are major predators of freshwater northern longneck turtles (*Chelodina oblonga*[‡]) in northern Australia. These freshwater turtles burrow into sediments as post-wet-season lagoons/wetlands dry out, and then aestivate[§] in sediments until the lagoons/wetlands refill next wet season. A study (Fordham et al., 2006) radio-tracked 38 northern longneck turtles through this process in Arnhem Land (Northern Territory) and revealed only 10 turtles (26%) were alive at the completion of the drying-out/aestivation process. Feral pigs were the main predator, causing 27 of 28 recorded deaths (96%). Photos of the aestivation sites over time revealed that feral pigs actively seek out and prey on aestivating turtles. Aestivation depth of the turtles never exceeded feral pig rooting depth. The study’s authors concluded that unless feral pig predation is severely reduced, Indigenous people may no longer be able to practice their ancient and hitherto-sustainable low-level harvest of these turtles, an action that will have damaging cultural consequences.

A second study (Fordham et al., 2008) modelled the impact of feral pig predation on freshwater northern longneck turtles using field-derived data from Arnhem Land. It found that levels of turtle mortality per lagoon/wetland caused by feral pigs (≥40%) exceeded levels that turtle populations can sustain over a 50 year timeframe. It concluded that if feral pig predation is left unmanaged, freshwater turtle populations in northern tropical Australia are under severe threat, and that extirpation of many freshwater turtle populations in the near future is all but assured. Conversely, the study found that in the absence of feral pig predation, compensatory increases in hatchling survival were sufficient to allow a traditional annual Indigenous harvest of up to 20% of sub-adult and adult turtles without causing extirpation or substantial population suppression.

Doupé et al. (2009) recorded serious degradation and destruction of lagoon/wetland turtle habitats by feral pigs in Lakefield National Park (Cape York, Queensland), but also demonstrated that fencing of lagoons/wetlands utilised by turtles can prevent feral pig impacts.

[‡] Formerly *Chelodina rugosa*

[§] A process similar to hibernation, employed by animals to survive periods of high heat and dryness



Figure 3. Feral pig diggings on the floodplain of the South Alligator River, Northern Territory, in the dry season. (Photo: Buck Salau, 2003.)

The Kowanyama community (Mitchell River delta, western Cape York) report that freshwater turtles are no longer found at popular harvesting sites due to feral pig predation, and Yolngu people (north-east Arnhem Land) and Thamarrur (Wadeye, Northern Territory) rangers report definite impacts on freshwater turtles as well. The Carpentaria Land Council's Ranger Coordinator noted that the more severe impacts occur in drier years when water levels are lower.

Feral pigs are responsible for high levels of predation on marine turtles nests (eggs and hatchlings) on nesting beaches. The marine turtle populations affected by feral pig predation of nests or hatchlings have been identified (EA, 2003; DotE, 2015) as:

- loggerhead turtles (*Caretta caretta*) from the eastern and western Australian populations
- green turtles (*Chelonia mydas*) from the southern Great Barrier Reef, Gulf of Carpentaria and North West Shelf populations
- flatback turtles (*Natator depressus*) from Arnhem Land, Gulf of Carpentaria, Queensland and North West Shelf populations
- olive ridley turtles (*Lepidochelys olivacea*) from the western Cape York population
- hawksbill turtles (*Eretmochelys imbricata*) from the north-eastern Australian populations.



Figure 4. Photo showing an autopsy of a feral pig that had been preying on marine turtle hatchlings in north Queensland. The photo shows at least 32 hatchlings from one feral pig. (Photo: Australian Quarantine and Inspection Service (AQIS), Cairns.)

A study on Pennefather Beach in western Cape York found that overall turtle nest mortality (flatback, olive ridley and hawksbill turtles) was 42%, and that feral pig predation was responsible for 89.6% of this mortality (Whytlaw et al., 2013). Previous studies on the same beach have recorded even higher turtle nest mortality rates of 65% and 70%, mostly due to feral pigs (Whytlaw et al., 2013). This study found that most turtle nest predation was the work of a small number of individual feral pigs specialising in turtle nest predation, rather than the work of the broader feral pig population. Consequently, this predation was far more effectively controlled by targeting individual “specialist” feral pigs with shooting and baiting on beaches during the turtle nesting season, rather than through the broader aerial mass shooting strategy currently used, which aims to reduce the general population feral pig population in the region (Whytlaw et al., 2013).

Fuentes et al. (2014) tested a decision framework that prioritised management actions in the region to reduce feral pig predation on flatback turtles (*Natator depressus*), and made similar findings to the above. Their study noted that the most important nesting sites for this population are in the north-east of the Gulf of Carpentaria and western Torres Strait. They found that predation of nests is one of the greatest threats to mainland flatback turtle populations, with more than 80% of nests affected by egg predation in some areas, with most of that egg predation being by feral pigs. They similarly found that mixed feral pig control strategies were more effective at reducing feral pig nest predation than aerial-culling-only strategies, due to the fact that the minority of feral pigs that live on beachfronts are usually the major turtle nest predators. This minority of feral pigs are not fully controlled by aerial-culling-only strategies, so it is important to identify and kill these feral pigs at ground level to protect turtle nests (Fuentes et al., 2014).

The degree of awareness Indigenous people have regarding feral pig damage on marine turtle nests, and the amount of feral pig control carried out for marine turtle conservation, is partly related to the degree of prominence turtles have in their local culture. The Nest to Ocean Turtle Protection Program, funded jointly by the Australian Government and Queensland Government and running between 2014 and 2018, aims to fund and empower Indigenous and other community groups to tackle this feral pig nest predation and improve survival rates for marine turtle nests. An example of group participation in the program is by the Kurtijar at Delta Downs who have been shooting feral pigs on the beach to protect marine turtle nests. An element of this program is the identification that it is necessary to cull feral pigs living behind the coast as well as directly on the beaches.

3.2.1.2. Habitat degradation

Mitchell (2010) carried out in-depth investigations on the impact of feral pigs on ephemeral lagoons and wetlands in tropical savannah/floodplain regions in Lakefield National Park (Cape York, Queensland), based primarily on comparisons of fenced and unfenced lagoons and wetlands. Feral pigs had a marked negative impact on the ecological condition of unfenced lagoons and wetlands as they shrank over the course of the dry season. Feral pig foraging caused major destruction of aquatic vegetation and strong declines in water quality. They caused significant increases in turbidity through their foraging, fouled water and raised nutrient levels via their bodily wastes, and thus reduced dissolved oxygen levels and pH levels to biologically stressful levels. Mitchell (2010) found that if feral pig diggings covered more than 25% of unfenced lagoon perimeters there was a rapid reduction of plant richness, which declined to zero when feral pig diggings became extensive. Mitchell (2010) also suggested that feral pig disturbance may affect water body permanence where the lagoons are very shallow with broad wetland margins.

Doupé et al. (2009, 2010) recorded serious degradation and destruction of lagoon/wetland turtle habitats by feral pigs at the same sites used by Mitchell (2010), but demonstrated that fencing of lagoons/wetlands utilised by turtles can prevent feral pig impacts.

Indigenous peoples of western Cape York recognise the degradation of the wetlands causes negative impacts on magpie geese (*Anseranas semipalmata*) populations and local plant food sources such as 'panja' (water chestnuts (*Eleocharis dulcis*)).

The Carpentaria Land Council has observed a dramatic improvement in water quality and aquatic plant growth after exclusion fencing of feral pigs and cattle from the Lotus Horseshoe Lagoon on the Delta Downs station.

The Kowanyama community of the Mitchell River (western Cape York) have observed feral pig disturbing freshwater habitats causing extreme turbidity, feral pigs defecating into and fouling water, and feral pigs consuming anything aquatic—including crabs, eggs, tubers and plants. For the Kowanyama community, exclusion fencing of feral pigs has also been successful.

The Yolngu, in north-east Arnhem Land, state the most visible and significant damage feral pigs do is to wetland areas and freshwater places when they contract to a small size in the dry season. This is where the feral pigs congregate and foul waters. Their impacts on freshwater holes, turning them over in the course of their feeding, are a big problem. Exclusion fences in some areas have made a huge difference. Feral pigs are also targeting yams (which are bush foods) and making them rare.

The Thamarrurr (Wadeye, Northern Territory) rangers have observed the feral pigs rooting up the country and damaging swamps, which in turn damages important bush foods. In particular, "cheeky yams", a large tuber (*Amorphophallus paenifolius*), have disappeared from the south side of Moyle River and around White Cliff Point due to feral pigs. This is considered serious as these yams are a totem for the Perrederr Indigenous group in this area.

On the Tiwi Islands, Northern Territory, there is widespread acknowledgement that feral pigs damage freshwater stream beds and banks as they search for freshwater mussels. As well as direct damage to the banks, the digging by the feral pigs causes turbidity of the waters.



Figure 5a. A lagoon in the Archer River Basin, Cape York, Queensland, immediately after the end of the wet season. 15 May 2015. (Photo: Kalan Enterprises.)



Figure 5b. The same lagoon seriously degraded by feral pigs only two months into the dry season. Note the now-bare banks, turbid water and complete lack of aquatic vegetation. 25 July 2015. (Photo: Kalan Enterprises.)



Figure 6a. Nalawan Lagoon, western Cape York, Queensland, in 2009, severely degraded by feral pigs. (Photo: Emilie Ens.)



Figure 6b. Nalawan Lagoon in 2012, reverting to its natural state after feral pigs were excluded from it with fencing. (Photo: Kalan Enterprises.)

3.2.1.3. Competition

Feral pigs are likely to compete with brolgas (*Grus rubicundus*) and magpie geese for tubers and bulbs in northern Australia (Tisdell, 1984).

3.2.2. Wet Tropics

3.2.2.1. Predation

In the Whitsunday Ranges, feral pigs feed heavily on the seeds and juvenile plants of the Alexandra palm (*Archontophoenix alexandrea*) and dislodge further juvenile palm plants with their diggings, to the point where no small palms were surviving in study areas prior to feral pig control (Nolan and Bennison, 2014).

