THREAT ABATEMENT PLAN

Predation, Habitat Degradation, Competition and Disease Transmission:

Feral Pigs

Natural Heritage Trust
Helping Communities Helping Australia
An Australian Government Initiative

Australian Government
Department of the Environment and Heritage

THREAT ABATEMENT PLAN

for

Predation, habitat degradation, competition and disease transmission by feral pigs

Department of the Environment and Heritage

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Note
This threat abatement plan sets out a framework for reducing predation, competition and disease transmission by feral pigs to an acceptable level. The Australian Government is committed to acting in accordance with the plan and to implementing the plan as it applies to Commonwealth areas.
The plan has been developed with the involvement and cooperation of a broad range of stakeholders, but the making of this plan does not necessarily indicate the commitment of individual stakeholders to undertaking any specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

Foreword

Predation, habitat degradation, competition and disease transmission by feral pigs was listed in July 2001 as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A key threatening process under the EPBC Act is defined as a process that 'threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community'.

Under the EPBC Act, the Australian Government implements the Plan as it applies to Commonwealth areas, and seeks the co-operation of the states and territories and other stakeholders to implement the Plan as it applies to them. The Australian Government also supports this national effort by implementing key national level actions in the Plan, usually in partnership with other stakeholders. These key actions include research and demonstration projects to develop tools to help landholders and other managers be more effective in their on-ground threat abatement work.

Feral pigs have a serious impact on Australia's wildlife and habitats. They consume a wide range of native fauna and flora, such as reptile and bird eggs, frogs, earthworms, other invertebrates, fungi, roots and tubers. In this way they cause major ecological damage by competing with native fauna, and by helping weeds to replace native plants.

Threat abatement plans focus on strategic approaches to reduce the impacts of key threatening processes that jeopardise the long-term survival of native species and ecological communities.

To address this key threatening process, this Threat Abatement Plan has two broad goals:

- to protect listed threatened native species and ecological communities from the impacts of pigs
- to prevent the impacts of pigs from causing further species and ecological communities to decline so that they become eligible to be listed as threatened.

The Department of Environment and Heritage is very grateful for the assistance of the broad range of stakeholders who have contributed to the development of this Plan.

David Borthwick
Secretary
Department of the Environment and Heritage

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Executive Summary

The *Threat Abatement Plan for the Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs* (the Plan) sets out a national framework to guide coordinated actions to contain the spread of this threatening process and manage the impact on threatened species and ecological communities as listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Plan recognises that feral pigs are but one of a number of other factors that can impact on nationally listed threatened species and ecological communities. Successful management of the environmental threat due to feral pigs requires an integrated approach that also addresses a range of threatening processes and other sustainability issues associated with land management practices.

Feral pigs are common and widely distributed over large expanses of Australia. While their environmental impact is not well quantified, they appear to threaten the long-term survival of a number of species of native plants and animals across Australia. Their impacts may be direct through predation of native animals or consumption of native plants or less direct; for example they have been implicated in the spread of the root-rot fungus *Phytophthora cinnamomi.*

Eradication, that is the permanent removal of every last pig, with currently available technology, is not possible except on islands and in some local areas. Consequently, management needs to aim for sustainable control of the damage caused by feral pigs, based on current or realistically predicted levels of resources. Knowledge about the biology of pigs, their impact, distribution, social and economic consequences, regulatory controls, management techniques and strategies and research need to be considered.

The Plan recognises that community perceptions of feral pigs vary. Feral pigs are viewed as an agricultural pest, an environmental pest, an animal of cultural value, a food resource, a commercial resource, an endemic and exotic disease hazard and a recreational hunting resource. The Plan acknowledges this range of perceptions, and particularly the significant agricultural impacts of pigs. While the actions in the Plan will contribute to addressing agricultural impacts, the Plan does not set out to be comprehensive in that regard, as the reason for the plan is primarily to abate environmental impacts, in compliance with the EPBC Act. Some of the methods used to control feral pigs also raise animal welfare concerns. While the depth of concern and the range of groups with an interest will vary, a local or regional feral pig management plan is unlikely to be successful unless the full range of interests and concerns are identified and the relevant groups and individuals are fully consulted.

In most cases, managing feral pigs to control their impacts on biodiversity cannot be confined to conservation areas. Consequently, agricultural producers and other key groups and individuals will need to be involved for the successful development, implementation and monitoring of any management plan.