Studies have reported conflicting results on feral pig predation of earthworms in the Wet Tropics. One study found that feral pigs harvested over 95% of the available worms at paired sites in ephemeral swamps near Cape Tribulation (Pav Ecol, 1992), while a second study found identical numbers of earthworms in feral pig diggings and surrounding areas in the same general region (Mitchell, 1993).

Feral pigs, through either direct predation or habitat disturbance, may have contributed to the declines in some populations of endemic tropical rainforest frogs and may have contributed to the extinction of the gastric brooding frog (*Rheobatrachus silus*) (Richards et al., 1993).

Feral pigs are reported to destroy nests and eat the eggs and young of cassowaries (*Casuaris casuaris johnsonii*), scrubfowl (*Megapodius reinwardt*) and brush-turkeys (*Alectura lathama*), (Hopkins and Graham, 1985; Crome and Moore, 1990; Mitchell, 1993). However, an Australian literature review of feral pig impacts reported that monitoring of artificial nests provided no evidence of predation by feral pigs, and those researchers concluded native rodents were the dominant predators (Bengsen et al., 2014).

3.2.2.2. Habitat degradation

Feral pig digging may cause significant erosion of creek banks in the rainforests of Queensland, leading to the silting of downstream swamps (McIlroy, 1993, 2001). This may be minor, though, compared to the concentration of suspended sediment in streams in the area from vehicles crossing them, and from the widespread overland flow of water and saturated soil profiles associated with torrential rainfall, particularly from cyclones during the wet season (Gilmour, 1971; Gillman et al., 1985).

A study in the Wet Tropics World Heritage Area (Queensland) found feral pigs had dug up 4.3% of the ground surface at 31 randomly selected sites. Approximately 70% of feral pig diggings were within ten metres of a road, track, surface water or a drainage line, particularly along watercourses (36%) and drains (8%). Only 1% of the ground surface more than ten metres away from roads and watercourses had been dug up (Mitchell and Mayer, 1997; Mitchell, 2001). This study did not find any significant impact on earthworm populations, root biomass, soil moisture and litter biomass by these feral pig diggings. However, revegetation was slow in areas that had been dug over by feral pigs and the dominant grassy vegetation and some small native herbs were greatly reduced in abundance (Mitchell, 2001).

Similarly, a study comparing plots where feral pigs had been excluded long term (12 years) with unprotected plots found feral pigs had caused significant declines in seedling density, soil macroinvertebrate density and leaf litter cover, but caused no significant change in other variables (Taylor et al., 2011). An Australian literature review of feral pig impacts compared the results of this study and a subsequent study (Elledge et al., 2011, cited in Bengsen et al., 2014). The subsequent study used plots protected from feral pigs for two years, and the same long-term plots from the first study, and found no statistically significant differences between seedling densities in protected and unprotected plots. Neither study found detectable differences in soil characteristics such as pH, conductivity or nutrient status after 2 or 12 years

of feral pig exclusion. However, long term changes in plant community composition could not be ruled out however (Bengsen et al., 2014).

Mitchell et al. (1997) studied the impact of feral pig diggings in the Wet Tropics World Heritage Area (Queensland), in the context of the rainforest as a mosaic of small-scale microhabitats. They concluded the amount of feral pig diggings was minor in most rainforest microhabitats but severe in the microhabitats of 'creek' and 'swamp'. Such diggings may not affect the rainforest as a whole, but may have a severe impact on these creek and swamp microhabitats. The clear preference of feral pigs to dig in swamps and creeks may have important ramifications if these habitats are refuges for rare or endangered plant and animal species. An Australian literature review similarly concluded populations of widespread generalist plant species are unlikely to be affected by feral pigs because diggings tend to be concentrated in profitable foraging areas, allowing plant seedlings in less favoured areas to escape (Bengsen et al., 2014). However, areas favoured by feral pigs for digging may also be the preferred habitats of specialist plant species. North Queensland rainforests, for example, support many rare and endemic plant species, some of which are largely restricted to the vicinity of drainage features (e.g. creek lines, swamps) where feral pigs concentrate their digging activities (Bengsen et al., 2014). These specialist plant species may be seriously threatened by feral pig diggings.

Feral pigs undermine shrubs and trees by their digging, causing them to topple (Mitchell, 1993), but it is not clear if other factors, such as cyclone damage, may also have a contributory effect (McIlroy, 1993).

3.2.2.3. Competition

Feral pigs may compete with specialist feeders such as the mainly fruit eating cassowaries, by feeding on a temporarily abundant food source such as fallen rainforest fruit, until the supply is almost depleted, before switching to others, such as sugarcane (Tisdell, 1984; Buosi and Burnett, 2006). An Australian literature review of feral pig impacts however found no reliable information to evaluate these suggested impacts (Bengsen et al., 2014).

3.2.3. Temperate forests and grasslands

3.2.3.1. Predation

In temperate forests of south-western Western Australia, feral pigs have been identified as a major problem to declared rare flora taxa, particularly geophytes (plants with underground food storage organs such as bulbs, tubers, corms or rhizomes) such as orchids (Hearn et al., 2006). Recent metagenomic (DNA) analysis of feral pig faeces from natural forest sites in south-west Western Australia have confirmed that feral pigs are consuming a wide variety of native plant materials including orchid species (Bunce, pers. comm., 2016). Feral pig diggings have been identified as a key threat to the EPBC-listed, endangered majestic spider orchid (*Caladenia winfieldii*), as they destroy the underground storage tubers of the orchid and affect the growth of symbiotic fungi essential for providing starches for plant and seed germination (Hoffman and Brown, 1992).

The south-west of Western Australia is comprised of several identified Biodiversity Hotspots (DotE, 2016). With a drying climate, shrinking water resources, and increasing feral pig populations, the impact of feral pigs in this region are intensifying to a degree that now threatens a very broad range of regional ecosystems, threatened ecological communities, and threatened species. There is also potential for collateral damage in regional ecosystems due to the wide-ranging foraging activity of feral pigs—they now move into seasonally dry sites (e.g. granite rock-apron communities), as well as remove geophytic plants required by other fossorial (digging/burrowing) mammals such as bandicoots (Dixon, pers. comm., 2016).

3.2.3.2. Habitat degradation

As mentioned in the overview, feral pigs can seriously degrade temperate forest by spreading the plant pathogen *Phytophthora cinnamomi*, causing the plant disease commonly known as

Phytophthora dieback. There is increasing evidence that feral pigs spread this plant pathogen (Kliejunas and Ko, 1976; Krull et al., 2013b, Li et al., 2013).

An international review found that nest building by pregnant females, creating wallows (mud hollows in which feral pigs roll) and tree rubbing may also contribute significantly to vegetation damage in forest areas (Barrios-Garcia and Ballari, 2012). In New Zealand temperate rainforests, Krull et al. (2013a) found significantly more nitrate in feral-pig-disturbed plots. Seedling density was not significantly reduced, but seedling/sapling species richness [i.e. number of different species] was reduced and species composition was altered (Krull et al., 2013a).

An international review found digging by feral pigs can adversely affect soil nutrient cycling and erosion, but the extent of this impact is not quantified. The enrichment of areas with nutrients from feral pig waste may remove the competitive advantage that endemic plants adapted to lower nutrient levels have over introduced plants (Barrios-Garcia and Ballari, 2012).

There is a strong correlation between digging damage and soil moisture (Hone, 1988, 1995, 2002), soil friability and the presence of large numbers of earthworms, other invertebrates and bulb-producing plants. A few feral pigs can dig up a significant area. The ground disturbance within natural areas caused by feral pigs, especially national parks and reserves, is often obvious and a major source of concern to park users (Hone, 2002). Managing complaints about soil disturbance may be the main aim of some feral pig management programs. In Namadgi National Park in the Australian Capital Territory, a large reduction in the feral pig population was required to obtain a significant reduction in ground digging (Hone, 2002).

In Strzelecki National Park on Flinders Island, feral pigs dig up extensive parts of the moist rich gullies, leading to erosion, loss of regenerating forest plants and their replacement by thick, impenetrable stands of bracken fern (*Pteridium esculentum*) (Statham and Middleton, 1987).

3.2.4. Temperate wetlands/marshes

3.2.4.1. Predation

The rare Gondwanan-relict sedge species reedia, listed as endangered under the EPBC Act, and found in wetlands of south-western Western Australia, is targeted by feral pigs and easily killed by them. This is due to essential tap roots issuing from the top of the plant, where they are easily severed by feeding feral pigs (TSSC, 2008). The EPBC-listed, threatened, white-bellied frog (*Geocrinia alba*) (endangered), orange-bellied frog (*Geocrinia vitellina*) (vulnerable) and sunset frog (*Spicospina flammocaerulea*) (endangered) found in these habitats are also taken by feral pigs, and are negatively affected by feral pig activities (Burbidge and Roberts, 2002; WA DPaW, 2014a).

3.2.4.2. Habitat Degradation

The unique wetlands of south-western Western Australia, including a number of peat swamps habitats, and areas with moist organic soils, are seriously degraded by rooting activities of feral pigs and nutrient enrichment and pollution from their bodily wastes.

3.2.5. Alpine/sub-alpine areas

At Smokers Gap, in the Australian Capital Territory, drainage lines, depressions, and grassy flats were the areas of sub-alpine vegetation most susceptible to damage by feral pig digging (Alexiou, 1983). Feral pig diggings along drainage line have had particularly destructive effects on orchid species after the 2003 bushfires burnt this area (Jones et al., 2008).