Five main objectives are proposed to manage the threat by feral pigs:

1. to prevent feral pigs from establishing in areas where they currently do not occur or are in low eradicable numbers, and where they are likely to pose a threat to biodiversity; especially where they would impact on nationally listed threatened species and ecological communities
2. to integrate feral pig management plans and their implementation into natural resource planning and investment at the regional, state and territory, and national level through consultation and liaison with key stakeholders
3. to increase awareness and understanding of land managers and the general community about the damage that feral pigs cause and management options
4. to quantify the impacts feral pigs have on biodiversity (especially nationally listed threatened species and ecological communities) and determine the relationship between feral pig density and the level of damage
5. to improve the effectiveness, efficiency and humaneness of techniques and strategies for managing the environmental damage due to feral pigs.

It is recommended that, where feasible, an adaptive management approach be adopted for managing feral pigs. The aim is to increase knowledge about the responses of ecosystems and take into account people's attitudes, and consequently, to progressively improve management programs. Critical elements of this approach are stakeholder consultation, models of how control activities and ecosystems interact, experimental design, monitoring of results, and ongoing review as understanding grows.

This threat abatement plan will be reviewed within five years of adoption.

Chapter 1 – Introduction

This Plan has been prepared to meet the Australian Government's obligations under the EPBC Act following the listing of Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs (*Sus scrofa*) in July 2001 as a key threatening process. Section 271 of the EPBC Act sets out the content requirements for a threat abatement plan (see Appendix 2 for the requirements under this section).

The Plan sets out a national framework to guide the coordinated implementation of the objectives and action considered necessary to manage the environmental damage caused by feral pigs to species and ecological communities affected by the process. The information in the Plan draws heavily on the major review publication on feral pigs and their management 'Managing Vertebrate Pests: Feral Pigs' Choquenot *et. al.* (1996). Managing Vertebrate Pests: Feral Pigs contains more detail on many of the issues raised in the Plan, and is a useful text for those developing management techniques and strategies.

The Plan recognises that feral pigs are but one of a number of land use and other factors that may threaten native species and communities. Successful management of the environmental threat due to feral pigs requires an integrated approach that also addresses a range of unsustainable land management practices and other threatening processes (Braysher, 1993; Choquenot *et. al.* 1996; Olsen, 1998; Agriculture and Resource Management Council of Australia and New Zealand and Australian and New Zealand Environment Conservation Council (ANZECC), 1999; Braysher and Saunders, 2003). Those developing regional or local plans, should also integrate aspects of the threat abatement plan with other relevant resource protection and management plans, such as Commonwealth, state and territory threatened species recovery plans, other threat abatement and reserve management plans, and catchment management plans.

The Plan recognises that community perceptions of feral pigs vary. Feral pigs are viewed as an agricultural pest, an environmental pest, an animal of cultural value, a food resource, a commercial resource and a recreational hunting resource. Some methods used to control feral pigs also raise animal welfare concerns. While the depth of concern and the range of groups with an interest will vary, a feral pig management plan is unlikely to be successful unless the full range of interests and concerns are identified. This would involve ensuring relevant groups and individuals are fully consulted, especially where management action cannot be confined to a conservation area. Usually management is undertaken on a broad scale that requires incorporating other objectives (such as reduction in exotic disease risk, and reduction in agricultural losses) as integral components of the plan to address the environmental damage due to pigs.

As for all of Australia's established pest animals, eradication or the permanent removal of the last feral pig is unlikely with currently available technology and practices, except possibly at the local level or on offshore islands (Bomford and O'Brien, 1995; Olsen, 1998; Braysher and Saunders, 2003). In most cases, management must aim for sustainable control of the damage due to feral pigs based on current or realistically predicted levels of resources. It must also reflect our current knowledge on the biology of feral pigs, their impact, distribution, social and economic consequences, regulatory controls, management techniques and strategies, and research needs (Braysher and Saunders, 2003).

1.1 Background

Feral pigs in Australia are a result of releases and escapes of various breeds of domestic pigs dating back to the 1700's (McIlroy, 1990). Population sizes and spread have been enhanced by escapes from domestic populations and the release of pigs for recreational hunting. Indeed, continued release of feral pigs for hunting, either in new areas or in areas that they do not currently occupy is a major threat to effective management of feral pigs and their damage. Feral pigs are widely distributed in Queensland, the Northern Territory, New South Wales and the Australian Capital Territory (Wilson *et al.* 1992; Choquenot *et al.* 1996). They are also now well established in the Kimberley, Central Coast and south-west of Western Australia (Twigg, 2003). There are isolated

populations in Victoria, Kangaroo Island in South Australia, and in Tasmania. There are estimated to be between 3.5 million and 23.5 million feral pigs, with a range across approximately 38% of mainland Australia (Hone, 1990). The range of the estimated population is so great not only 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 and control programs can halve feral pig densities than that found under more productive seasons (Giles, 1980), but feral pigs can recover their numbers at a rate of up to 86% a year with good seasons, a reproductive potential that is closer to that of rabbits than to other pests of a similar size (Choquenot *et al.* 1996).