3.3. Feral pig densities, landscape use, and food resource use

The relationship between feral pig density and environmental damage is still being researched, but clearly varies between locations and ecosystems. A study in the southern highlands of New South Wales demonstrated a positive relationship between feral pig density and the extent of rooting/digging (Hone, 2002). A study in tropical savannahs in Cape York (Queensland) also

found the level of impact caused by feral pig diggings is positively associated with the level of feral pig abundance, i.e. more feral pigs, more diggings. The study also found that when feral pig abundance is high, a minimal level of population control will substantially reduce impacts, while when feral pig abundance is low, a substantial level of feral pig control is required for a minimal decrease in impact levels. The study found that the point where control measures had maximum effectiveness for effort was when feral pig visitation frequency reached 50% in plots being monitored for signs of feral pig presence (Mitchell, 2010). In contrast, a study in western Cape York found that most feral pig predation on turtle nests was the result of small numbers of individual (territorial) feral pigs within their specific areas of beach (Whytlaw et al., 2013).

Seasonal use of landscapes and resources by feral pigs in Australia is not fully understood. It is an area of active research and new findings are being made. For instance, recent studies found feral pigs were using the Whitsunday Great Walk track as a thoroughfare to feed on Alexandra palms (*Archontophoenix alexandrea*) in the Whitsunday Ranges, and also identified the feral pigs' use of four seasonal food groups (Nolan and Bennison, 2014). These were: palm seeds (November through to Jan/Feb); earthworms (Feb/March, sometimes into April); palm hearts (heads) (April/May through to July); and generalist feeding (mainly invertebrates) (August to November). Transition between food groups was approximate, and in some cases dependent on the end of the wet season and soil saturation levels (e.g. earthworms). This enabled the researchers to confirm, through trials and the use of remote cameras, that the best time to bait feral pigs in the area was September/October with early to mid-October being the optimum. At this time of year, feral pigs were observed fighting over baits and would readily consume baits soon after they were first encountered (Nolan and Bennison, 2014).

Another study found that feral pigs in the Wet Tropics have small home ranges of 3–10 km² and very little seasonal movement due to abundant food, water and shelter. This study found protein content in the diet was important and guided landscape use, with earthworms targeted during the wet season (commencing January/February) and consumption of fallen fruit in the dry season peaking in September. Some feral pigs used rainforest/cane field boundaries and moved into the cane fields for foraging and shelter in the dry season (Fletcher et al., 2014).

One impediment to understanding landscape use by feral pigs has been the difficulty of spotting feral pigs when they are in forest habitats. However recent aerial trials using fixed wing aircraft and downward-facing thermal sensors successfully detected feral pigs at several altitudes under forest canopy providing up to 98% ground cover (Adams and Rampant, 2014).

4. Disease

Feral pigs have been identified as actual or potential reservoirs and vectors for a number of diseases and parasites including foot-and-mouth disease, leptospirosis, brucellosis, melioidosis, tuberculosis and sparganosis (Pullar, 1950; Keast et al., 1963; Geering et al., 1995; Wilson and Choquenot, 1996; ARMCAZ, 2000; Black, 2004; Sharp and Saunders, 2012).

An Australian literature review of feral pig impacts reported that the two most common diseases isolated from feral pigs in Australia are the bacteria *Leptospira* spp. and *Brucella* spp. These can cause leptospirosis and brucellosis, resulting in birth defects, abortion and infertility in livestock and humans.

Spirometra are a type of cestode tapeworm that can cause a serious condition in humans called sparganosis. *Spirometra* can be highly prevalent in feral pigs in north Queensland, where consumption of feral pig meat is common in remote communities. Although sparganosis is not common, it could occur through consuming *Spirometra* in undercooked feral pig meat (Bengsen et al., 2014).

The literature review also found pathogenic organisms such as *Escherichia coli*, *Giardia*, *Cryptosporidium* and *Balantidium coli* can cause serious illness or death in people who consume water or agricultural produce contaminated by feral pigs (Bengsen et al., 2014). Similarly, a study of a remote, isolated feral pig population on the Fitzroy River floodplain in the Kimberley (Western Australia) found the population consistently carried *Salmonella* bacteria. The *Salmonella* bacteria was transmitted from older to younger feral pigs, possibly via landscape features such as water features, which may have implications for infection of co-grazing livestock within that environment (Ward et al., 2013).

Feral pigs are also susceptible to many virulent exotic pathogens, with foot and mouth disease virus being the greatest concern. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has modelled the cost of hypothetical foot-and-mouth disease outbreaks in Australia. ABARES has estimated that two small foot and mouth disease outbreaks in Queensland and Victoria would result in revenue losses of between \$5.6 billion and \$6.2 billion (in present value terms) over 10 years, depending on the response strategy used. In the event of a large multi-state foot and mouth disease outbreak, ABARES estimated revenue losses of between \$49.3 billion and \$51.8 billion (in present value terms) over 10 years. These revenue losses account for around 99 percent of direct economic costs, with the remaining 1 percent being the cost of disease control (Buetre et al., 2013).

If there were a foot and mouth disease outbreak in Australia, feral pigs could contribute to the persistence and transmission of the disease, because they are highly susceptible to the virus, they are abundant in northern Australia, they are often in close contact with livestock, and they are highly efficient amplifiers and transmitters of the virus. The wide range of landscapes/habitats in which feral pigs occur also makes it difficult to predict the spread and persistence of a foot and mouth disease outbreak (Bengsen et al., 2014). The Commonwealth, state and territory governments and livestock industry groups have formulated a contractual Emergency Animal Disease Response Agreement to prepare for, and respond to, emergency animal disease incursions. Preferred approaches to diseases listed under the Emergency Animal Disease Response Agreement, including foot and mouth disease, are captured in the Australian Veterinary Emergency Plan (AUSVETPLAN). A foot and mouth disease outbreak in feral pigs would be managed under the Wild Animal Response Strategy manual, which sets out the management strategies and overall control procedures for wild terrestrial animals for use in an animal health emergency in Australia.

The potential for feral pigs to transmit diseases of any kind to livestock is high in areas such as semi-arid extensive pastoral systems, where feral pigs may occur at locally high densities near water, and stock can become infected from contact with contaminated substrates such as water, soil and, in some cases, air (Bengsen et al., 2014). It is not known what effect the variety of pathogens feral pigs harbour or vector have on native wildlife.

5. Community perception

Feral pigs are variously regarded as an agricultural pest, a disease carrier, an environmentally-damaging pest, an export commodity and a recreational hunting resource (Choquenot et al., 1996). The status of feral pigs in any of these categories can vary with location, time and observer perception. This can lead to conflict in developing and implementing feral pig control programs that are aimed at addressing environmental problems. Similarly, a poor understanding of feral pig problems and issues can lead to unrealistic perceptions of feral pig problems and unrealistic expectations of control programs.

Recognition of the problem of feral pigs in the urban community is still poor, despite information being readily available. This may be because feral pigs generally do not impact on towns and cities. Conversely, agricultural and environmental impacts from feral pigs are well recognised within rural communities and natural resource management community groups (DSEWPAC, 2011).

Governments at all levels have an important role in developing community understanding and awareness through appropriately packaged and targeted information. Non-government groups such as landholder community groups, industry groups and associations, animal welfare societies, hunting groups and conservation societies can also play an important role in conducting or supporting control programs, and are key groups to target with educational material. Special attention should be given to providing information about the potential risks and problems due to feral pigs to key stakeholders, such as recreational hunters and bushwalkers. Land managers where jurisdictions require they undertake feral pig control will also require specific information.

5.1. Indigenous communities

Feral pigs are found on some lands owned or managed by Aboriginal and Torres Strait Islander people. As is the case for other Australians, there is no one attitude held by all Indigenous groups. Attitudes vary considerably across the country and are changing with time (Roberts et al., 2001). Some of the issues and concerns are:

- hunting and commercial harvest of feral pigs is often used by elders to encourage young people into the field to teach them traditional knowledge and as a way of helping to maintain the kinship system, and provide employment and additional cash flow to Indigenous communities
- feral pigs are an important supplement to the diet of Indigenous people in some remote areas
- feral pigs are a traditional feast animal at ceremonies for some groups such as Torres Strait Islanders
- “too many pigs” are seen as a threat, especially from the perspective of disease outbreak, for groups that run pastoral operations, and
- the damage that feral pigs may cause to traditional food sources (roots and tubers), to totemic species and to the cultural landscape.

Managing feral pigs where they are having environmental impacts but are also a resource for an Indigenous community is a particular challenge. Fordham et al. (2006) describe this challenge in relation to freshwater northern longneck turtles, which are seriously threatened by feral pigs:

“Feral pigs in Arnhem Land present a management paradox since feral animals often constitute a culturally and economically important resource for Indigenous people ... Communities at a regional level must collectively choose between an annually available food source in the form of pig meat and conserving the traditional harvest of [northern longneck turtles], a food source that is at best seasonally abundant. Effective management can only be achieved if all stakeholders choose to view pigs as a pest ...”

Koichi et al. (2012) reviewed the literature on the many and varied Indigenous opinions on feral pigs, as well as providing opinions of Aboriginal Rangers from the Wet Tropics. They report that Indigenous people who rely on bush tucker, which is subject to feral pig damage, were usually in favour of feral pig control. Conversely, in north-western Arnhem Land, feral pigs were valued as a resource to be used for game meat and hunting activities because few commercial opportunities existed in such remote areas. Feral animals have become an important dietary component for some people in some more remote areas of far north Queensland. In this area, the economic necessities of relying on fresh pig meat, instead of expensive store-bought food, and the social and cultural value of feral pig hunting, were stressed. Aboriginal Rangers recognised these ‘positive’ aspects of feral pigs but were very cognisant of the severe environmental damage feral pigs cause, including to traditional food sources, and the need for effective feral pig control.

Recent projects funded in the 2014–2018 Nest to Ocean Turtle Protection Program on Cape York, which aims to control feral pigs preying on marine turtle nest, has further highlighted the complicated and mixed attitudes Indigenous people have towards feral pigs. Notwithstanding Indigenous people's close connection with their land, it should not be automatically assumed that local Indigenous communities are fully aware of all feral pig impacts in their area. Engaging with local Indigenous groups to outline feral pig impacts and the need for control can be an essential step in control programs.

The damage that feral pigs can do to sites (for example, ceremonial stone arrangements), or particular totem species (for example, the “cheeky yams” of the Perrederr people) cause significant concern for Indigenous people.

Some of the Indigenous communities contacted in the drafting of this Background document provided details on Indigenous attitudes towards feral pigs:

Carpentaria Land Council (north-western Queensland): Indigenous views of feral pigs in the Carpentaria Land Council region vary. Some people view them positively, as a valuable food resource and a resource generally. This view extends to the Indigenous-run Delta Downs cattle station (Kurtjar people), where they have been used for the chiller trade (i.e. meat for human consumption) in the past and now for tourism (i.e. hunting). The commercial hunting opportunities for the cattle station have shaped the current land management of this property with a stop on feral pig culling while protective fencing of productive or culturally and environmentally significant areas has continued.

Pastoralists (Indigenous and non-Indigenous) in the area are taking feral pigs more seriously now as they recognise that feral pigs can cause significant pasture damage, which impacts on cattle grazing. Their feral pig control efforts feed into and support the Carpentaria Land Council's feral pig control programs. The demonstration of concerted, long-term feral pig control substantially reducing numbers has changed pastoralist's attitudes towards supporting and engaging in control programs.

Western Cape York, Queensland: There are mixed attitudes towards feral pigs and the level of concern varies between and within Indigenous communities in western Cape York. There is generally recognition of the environmental damage feral pigs cause, however, as noted elsewhere, there is little support for total elimination of feral pigs as they provide a valuable source of meat and hunting of feral pigs is valued as a cultural and recreational activity.

Some ranger groups in the region have made concerted efforts to show traditional owners/elders the visible improvement in the health of wetlands as feral pig numbers have been reduced, which has increased support for feral pig control efforts.

Kowanyama Community, western Cape York, Queensland: The Kowanyama people are aware of the damage that feral pigs can cause but also look on feral pigs as a food resource—people in this region rely on fish, feral pigs and cattle as their main sources of protein. Locals go out and hunt them occasionally, however, it is selective harvesting—only fat pigs in good condition are taken—so there is little impact on feral pig population.

Yolngu People, north-east Arnhem Land, NT: Feral pigs are seen as a pest by the Yolngu people and there are no other values attached to them. They are not trusted as a food source because of parasite concerns.

Tiwi Land Council (islands off north-west NT): There are two main islands in the area—Melville and Bathurst Island. Bathurst Island has had feral pigs since missionaries introduced them in 1911. On Bathurst Island, feral pigs are widespread. People have grown up with them present and accept they're there. But there is no resistance from people to feral pig control programs as people do recognise the damage feral pigs do. There is some opportunistic hunting and eating of feral pigs.

On Melville Island, people would like to eradicate feral pigs. The island has only had feral pigs since 2003, when they were illegally introduced. Currently the feral pigs are fairly well embedded in an isolated wetland. Using ranger funding from 2009–2011, there was an extensive program of trapping and 1080 baiting. In some areas, well-used digging areas have completely regenerated. Rangers are not doing any control now due to a lack of funding. It appears that wild dogs keep feral pig numbers under control—the wild dogs prey heavily on piglets and even sows.

5.2. Agricultural producers

Feral pigs are viewed variously by the agricultural community. Some producers see feral pigs as a potential resource, especially when the game meat price is high and/or the price of agricultural commodities is low. However, the majority of producers view feral pigs negatively because of the damage they cause to livestock and crop enterprises, and also because of their potential role in outbreaks of exotic diseases.

Achieving broad scale control of feral pigs in an agricultural landscape can be challenging even where feral pigs are viewed negatively. Gaining the support of sufficient landholders to ensure there are no gaps in the control program is essential. The use of remote sensing cameras is a useful tool to demonstrate to land managers that feral pigs are present in the area and using their properties. To be effective, multiple control methods are required and the timing of application of the methods needs to fit in with different cropping, lambing or other activities being conducted (Marshall et al., 2014).

5.3. Recreational hunters

A survey by Finch et al (2014) concluded there are likely to be at least 200,000 and more likely 300,000 recreational hunters in Australia, spending in excess of \$1 billion annually on hunting. Further, their survey of 7,202 hunters indicated hunters were willing to participate in direct wildlife management activities, such as pest control. However, there is no evidence that recreational hunting has a role in controlling feral pig numbers (e.g. McIlroy and Saillard, 1989; Caley and Ottley, 1995; Mitchell and Dorney, 2002; Bengsen and Sparkes, 2016).

The community can assist in integrated control programs. An example is the Sporting Shooters Association of Australia Farmer Assist program. Members who have achieved a shooting skill competency equivalent to professional kangaroo harvesters are able to provide assistance to farmers in wildlife management, including feral pig management.

Twenty-three percent of recreational hunters surveyed by Sparkes et al. (2016) use dogs in their hunting and 52% of these respondents were targeting feral pigs. There are a number of risks in using dogs while hunting; for the welfare of the dogs if feral pigs attack, for native wildlife if the dogs fail to return to their owners, and for the welfare of the feral pigs if the dogs are not managed appropriately (i.e. as outlined in the standard operating procedures for ground shooting of feral pigs (Sharp, 2012)).

While there is no firm evidence of people deliberately doing detrimental things related to feral pigs, there is a need to discourage behaviours such as the translocation of feral pigs to new areas and burning areas to improve access.

5.4. Animal welfare groups

Animal welfare groups aim to protect animals from cruelty and exploitation, and encourage considerate treatment of animals regardless of their status in human society. While there is a range of views held by such groups, in general they oppose control practices that cause animals unnecessary pain or suffering, and desire cogent justifications for control programs before they commence. Such groups demand that only best-practice, most-humane control methods are used. Information about control methods are provided in the following chapter.

6. Control methods

There are a range of control methods and strategies for managing the damage caused by feral pigs. When strategically applied, using well planned and appropriately resourced programs, they have been very effective in reducing the damage feral pigs cause. The most effective methods for large-scale management/control are poisoning and aerial shooting. However, these methods are less effective for managing feral pigs in areas such as dense forest where access is difficult and methods such as aerial shooting are not feasible. There may be further restrictions on some methods, for example where non-target animals are at risk from the method, or in areas close to human habitation (e.g. restrictions on the use of 1080 poison). A discussion of issues associated with some methods follows.

An over-arching Model Code of Practice for Feral Pig Control is available at: <http://www.pestsmart.org.au/pest-animal-species/feral-pig/>. Detailed guidance on the use of the various control methods for feral pigs, in the form of Standard Operating Procedures, is available at <http://www.pestsmart.org.au/pest-animal-species/feral-pig/>. Table 1 (end of this chapter) provides a summary of approved control methods by state and territory.

6.1. Trapping

Trapping is an effective method, however, the limited number of individuals it removes from feral pig populations means it rarely has meaningful impacts on feral pig abundance. Where trapping is used, it needs to be expertly applied, as feral pigs quickly become trap-shy if they suffer a near miss. There have been some useful advances in trap application. For example, New South Wales National Parks and Wildlife Service has used auto-feed and satellite signal traps in remote areas so that animals can be removed when trapped. Past studies have investigated increasing the effectiveness of traps using more effective attractants and trap designs (Dorrington et al., 2001).

Prior to trapping, free feeding of bait is offered at sites where feral pigs are active. After selecting a suitable site, a trap is then erected and free feeding is continued for a number of days before the trap is set. After feral pigs have been caught they are shot whilst still inside the trap. Good trapping techniques may enable whole groups of feral pigs to be caught at one time with minimal impact on non-target animals.

The revised '*Standard Operating Procedure: PIG001: Trapping of feral pigs*' (Sharp, 2012a) offers detailed advice. In particular:

- “Traps should be set up at sites where vegetation can provide shade and shelter. Pigs have poor thermoregulation and can suffer greatly when exposed to extremes of heat and cold.”
- “To minimise the possibility of dehydration and heat or cold stress, all traps must be inspected daily. Shade cloth or hessian can be used for protection during extremes of weather.”

6.2. Aerial shooting

Aerial shooting of feral pigs from a helicopter is used in extensive or otherwise inaccessible areas where the density of feral pigs is high (Sharp, 2012b). The effectiveness of this method is influenced by factors such as type of terrain, the amount of vegetation cover and flying conditions (Choquenot et al., 1996), but it is an effective and relatively cost-efficient method of quickly reducing feral pig populations.

Policy and procedures for aerial shooting feral pigs vary greatly between state and territory jurisdictions. This can influence the effectiveness of aerial control campaigns. Considerable

differences also exist between private contract shooting and government funded and operated aerial shooting campaigns.

Aerial shooting can be a very humane method of destroying feral pigs when it is carried out by experienced and skilled shooters and pilots.

The revised '*Standard Operating Procedure: PIG002: Aerial shooting of feral pigs*' (Sharp, 2012b) offers detailed advice.

6.3. Ground shooting

Although intensive ground shooting operations may reduce local populations of feral pigs, it is rarely effective for damage control and is not suitable as a long-term control method (Sharp, 2012c). Ground shooting can actually be counter-productive to other methods in that it can disperse feral pigs or make them more wary (Choquenot et al., 1996).

Dogs may assist land managers to remove solitary animals after application of a broad-scale management program (Caley and Ottley, 1995). A study by Mitchell and Dorney (2002) in cane and banana farms in north Queensland found that hunting with dogs and shooting were less cost effective than trapping but was able to target specific problem animals. Nevertheless, a study in Namadgi National Park by McIlroy and Saillard (1989) using radio-tracked feral pigs showed standard hunting techniques with dogs were often surprisingly ineffective in well vegetated areas, with dogs frequently failing to detect feral pigs close by, and feral pigs frequently able to circle back behind hunters and avoid detection.

A distinction is made in this document between tracking dogs and hunting dogs. The revised '*Standard Operating Procedure: PIG003: Ground shooting of feral pigs*' (Sharp, 2012c), the Code of Conduct, and some state legislation (e.g. Victoria), state that use of dogs in feral pig control must be restricted to detecting and flushing out feral pigs, and that it is unacceptable to encourage or allow dogs to attack feral pigs. Ideally, only tracking dogs, which detect and track pigs, rather than hunting dogs that are inclined to attack feral pigs, should be used.