Feral pigs are relatively intolerant of heat. Their distribution is therefore largely limited by lack of cover or access to free water. However, 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. A primary objective of the Plan is to clearly identify those areas where feral pigs may spread but where they currently do not occur, and to develop strategies to prevent their spread to these areas.

Chapter 2 – Environmental impacts attributed to feral pigs

The following assessment of the impacts of pigs builds on the advice from the Threatened Species Scientific Committee on listing of 'Predation, habitat degradation, competition and disease transmission by feral pigs' as a key threatening process under the EPBC Act.

Predation, habitat loss, competition and disease transmission by feral pigs includes the impacts on native ecosystems, flora and fauna due to the presence of feral pigs, their movement, rooting, wallowing, trampling, tusking or rubbing trees, and consumption of water, animals, plants and soil organisms. Feral pigs are found in all states and mainland territories of Australia, particularly in association with wetlands and riparian ecosystems. Ecological parameters affected include species composition, succession, and nutrient and water cycles. Impact can be direct or indirect, acute or chronic, periodic or constant, and may be seasonally influenced.

Feral pigs consume bird chicks, reptiles, reptile and bird eggs, frogs, soil organisms, earthworms and other invertebrates, carrion, underground fungi, fruit, seeds, roots, tubers, bulbs and plant foliage. Habitat changes due to feral pigs include: destruction of plants; changed floristic composition; reduced regeneration of plants; alteration of soil structure; increased invasion and spread of weeds; increased access for other predator species; reduced amount and quality of water available; spread of exotic earthworms; and creation of habitat suitable for disease vectors. They provide reservoirs for endemic diseases, can be vectors of exotic diseases, and have been implicated in spreading the root-rot fungus *Phytophthora cinnamomi*.

The Threatened Species Scientific Committee identified that this threatening process adversely affected at least eighteen nationally listed threatened species, including: two mammals (Northern Bettong *Bettongia tropica* and Long-footed Potoroo *Potorous longipes*); three frogs (White-bellied Frog Geocrinia alb, Orange-bellied Frog *Geocrinia vitellina* and the southern Corroboree Frog (*Pseudophryne corroboree*); three birds (Southern Cassowary *Casuarius casuarius johnsoni*, Black-breasted Button-quail *Turnix melanogaster* and Eastern Bristlebird *Dasyornis brachypterus*); one fish (Red-finned Blue-Eye *Scaturiginichthys vermeilipinnis)*; two turtles (Hawksbill Turtle *Ereimochelys imbricata* and Flatback Turtle *Natator depressus*); and seven plants (*Caladenia elegans*, *Eriocaulon carsonii*, *Phaius australis*, *Phaius tankervilleae*, *Pterostylis sp.* Northampton, *Ptychosperma bleeseri* and *Caladenia winfieldii*). Appendix 1 provides a collation of species identified in recovery plans as being affected or perceived to be affected by pigs, which varies slightly from the above list due to its origins.

Feral pigs cause approximately $100 million in agricultural damage in NSW and Queensland alone. The relationship between pig density and damage has been quantified for lamb production in NSW (Choquenot, 1999) and for grain in the Northern Territory (Caley, 1993). The effects of feral pigs on native species and natural ecosystems are not as clearly defined nor as easily measured, and there are few quantitative data on actual impacts. The relationship between feral pig density and the level of environmental damage is also unknown, an exception being the relationship between feral pig density and the extent of rooting in the southern highlands (Hone 2002). Consequently, the level of feral pig control required to achieve desired conservation outcomes is difficult to assess. A recent review (Hone, 2002) of 20 years research and management of feral pigs in Namadgi National Park, (ACT) concludes, "The research and management in Namadgi National park has not yielded much information on long-term impacts of feral pigs on specific plant animal species and communities, whether the conservation of any species (within the Park) is threatened by pigs, whether erosion is significantly increased by rooting, whether there are effects of pigs not related to rooting, such as from grazing and predation, and about non-target effects of baiting".

When reviewing the management of pest animals for the NSW National Parks and Wildlife Service, English and Chapple (2002) stated that the lack of reliable information was an important factor limiting effective management. Further studies are needed to review the level of impact on the species listed in Appendix 1 and other nationally listed threatened species and ecological communities, to lead to the development of integrated management activities that are better targeted and outcome driven.