6.4. Use of Judas pigs

Radio-collared 'Judas' pigs are used to locate groups of feral pigs that are difficult to find using other methods. This method involves attaching a radio-collar to a feral pig and releasing it with the expectation that it will join up with other feral pigs. Feral pigs are gregarious, although not to the point of forming large herds as goats do. The nuclear social unit is based around one to several females and their offspring. Other individuals may loosely associate with these groups particularly older adult males when females are in oestrus. Once their position is established, the feral pigs accompanying the Judas pig are either trapped or destroyed by shooting (refer to *PIG001 Trapping of feral pigs*, *PIG002 Aerial shooting of feral pigs* and *PIG003 Ground shooting of feral pigs* for further details on these methods of control). The Judas pig is usually allowed to escape so that it will search out other groups of feral pigs. Once eradication is achieved the Judas pig is located, then shot and the radio-collar retrieved (Sharp, 2012d).

The revised '*Standard Operating Procedure: PIG004: Use of Judas pigs*' (Sharp, 2012d) offers detailed advice.

6.5. Poisons

Poisoning with poison baits is a widely-used feral pig control method. Poisoning is also generally the most effective and lowest-cost control method.

Generally, the only toxin now used for feral pig control is sodium fluoroacetate (1080). The toxin 1080 has several advantages in that it is odourless and tasteless (increasing bait acceptability), kills most feral pigs reasonably rapidly (3–8 hours, average 4 hours) and biodegrades fairly readily in comparison to many other poisons, particularly when exposed to moisture/rainfall. Studies in the Fitzroy River region of north-western Australia observed signs

of very sudden collapse and death without kicking in feral pigs poisoned with fermented wheat containing 1080, suggesting the technique is relatively humane (Twigg et al., 2005, 2006).

Conversely, the toxins warfarin and yellow phosphorus (CSSP) are considered inhumane and strongly discouraged, due to the severe physiological distress these toxins cause poisoned feral pigs, and the tendency for these toxins to take several days to kill. The '*Model Code of Practice for the humane control of feral pigs*' (Sharp and Saunders, 2012) classifies warfarin and yellow phosphorus as inhumane and states they must not be used.

The revised '*Standard Operating Procedure: PIG005: Poisoning of feral pigs with sodium fluoroacetate (1080)*' (Sharp, 2012e) offers detailed advice on controlling pigs through 1080 poison baits. In particular, it is recommended to use a pre-feeding program with non-poisoned baits to allow an assessment of what types of animals (e.g. feral pigs or non-target animals) are eating the baits before poison is used. A pre-feeding program also ensures the maximum number of feral pigs take poisoned baits when they are put out (Sharp, 2012e).

The development of feral-pig-specific 1080 baits assists in reducing non-target species poisoning. The product PIGOUT® for instance, is a cylindrical bait pellet that is large in size (to prevent consumption by native animals smaller than feral pigs), has an internal poison core (to prevent small native fauna making contact with the 1080), a flavour/aroma formulation attractive to feral pigs, and a green colour to reduce their attractiveness to native birds. While colouring baits green discourages birds, nevertheless, birds and monitors do still consume (small) 1080 baits, introducing the risk of poisoning of these non-target species (Millar et al., 2014). The use of bait feeding dispensers designed to discourage or exclude animals other than feral pigs reduces non-target species poisoning. An example is the HogHopper™, a feeder box with heavy vertically-sliding doors, which allows feral pigs to gain access to the bait but which prevents non-target animals from accessing the bait. Similarly, in the Wet Tropics, the use of 1080-infused corn bait under light covers (that feral pigs can push aside) has effectively targeted feral pigs and reduced non-target species poisoning (Bengsen et al., 2011).

It is worth noting that bait selectivity issues have been documented in feral pig populations in some parts of Australia. In western Cape York, feral pigs, particular large boars, have been observed avoiding PIGOUT® style baits. In this area, oatmeal mixed with 1080 is proving more effective (Perry, pers. comm., 2014). Similarly, two studies on the effectiveness of 1080 baiting during dry seasons in the Fitzroy River region of north-western Australia found that fermented wheat and malted barley were the preferred baits. Lupins and commercial feral pig bait pellets were consumed in lesser amounts, indicating they are less acceptable/not acceptable to some feral pigs (Twigg et al., 2005, 2006).

In these studies, fermented wheat was prepared by soaking in equal parts of water for at least 24 hours. The inclusion of a small amount of blood and bone proved to be an attractant and became a standard additive. Fish oil was also tested but found not to be an attractant. At least several days pre-feeding with non-poisoned grain was found to be essential. Once poisoned grain was put out, bait take normally ceased with 1–3 days. Almost no native fauna ate the bait, except for several instances where wallaby/kangaroo species ate small amounts of bait. No dead native fauna were found during thorough searches for feral pig carcasses. These studies recorded effectiveness rates of 81–91% (i.e. estimated percentage of resident feral pigs in study sites killed) (Twigg et al., 2005, 2006).

Another study tested the palatability of five grain-based baits, and the effectiveness of preferred baits when treated with 1080, on feral pigs in the Mediterranean agricultural region of Western Australia. Wheat and malted barley were again the preferred baits, there was a variable response to lupins, and commercial feral pig pellets were consumed least. There was minimal evidence of bait take by non-target species, and, where this occurred, it generally involved the consumption of the fermented wheat 1080 baits by kangaroos (*Macropus* spp.) and foxes (*Vulpes vulpes*). Six foxes were known to have been poisoned during the study with 1080-treated grain baits. Excluding foxes, no other non-target animals, including native

species, were found dead during intensive searches for poisoned feral pigs (Twigg et al., 2007).

Some ranger groups in western Cape York (Northern Peninsula Area, Mapoon, Napranum, Pormpuraaw or Kowanyama rangers) are reluctant to poison-bait feral pigs due to concerns about off-target bait take and secondary poisoning from 1080.

A disadvantage with 1080 is that the standard dose used for feral pigs—72 milligrams per bait—is very large. For instance, the standard dose of 1080 for wild dogs is only 6 milligrams per bait. Other disadvantages with 1080 include a risk of secondary poisoning of scavengers of feral pig carcasses, bait-shyness in feral pigs that receive sub-lethal doses, and the possibility of poisoned feral pigs vomiting (this can create a risk of secondary poisoning to scavengers eating the vomit) (Choquenot et al., 1996; Lapidge and Eason, 2010; Sharp, 2012e). However, studies of 1080 baiting in the Fitzroy River region found 1080-poisoned feral pig carcasses had full stomachs, and failed to find pig vomit despite searches around all feral pig carcasses, indicating that very few 1080-poisoned feral pigs in their studies vomited (Twigg et al., 2005, 2006).

Sodium nitrite has been identified as a new feral pig toxin. It is being developed by the Invasive Animals Cooperative Research Centre into a poison bait called HOG-GONE®, which utilises the existing PIGOUT® bait matrix. It has been field-trialled successfully in Australia and the USA (IVMS, 2010; Lapidge and Eason, 2010), though it will be quite some time before it receives regulatory approval and becomes commercially available.

The development of sodium nitrite as a feral pig toxin will make feral pig control through poison both more targeted and more humane. Feral pigs are particularly susceptible to this compound, the symptoms it causes are moderate, and time to death is rapid. Sodium nitrite ultimately works by blocking the oxygen-carrying role of haemoglobin in red blood cells. The effect is to gradually deprive feral pigs of blood-borne oxygen, causing lethargy, rapid unconsciousness, and rapid death (Lapidge and Eason, 2010).

Sodium nitrite is also likely to reduce the rate of secondary poisoning in non-target animals and birds because:

- sodium nitrite and/or the HOG-GONE® bait matrix appears to repulse most marsupial species, including Bennett's wallaby (*Macropus rufogriseus*) and the Tasmanian pademelon (*Thylogale billardierii*)
- sodium nitrite doses required to kill are far higher than with 1080, so non-target species would need to consume more bait than with 1080 to receive a lethal dose
- sodium nitrite biodegrades very rapidly, thus making it unlikely that scavenging animals and birds will get a lethal dose from nitrite-poisoned feral pig carcasses, and
- sodium nitrite causes less vomiting in feral pigs than 1080, thus reducing a potential source of secondary poisoning.

6.6. Fencing

Fencing may be of value in some areas but it is expensive to erect and maintain. Electric fencing may have use for short-term control, for example to protect a small remnant plant population while regenerating. However, feral pigs seem to quickly recognise electric fences and will eventually crash through them if the incentive to reach food on the other side is sufficient. Standard fencing can be effective however if built robustly and regularly checked/maintained. Doupe et al. (2009, 2010) and Mitchell (2010) demonstrate fencing was effective in preventing severe feral pig damage to ephemeral tropical billabongs/wetlands, and protecting aestivating northern long-necked turtles from severe feral pig predation within these billabong/wetlands. Numerous Indigenous groups have also reported dramatic improvements in billabong/wetland condition after exclusion fencing.

6.7. Coordination with commercial harvesters

Commercial harvesting (for export to Europe) occurs mainly in northern New South Wales and southern Queensland. Usually, commercial harvesters of feral pigs operate where it is most profitable. Factors that affect the economic viability of harvesting include feral pig density, distance to processing facilities, ease of access for harvesters and chillers, disease status and condition of the animals, and the attitude of landholders to their operations. Harvest also varies with market conditions and seasonal factors. Consequently, harvesting operations may not coincide with those areas where feral pigs are believed to be threatening native species and communities.

A study of harvest operations of feral pigs on numerous sites in southern Queensland found that harvest rates were typically low (<50%), well below replacement levels, and consequently populations would quickly recover (Gentle and Pople, 2013).

6.8. Habitat manipulation

There is limited opportunity to manage feral pigs by manipulating the habitat. This is primarily based on taking advantage of feral pigs' need for access to water. Techniques can include preventing access to dams and closing off open bore drains. There is also the potential to restrict access of feral pigs to essential 'out-of-season' food sources such as crops or crop waste when natural food sources are depleted.

6.9. Bio-control methods

The Pest Animal Control Cooperative Research Centre investigated the potential for the biological control of feral pigs using an immuno-sterility approach. The Cooperative Research Centre (Peacock, 2003) concluded that this approach was not feasible for a number of reasons, including:

- the unacceptable risk that such a method would pose to the domestic pig industry
- the fact that inducing infertility in pigs has proven very difficult by any method, including chemicals—pigs have proven to be one of the least susceptible animals to fertility disruption, and
- the prohibitive cost of research and development.

Fertility control using bait-delivered fertility-controlling agents is also not viable for wide-scale control of feral pigs, primarily because there is no fertility-controlling agent available, and also because of the cost and difficulty of delivering any such fertility agent to a widely dispersed and highly productive animal (Choquenot et al., 1996).

A study by Quy et al. (2014) trialled a single-dose injectable immunocontraceptive vaccine (GonaCon™) on a small, localised feral pig population in woodland in the West Midlands region of England. This vaccine works by inducing the feral pigs' bodies to produce antibodies that targets and destroys the gonadotrophin-releasing hormone (GnRH), an essential hormone for reproduction. Ten sows and six boars were used in the trial, and effects of the vaccine were measured by blood analysis and movement tracking. The vaccine had some effect in boars, while in sows reproductive output was inhibited for 4–6 years. No obvious detrimental effects on physiology and behaviour were noted, and could be an appropriate control method for small populations where other control methods are not appropriate to be used. This technique is not applicable to feral pig control in Australia yet, given the feral pigs in this study had to be captured and injected by hand with the vaccine.

An Australian literature review of feral pigs impacts concluded that, despite recent international advances, fertility control is not likely to be available in a practical form for widespread use in Australia until anti-fertility drugs can be administered orally in a target-specific manner, and until fertility control can be demonstrated to produce consistent results in wild populations (Bengsen et al., 2014).

6.10. Animal welfare considerations

The need to consider the welfare of animals during animal control activities is now widely recognised. Each state and territory has animal welfare legislation that pest animal controllers are required to adhere to. Animal welfare groups and state and territory pest management agencies encourage well planned and coordinated strategies aimed at achieving a long-term reduction in the damage caused by feral pigs using the most humane cost-effective methods and strategies.

A national animal welfare code of practice that applies to feral animals, *Feral Animals and Livestock, Destruction or Capture, Handling and Marketing* was released in 1991 and updated in 2003 (SCAW, 1991; NCCAW, 2003).

The Model Code of Practice for control of feral pigs and the national Standard Operating Procedures for control of feral pigs were revised in 2012, and are available online at <http://www.pestsmart.org.au/pest-animal-species/feral-pig/>. These are supported by the Australian Government, and are an important guide for all feral pig management and control activities.

6.11. Approved methods of control by state and territory

The following table provides details on the methods of control available for use in each state or territory. Included are approved baits, approved trapping methods, use of exclusion fencing, other available methods, and animal welfare requirements. This table was compiled with information provided by states and territories and updated in 2014.

Table 1. Summary of approved methods of feral pig control by state and territory.

(Compiled by the Commonwealth Department of the Environment and Energy from comments and advice provided on request from state and territory agencies in June 2010, and 2014–2015.)

Methods of Control—Approved baits	
Australian Capital Territory	PIGOUT® 1080 baits, which are registered for use in Australian Capital Territory, or grain bait using 1080 concentrate registered for use in Australian Capital Territory.
New South Wales	Grain, pellets and registered manufactured products (currently PIGOUT®) are the only approved baits for use with 1080 concentrate poison under the 'Pesticide Control (1080 Liquid Concentrate and Bait Products) Order 2010' issued by the Office of Environment and Heritage's Chemical Policy Unit. Grain and pellets must be fed in bait stations, not piled or trailed on the ground, except in paddocks where stock are not currently grazing.
Northern Territory	PIGOUT® 1080 baits, fresh meat baits with 1080 (if injected by Parks and Wildlife).
Queensland	1080 recommended. Phosphorus-based poisons are available but not recommended.
South Australia	1080.
Tasmania	n/a
Victoria	Australian Pesticides and Veterinary Medicines Authority Registered products using 1080, or perishable baits made using 1080 Aqueous Solution Free-feeding prior to conducting a baiting program is recommended.
Western Australia	PIGOUT® 1080 baits, which are registered for use in WA
Methods of Control—Approved trapping methods	
Australian Capital Territory	As per the national Model Code of Practice and Standard Operating Procedures for feral pigs. Trapping is also regulated by the <i>Animal Welfare Act 1992</i> .

New South Wales	Standard cage traps of various designs including silo traps or heart shaped traps and cage traps with a number of designs for trap doors are common. Portable traps that can be lifted in by helicopter are used by the Office of Environment and Heritage (National Parks).
Northern Territory	Can be undertaken by landowners.
Queensland	Trapping can be undertaken.
South Australia	Trapping is permitted.
Tasmania	n/a
Victoria	Trapping can be carried out with traps allowed under the <i>Prevention of Cruelty to Animals Act 1986</i> and associated regulations.
Western Australia	Trapping is extensively used and there are numerous effective trap designs available. Trapping subject to animal ethics requirements. Traps should be built using designs approved by the Department of Agriculture and Food.
Methods of Control—Exclusion fencing	
Australian Capital Territory	Fencing is permitted.
New South Wales	Rarely used but may appear in heavily populated areas on the New South Wales north coast.
Northern Territory	Can be undertaken by landowners.
Queensland	Can be used. Electric fencing is recommended, but even this may not be effective if the feral pigs are habituated to the food source.
South Australia	Fencing is permitted.
Tasmania	n/a
Victoria	Exclusion fencing is allowed.
Western Australia	Fencing is used to protect <i>Reedia spathacea</i> in the south-west of WA, but is expensive and requires maintenance.
Methods of Control—Other methods	
Australian Capital Territory	Shooting is permitted.
New South Wales	Shooting. A Judas pigs are used by the Office of Environment and Heritage.
Northern Territory	Can be used if they meet the [Northern Territory] <i>Animal Welfare Act 2000</i> .
Queensland	Shooting, both ground and aerial is permitted.
South Australia	Shooting, both ground and aerial is permitted.
Tasmania	n/a
Victoria	Shooting, both ground and aerial is permitted.
Western Australia	Some ground shooting operations in the Walpole Wilderness area, south-west WA.
Australian Government	Standard Operating Procedures for Judas pigs.

Methods of Control—Animal welfare considerations	
Australian Capital Territory	Feral pig control carried out in accordance with national Model Code of Practice and Standard Operating Procedures and the [Australian Capital Territory] <i>Animal Welfare Act 1992</i> .
New South Wales	As per the national Model Code of Practice and Standard Operating Procedures for feral pigs.
Northern Territory	Feral animal management may only be undertaken if it complies with the [Northern Territory] <i>Animal Welfare Act 2000</i> .
Queensland	No specific state codes. Model Code of Practice for the Welfare of Animals: Feral Livestock Animals. National Model Code of Practice and Standard Operating Procedures.
South Australia	No specific state codes. National Model Code of Practice and Standard Operating Procedures.
Tasmania	n/a
Victoria	Tools and practices allowed under the <i>Prevention of Cruelty to Animals Act 1986</i> and Prevention of Cruelty to Animals Regulations 2008.
Western Australia	The [Western Australia] <i>Animal Welfare Act 2002</i> and Animal Welfare Regulations 2003 apply to feral pig control activities.
Australian Government	Australian Animal Welfare Strategy (2008). National Model Code of Practice and Standard Operating Procedures.

7. Regulation and management

The regulation and management of feral pigs, including control activities, is the responsibility of the states and territories in which they occur. It is each state's and territory's legislation that establishes the pest status of feral pigs and management responsibilities and considerations. These may include:

- setting priorities for natural assets for protection from feral pigs
- ensuring regional biodiversity management plans include relevant actions on feral pigs
- providing appropriate support, awareness and extension services for private landholders, Indigenous land managers, government land managers and community groups such as Landcare on the impacts and management of feral pigs
- conducting relevant studies to quantify the environmental damage due to feral pigs
- contributing to cross-jurisdictional or national committees on managing pest animal damage
- updating and modifying feral pig management strategies as appropriate, and
- ensuring that all control methods used to manage feral pigs comply with state/territory or national codes of practice, standard operating procedures and regulations.

The role of the Australian Government on feral pig issues is primarily to:

- provide Australian Government recognition, under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), that feral pigs are a key threatening process to many Australian ecosystems, fauna and flora

- disseminate knowledge to the public and relevant stakeholders on feral pig impacts in Australia, and
- to assist states and territories in the planning and coordination of feral pig management, particularly in regards to protecting ecosystems, fauna and flora of national environmental significance.

The Australian Government undertakes direct management of feral pigs on lands under its control, including Kakadu National Park and Defence lands.

7.1. The need for coordinated action

Feral pig populations and the environmental damage they cause are not confined to national parks. Approximately 87% of Australia's land and associated biodiversity lies outside of parks and reserves (Ritchie et al., 2013), often in private ownership. This coupled with the high mobility of feral pigs and their high reproductive potential, means that managing environmental damage due to feral pigs requires an integrated and coordinated approach, often across a variety of land uses. In most settings, plans to manage the environmental impact of feral pigs need to consider the concerns and needs of neighbours, particularly agricultural neighbours. Relevant stakeholders need to be identified early and be actively involved in the planning and implementation of the program. An integral part of designing a management program is to identify the range of issues and concerns about feral pigs and their management, including for those who use feral pigs as a resource.