2.1 Direct impacts

The most significant direct environmental impact that feral pigs have are habitat degradation and predation. However, there are few studies that provide good quantitative data on direct environmental impacts. It is important that these impacts are quantified so that the extent of damage can be more clearly understood and appropriate management strategies developed. Choquenot *et. al*. (1996), quoted a Northern Territory example where there was concern about the impact of pigs on lowland evergreen monsoon rainforests. The forests typically occur in small patches of about 0.5 square kilometres and are of high conservation value. However, a study by Bowman and McDonough (1991) showed that pigs mainly use the forests for shade during the day, and have only limited impact on them, because greater food resources are available in adjacent areas where the damage due to pigs was probably more significant. Similarly, extensive trampling, uprooting of vegetation or the ground by pigs, and the succeeding invasion of weeds, may be dramatic evidence of the presence of pigs, but may not necessarily be highly significant in terms of the long-term processes of plant dynamics or community structure.

Measuring or identifying environmental impact by feral pigs is difficult. In some cases their impacts may be direct or obvious, such as damage to turtle nests and eggs. While predation of the eggs by feral pigs is common, the impact of predation on annual recruitment of turtles has not been quantified. There is an intrinsically high juvenile mortality of turtles and other factors such as loss of adults through fishing by catch or loss of nesting sites, may be much more significant factors influencing the long-term survival.

Habitat damage by pigs is mostly due to their digging up of soils, grasslands and forest litter. Such disturbance can be locally extensive, such as in or around swamps and lagoons, and is often associated with sites modified by people, or close to roads, tracks and watercourses.

Mitchell and Mayer (1997), and Mitchell (2001) found that only 4.3% of the ground surface at 31 randomly selected sites throughout the Wet Tropics World Heritage Area of Queensland had been dug up and the digging was relatively confined. Approximately 70% of pig diggings were within ten metres of a road, track, surface water or a drainage line, particularly along watercourses (36%) and table drains (8%). Only 1% of the ground surface more than ten metres away from roads and watercourses had been dug up. Although not proven, there appears to be a strong correlation between digging damage and soil moisture (Hone, 1988; 1995; 2002), soil friability and probably the presence of large numbers of earthworms, other invertebrates and bulb-producing plants. However, the work of Mitchell (2001), did not demonstrate a significant ecological impact of pig diggings on earthworm populations, root biomass, soil moisture and litter biomass.

Similarly, Alexiou (1983) found that the areas of sub-alpine vegetation most susceptible to damage by pig digging at Smokers Gap, in the ACT, were along drainage lines, in depressions, and around grassy flats. Revegetation was slow and the dominant grassy vegetation, and some small native herbs, were greatly reduced in abundance at sites disturbed by feral pigs. Several native plants, however, became vigorous colonisers of damaged areas.

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).

Digging by pigs can adversely affect soil nutrient cycling and erosion, but the extent of this impact is not quantified. 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) or the lowering of water quality in other parts of Australia (Oliver *et. al.* 1992). 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).

However, a few 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 a main aim of some management programs as it is in Namadgi National Park in the ACT (P. Hann, *pers. comm*. Canberra, 1999). Hone (2002) showed that a large reduction in feral pig population is required to get a significant reduction in ground digging.

Feral pigs eat a range of native and exotic plants, including their foliage and stems, fruits and seeds, and rhizomes, bulbs, tubers, roots or other underground parts such as native fungi that are an important food source to small macropods such as bettongs. They also 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 had a contributory effect (McIlroy, 1993). The effect of pigs on rare or threatened plants and on plant succession in Australia, however, is not well known. The consensus of opinion is that feral pigs do not cause significant damage to, or eat, tree-ferns in the wet tropics of Queensland, in contrast to their behaviour in Hawaii and New Zealand (McIlroy, 1993). This may be because there are more palms for them to eat in the wet tropics of Queensland than in the other countries.

The extent to which feral pigs eat or disperse seed is unclear. There is evidence that they can spread some of the Weeds of National Significance either through their faeces or carried in their fur (McIlroy, 1993; Fensham, 1996; Lynes and Campbell, 2000). Feral pigs are likely to eat a much greater range of fruits and seeds than has been reported, but the viability of the seeds in pig faeces is not well known.

Although not quantified, there is some evidence that feral pigs may help spread root-rot fungus (*Phytophthora cinnamomi*), responsible for die-back disease in native vegetation. Although there is still no evidence of spread via the gut following ingestion of infected material (Masters, 1979), three of four feral pigs examined in Hawaii were found to be carrying the organism in soil on their hooves (Kliejunas and Ko, 1976). Pigs could also carry infected material on other parts of their body, particularly after wallowing when conditions favour the formation of zoospores (Masters, 1979). The spread of the fungus has also been associated with soil disturbance and reduction of litter cover by pigs (Brown, 1976). Pigs also chew or tusk the bark on buttress roots and lower trunks of trees, which might allow the entry of fungi.