Cowled et al. (2009) suggests current management units for feral pig control are often small and inadequate. The authors studied feral pigs from a 500,000 km² region in the rangeland of south-western Queensland and north-western New South Wales. The population structure was determined through the use of genotyping, which revealed five sub-populations. These sub-populations were moderately differentiated and had relatively high migration rates. The study concluded that generally management units for feral pig control in the rangelands should take into account geographical size and geographical features, especially major rivers in low rainfall areas.

7.2. Spread of feral pigs

Feral pigs can be highly mobile when conditions change, such as the drying of wetlands, and this can transfer or exacerbate the problems of predation, habitat degradation and disease transmission to new areas. Changes in land management may also provide increased opportunities for feral pig movement through increased water availability with farm dams or bores, and provision of suitable habitat or feed. Feral pigs' need for water however strongly limits their movement through arid country and their colonising ability over much of Australia.

It is suspected that a very small number of individuals are moving feral pigs and releasing them in new areas. Spencer and Hampton (2005) investigated the DNA of several feral pig populations in south-western Western Australia to look at the spread of feral pigs. They found that of the 269 feral pigs sampled, 12 individuals from three sites appeared to be immigrants. Ten of those individuals had DNA matching populations 200-400 km away and the other two had DNA matching a population 50 km away, with no evidence of genetic mixing of the feral pig populations in between.

Further research is needed into the natural and human-assisted spread of feral pigs in Australia and how this may be contributing to the problem of predation, habitat degradation and disease transmission.

7.3. Additional stakeholders

7.3.1. Local Government/pest management agencies

Local Government has a range of functions, powers and responsibilities at its disposal to influence feral pest management—on both private and public land—as public land managers

and as land-use planners. These include the power to place statutory controls on freehold land, implement pest risk control measures and act as a primary advocate for and coordinator of local community groups and interests. Local government also has a key role in translating the policies of Australian and state/territory governments into on-ground actions.

7.3.2. Community groups

Community groups can help reduce the environmental impacts of feral pigs by:

- ensuring feral pig control programs take account of local environmental plans and issues and, where appropriate, include best practice management
- assisting in identifying high priority areas for feral pig control
- cooperating and coordinating with government managers and other agencies and groups in strategic, coordinated feral pig control programs.

7.3.3. Private landholders (including Indigenous land managers)

Private landholders can help reduce the environmental impacts of feral pigs by:

- ensuring property management plans include best practice management of feral pig damage, where appropriate, but particularly in high priority areas with nationally listed threatened species and ecological communities
- cooperating with local/regional feral pig control programs
- providing input to local or regional databases on feral pig distribution and abundance.

7.4. Relevant State, Territory and Commonwealth legislation and practices

The table overleaf provides information on relevant state, territory, and Commonwealth legislation related to feral pigs and their status under this legislation. Agency and landholder responsibilities for feral pig control vary between states and territories and two sections of the table outline these responsibilities. Where cross-border arrangements are established, these are outlined, and finally, best practice requirements for feral pig control are listed. This table was compiled with information provided by states and territories in 2010 and updated in 2014.

Table 2. Feral pigs and relevant State, Territory and Commonwealth legislation and practices.
(Compiled by the Commonwealth Department of the Environment and Energy from comments and advice provided on request from state and territory agencies in June 2010, and 2014–2015.)

Relevant State, Territory and Commonwealth legislation	
Australian Capital Territory	<i>Pest Plants and Animals Act 2005 – feral pigs are declared as a pest animal but not notifiable or prohibited</i> <i>Animal Welfare Act 1992 – codes of practice for pest management</i>
New South Wales	<i>Local Land Services Act 2013</i> <i>Biosecurity Act 2015</i>
Northern Territory	<i>Territory Parks and Wildlife Conservation Act 2006</i> <i>Animal Welfare Act 2000</i>
Queensland	<i>Biosecurity Act 2014</i>
South Australia	<i>Natural Resources Management Act 2004</i>
Tasmania	No legislation
Victoria	<i>Catchment and Land Protection Act 1994</i> <i>Prevention of Cruelty to Animals Act 1986</i>
Western Australia	<i>Biosecurity and Agriculture Management Act 2007</i> <i>Animal Welfare Act 2002</i>

Australian Government	<i>Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)</i> Also: <i>Agricultural and Veterinary Chemicals Act 1994</i> (Agricultural and Veterinary Chemicals Code 1994) <i>Biosecurity Act 2015</i>
Feral pig status under State, Territory and Commonwealth legislation	
Australian Capital Territory	Declared Pest Animal under the <i>Pest Plants and Animals Act 2005</i> .
New South Wales	Declared Pest Animal under the <i>Local Land Services Act 2013</i> . A pest control order was issued in 2016 valid until 2021. It applies to all land in NSW.
Northern Territory	Feral Species under the <i>Territory Parks and Wildlife Conservation Act 2006</i> . Declared as a Feral Pest on the Tiwi Islands.
Queensland	Declared under the <i>Biosecurity Act 2014</i> .
South Australia	Declared Animal under the <i>Natural Resource Management Act 2004</i> .
Tasmania	Feral pigs are only found only on Flinders Island in Tasmania and are managed in accordance with the Feral Pig Management Plan Flinders Island (2002) . On mainland Tasmania, any pigs at large are considered to be domestic stock.
Victoria	Feral pigs and Pigs-Run-Wild (<i>Sus scrofa</i>) are Declared Established Pest Animals under the <i>Catchment and Land Protection Act 1994</i> .
Western Australia	Feral pigs are Declared Pests under the <i>Biosecurity and Agricultural Management Act 2007</i> .
Australian Government	Feral pigs are a declared Key Threatening Process under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
State/Territory agencies responsible for feral pig control and management	
Australian Capital Territory	Australian Capital Territory (ACT) Parks and Conservation Service, Territory and Municipal Services Directorate. Department of Defence manage some areas of National Land within the Australian Capital Territory and are responsible for management of feral pigs on that land.
New South Wales	Local Land Services. Office of Environment and Heritage (National Parks). Department of Primary Industries.
Northern Territory	Department of Land Resource Management. Department of Lands, Planning and Environment. Department of Primary Industries and Fisheries—administers the <i>Animal Welfare Act</i> .
Queensland	Department of Agriculture, Fisheries. Department of National Parks, Sport and Racing. Department of Heritage and Environmental Protection.
South Australia	Biosecurity South Australia, part of the Department of Primary Industries and Regions South Australia. Eight Regional Natural Resources Management Boards have responsibility for regional delivery of pest control programs. Department of Environment, Water and Natural Resources is responsible for pest control in protected areas and unoccupied crown land. Crown bound by the <i>Natural Resources Management Act</i> so agencies have direct land management responsibilities, e.g. South Australia Water, Forestry South Australia, Transport South Australia.
Tasmania	N/A

Victoria	<p>The Department of Economic Development, Jobs, Transport and Resources has the overall responsibility for policy for invasive plants and animals in Victoria, as well as the management of invasive plants and animals on private land.</p> <p>As landowners, the Department of Environment, Land, Water and Planning and Parks Victoria have responsibility for invasive plants and animals' management on their lands.</p>
Western Australia	<p>As landowners Department of Parks and Wildlife have responsibility for management of declared pest plants and animals on their lands.</p> <p>The Department of Agriculture and Food administers the legislation relating to declared pests.</p>
Australian Government	<p>Australian Government agencies responsible for issues relating to feral pigs: Department of the Environment and Energy, Department of Agriculture and Water Resources, Department of Defence.</p> <p>Under the EPBC Act, the Commonwealth must implement the feral pig threat abatement plan to the extent to which it applies in Commonwealth areas. These areas include Commonwealth national parks.</p> <p>Department of Defence land with feral pigs:</p> <p>Victoria: Puckapunyal Military Area, HMAS Cerberus Training School (Crib Point)</p> <p>New South Wales: Singleton Military Area</p> <p>Queensland: RAAF Base Scherger, Townsville training areas, Lavarack Barracks (including Mt Stuart), Tully, Cowley Beach, Tin Can Bay, Shoalwater Bay</p> <p>Northern Territory: Training areas at Bradshaw, Kangaroo Flat, Mt Bunday and Delamere Range facility.</p> <p>Western Australia: Yampi Sound Defence Training Area</p>
Landowner responsibilities for feral pig control	
Australian Capital Territory	<p>Rural landholders are responsible for managing feral pigs on their land. The Land Management Agreement the leaseholder signs for the leased land will stipulate that pest animals (including feral pigs where they occur) should be managed as part of any coordinated programs occurring in that area for a particular pest species. This may include actions required under a Pest Animal Management Plan prepared for feral pigs under the <i>Pest Plants and Animals Act 2005</i> (see above). At this time there has not been any Pest Animal Management Plan prepared for feral pigs.</p>
New South Wales	<p>Statutory obligation for land occupier to eradicate the pest by any lawful method. It is illegal to keep or transport live feral pigs.</p>
Northern Territory	<p>Declared as a feral pest on the Tiwi Islands, which means that in this location it is a requirement of landholders to actively manage feral pig populations.</p>
Queensland	<p>Under the Biosecurity Act 2014, there is a general biosecurity obligation to take all reasonable and practical steps to minimise biosecurity risks. A prevention and control program may also be authorised to manage a biosecurity matter.</p>
South Australia	<p>Landowners are required to be aware of declared pest species on their properties and take appropriate measures to control them. Feral pigs must not be released from captivity.</p>
Tasmania	N/A
Victoria	<p>Section 20 of the <i>Catchment and Land Protection Act 1994</i> states:</p> <p>"In relation to his or her land a land owner must take all reasonable steps to prevent the spread of, and as far as possible eradicate, established pest animals."</p>
Western Australia	<p>Under the <i>Biosecurity and Agriculture Management Act 2007</i>, landholders are required to control feral pigs (declared pests) on their properties.</p> <p>Any control option used must be in accordance with the <i>Animal Welfare Act 2002</i>.</p>
Australian Government	<p>The Commonwealth must implement the feral pig threat abatement plan to the extent to which it applies in Commonwealth areas.</p>

Cross-border arrangements and issues	
Australian Capital Territory	New South Wales National Parks and Wildlife Service are contacted prior to the annual Namadgi National Park feral pig management program in May to ensure coordination of any management of feral pigs occurring on adjacent National Parks and Wildlife Service estates.
New South Wales	Landholders with land either side of the Queensland border have difficulty understanding that control methods that are legal in Queensland such as 1080 meat baits are not legal in New South Wales under the New South Wales Pesticide Control Order for 1080 Concentrate.
Northern Territory	–
Queensland	No formal trans-border issues identified. Variation in control methods on either side of the New South Wales/Queensland border.
South Australia	Feral pig problems require good cooperation on cross border feral pig control programs between South Australia and Queensland, NSW and Victoria, particularly along river corridors where the rivers cross borders.
Tasmania	N/A
Victoria	No formal trans-border issues identified.
Western Australia	No issues with adjoining states of South Australia and the Northern Territory.
Best Practice Guidelines / Standard Operating Procedures / Codes of Practice	
Australian Capital Territory	Management is carried out in accordance with the national Model Code of Practice and Standard Operating Procedures.
New South Wales	New South Wales Department of Primary Industries has adopted the national Model Code of Practice and Standard Operating Procedures.
Northern Territory	Exotic Pest Animal Policy.
Queensland	Queensland Feral Pig Management Strategy.
South Australia	No South Australia-specific guidelines. South Australia follows the national Model Code of Practice and Standard Operating Procedures.
Tasmania	N/A
Victoria	Agriculture Victoria provides information to landholders about best practice management.
Western Australia	The Code of Practice for the Capture and Marketing of Feral Animals in Western Australia is supported by the [Western Australia] <i>Animal Welfare Act 2002</i> . The Southern Feral Pig Advisory Group also has a code of practice for community groups.
Australian Government	Model Code Of Practice for the Humane Control of Feral Pigs and associated Standard Operating Procedures are supported by the Commonwealth.

8. Economic impacts of feral pigs

McLeod (2004) estimated feral pig damage, in terms of total, national, economic costs (i.e. crop damage, control costs), at approximately \$106 million per year. McLeod (2004) also details a study monitoring feral pig damage to banana and sugar cane production in north Queensland between 2000 and 2002 (Mitchell and Dorney, 2002). Damage was determined from interviews with land holders and farm inspections. Feral pigs caused, on average, direct economic damage of \$1,800 per banana farm per year and \$5,350 per cane farm per year.

Feral pigs caused damage to 16,150 tonnes of sugar cane (valued at over \$377,000) or 5.65% of the sugar crop. There was no significant relationship between feral pig activity and the economic damage they caused for either banana or sugar cane farms. The total costs of feral pig damage and costs of control averaged \$4,100 per year for each banana farm and \$10,600 per year for each cane farm (Mitchell and Dorney, 2002).

Feral pigs preying on new-born lambs can be a significant problem in some areas of Australia. Gong et al. (2009) valued feral pig damage, in terms of economic surplus, at \$9.19 million per year. This was broken down into \$1 million for the lamb industry, \$2.32 million for the wool industry, and \$5.86 million for the grain industry. Gong et al. (2009) estimate production losses in the grain industry to be 1% at low feral pig densities, 2% at medium feral pig densities and 3% at high feral pig densities, and production losses in the wool and sheep meat industries through lamb predation to be 4% at low feral pig densities, 7% at medium feral pig densities and 9% at high feral pig densities. Predation on new-born calves has recently been reported in parts of the Gulf of Carpentaria (Carpentaria Land Council, 2015), but has not yet been studied or costed.

As discussed in Chapter 4, the economic impact of feral pigs would be severe in the case of outbreaks of exotic disease, particularly foot-and-mouth disease (FMD). ABARES has modelled the cost of hypothetical foot-and-mouth disease outbreaks in Australia. It estimated that two small foot-and-mouth disease outbreaks in Queensland and Victoria would result in revenue losses of between \$5.6 billion and \$6.2 billion (in present value terms) over 10 years, depending on the response strategy used. In the event of a large multi-state foot-and-mouth disease outbreak, ABARES estimated revenue losses of between \$49.3 billion and \$51.8 billion (in present value terms) over 10 years (Buetre et al., 2013).

Feral pigs are also at times the basis of a modest harvest industry. Most feral pigs harvested are exported as carcasses or meat cuts to Europe, where they are marketed as wild boar, though a small quantity is also used in the domestic pet food industry. Thus feral pigs can also represent a source of financial earnings, as well as a source of financial loss. Commercial harvesting of feral pigs has been undertaken in Australia since 1980 (Gentle and Pople, 2013). Commercial feral pig harvesting operations are restricted to those areas of New South Wales, Queensland and the Northern Territory where feral pig populations persist despite harvesting and management programs conducted by landholders and government agencies (Gentle and Pople, 2013).

The export industry is volatile. Feral pig export quantities have declined overall from 322,091 carcasses in 2001 to 75,056 carcasses in 2012. The 2012 exports added up to approximately 81 tonnes in weight and had an estimated value of A\$8.95 million (ABARES, unpub. data, 2014). Competition from European countries and unfavourable international exchange rates have reduced demand for Australian product in recent years and caused reductions in numbers of feral pigs harvested and prices paid. The industry has also been affected by the closure of processing plants. In 2013 it was uneconomical to export feral pig and very little export occurred (Gentle and Pople, 2013; ABARES, 2014; Gentle, 2014).

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APPENDIX A: STATE AND TERRITORY PRIORITY AREAS FOR PIG CONTROL

State and territory governments provided the following priority areas for feral pig control in 2010, as part of a review of the first threat abatement plan. Governments will be requested to update those priority areas as part of the implementation of the 2017 threat abatement plan. Those priority areas will be listed here when available.

1.

APPENDIX B: COMMONWEALTH LEGISLATION RELEVANT TO THREAT ABATEMENT PLANS

The following extracts from the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Environment Protection and Biodiversity Conservation Regulations 2000, which are relevant to the making of threat abatement plans, are provided for information only, and are not legal documents.

Content of threat abatement plans—*Environment Protection and Biodiversity Conservation Act 1999*

Section 271 Content of threat abatement plans

- (1) A threat abatement plan must provide for the research, management and other actions necessary to reduce the key threatening process concerned to an acceptable level in order to maximise the chances of the long-term survival in nature of native species and ecological communities affected by the process.
- (2) In particular, a threat abatement plan must:
 - (a) state the objectives to be achieved; and
 - (b) state criteria against which achievement of the objectives is to be measured; and
 - (c) specify the actions needed to achieve the objectives; and
 - (g) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).
- (3) In making a threat abatement plan, regard must be had to:
 - (a) the objects of this Act; and
 - (b) the most efficient and effective use of the resources that are allocated for the conservation of species and ecological communities; and
 - (c) minimising any significant adverse social and economic impacts consistently with the principles of ecologically sustainable development; and
 - (d) meeting Australia's obligations under international agreements between Australia and one or more countries relevant to the species or ecological community threatened by the key threatening process that is the subject of the plan; and
 - (e) the role and interests of Indigenous people in the conservation of Australia's biodiversity.
- (4) A threat abatement plan may:

- (a) state the estimated duration and cost of the threat abatement process; and
 - (b) identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan; and
 - (c) specify any major ecological matters (other than the species or communities threatened by the key threatening process that is the subject of the plan) that will be affected by the plan's implementation.
- (5) Subsection (4) does not limit the matters that a threat abatement plan may include.

Section 274 Scientific Committee to advise on plans

- (1) The Minister must obtain and consider the advice of the Scientific Committee on:
 - (a) the content of recovery and threat abatement plans; and
 - (b) the times within which, and the order in which, such plans should be made.
- (2) In giving advice about a recovery plan, the Scientific Committee must take into account the following matters:
 - (a) the degree of threat to the survival in nature of the species or ecological community in question;
 - (b) the potential for the species or community to recover;
 - (c) the genetic distinctiveness of the species or community;
 - (d) the importance of the species or community to the ecosystem;
 - (e) the value to humanity of the species or community;
 - (f) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.
- (3) In giving advice about a threat abatement plan, the Scientific Committee must take into account the following matters:
 - (a) the degree of threat that the key threatening process in question poses to the survival in nature of species and ecological communities;
 - (b) the potential of species and ecological communities so threatened to recover;
 - (c) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

Section 279 Variation of plans by the Minister

- (1) The Minister may, at any time, review a recovery plan or threat abatement plan that has been made or adopted under this Subdivision and consider whether a variation of it is necessary.
- (2) Each plan must be reviewed by the Minister at intervals of not longer than 5 years.
- (3) If the Minister considers that a variation of a plan is necessary, the Minister may, subject to subsections (4), (5), (6) and (7), vary the plan.
- (4) The Minister must not vary a plan, unless the plan, as so varied, continues to meet the requirements of section 270 or 271, as the case requires.
- (5) Before varying a plan, the Minister must obtain and consider advice from the Scientific Committee on the content of the variation.
- (6) If the Minister has made a plan jointly with, or adopted a plan that has been made by, a State or self-governing Territory, or an agency of a State or self-governing Territory, the Minister must seek the cooperation of that State or Territory, or that agency, with a view to varying the plan.
- (7) Sections 275, 276 and 278 apply to the variation of a plan in the same way that those sections apply to the making of a recovery plan or threat abatement plan.

Content of threat abatement plans—Environment Protection and Biodiversity Conservation Regulations 2000

Part 7 Species and communities

Regulation 7.12. Content of threat abatement plans.

For paragraph 271 (2) (g) of the Act, a threat abatement plan must state:

- (a) any of the following that may be adversely affected by the key threatening process concerned:
 - (i) listed threatened species or listed threatened ecological communities;
 - (ii) areas of habitat listed in the register of critical habitat kept under section 207A of the Act;
 - (iii) any other native species or ecological community that is likely to become threatened if the process continues; and
- (b) in what areas the actions specified in the plan most need to be taken for threat abatement.