Animals reported to be eaten by feral pigs include earthworms, amphipods, centipedes, beetles and other arthropods, crustaceans, snails, frogs, lizards, snakes, the eggs of the freshwater crocodile (*Crocodylus johnstoni*), turtles and their eggs, and small ground-nesting birds and their eggs (Tisdell, 1984; McIlroy, 1990; Mitchell, 1993; Roberts et. al. 1996). The New South Wales Government reports that pigs disturb waterbird-breeding colonies and eats chicks that have fallen out of their nests.

Pav Ecol (1992) found that feral pigs harvested over 95% of the available worms at paired quadrat sites in lowland ephemeral swamps near Cape Tribulation during April–July 1992. Mitchell (1993), in contrast, found identical numbers of earthworms in feral pig diggings and surrounding areas in the same general region south of Cape Tribulation. Frogs may also be a common food item for pigs in some areas. Richards et. al. (1993) suggests that 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, *Rheobatracus silus* (Miller WWF, 2003).

As for most pest animals, the damage caused by feral pigs is probably greatest where the organism under threat is confined to a relatively small area, such as an offshore island or a remnant habitat refuge. Miller and Mullette (1985) concluded that feral pigs were a major cause for decline in the Lord Howe Island woodhen (*Tricholimnus sylvestrus*). Feral pigs were eradicated from the island in 1985. A recent reassessment of the impact of feral pigs concluded that they may not have been as important as first thought in the decline of the woodhen (Harden, NSW NPWS *pers.comm*. 2003).

Feral pig impacts might be beneficial in some areas. Based on a study of feral pigs in flood plain marshes in central Florida, Arrington *et al.* (1999) concluded that while pigs can have detrimental effects on native biota and community structure, disturbance caused by feral pigs may in some instances enhance native plant species richness and associated micro habitat diversity in wetlands, at least in the short term. Possible beneficial impacts due to feral pigs have also been suggested by Osborne (pers. comm. 2003). Osborne suspects that while feral pigs may cause some damage to corroboree frogs, pig activity might help to keep open natural, and create additional, breeding pools for this endangered species.

The effect of pig predation on other invertebrates and small vertebrates in Australia needs further study, addressing such issues as what prey are actually eaten, the rates of predation, and the density and status of the prey. This also applies to their impact on larger ground-nesting birds, such as cassowaries, scrubfowl (*Megapodius reinwardt*) and brush-turkeys (*Alectura lathama*), despite reports of pigs destroying their nests and eating their eggs and young (Hopkins and Graham, 1985; Crome and Moore, 1990; Mitchell, 1993).

There is also insufficient information to evaluate the impact of feral pig competition with native animals for food. They could affect 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) suggests possible competition with brolgas (*Grus rubicundus*) and magpie geese (*Anseranas semipalmata*) for tubers and bulbs in northern Australia.

2.2 Less direct effects

Feral pigs may have significant impacts on biodiversity through less direct effects. For example, there are concerns that the dogs used by feral pig hunters in the wet tropics may take non-target wildlife such as the chicks of the endangered cassowary, as it is not possible for hunters to continuously control their dogs during hunting forays (Salleras, *pers. comm*. Community for Coastal and Cassowary Conservation, 1995).

Programs to manage pig damage to agricultural production may have detrimental impacts on the environment. For example, in some early pig management trials, cassowaries were caught in pig traps (Salleras, 1995). Where non-target animals such as cassowaries are at risk, traps have been modified to reduce the risk. Control of feral pigs because of their potential impact on native wildlife can also have unwanted detrimental impacts on other wildlife (Bryant, *in Press*). For example, feral pigs have been listed as a potential threat to the Northern Corroboree frog, *Pseudophryne pengilleyi* (ACT Government, 1997). Nearby sites also have populations of two nationally listed threatened species of rodents, the broad-toothed rat (*Mastocomys fuscus*) and the smokey mouse (*Pseudomys fumeus*). Most states and territories including the ACT undertake an appropriate assessment of non-target risks and, where appropriate, adopt precautions to minimise the risk (Bryant, *in Press*). Suitable precautions include surveys to determine if potential non-target species are present, free-feeding with unpoisoned bait to attract the target species and check that non-targets are not taking it, and using a bait and a method of presenting the bait that is attractive to feral pigs but less so to potential non-target species.

Chapter 3 – Factors that influence management of feral pigs

3.1 Resource value

The feral pig is regarded by some as a game animal and is most commonly taken by hunting on foot, with or without dogs, or from vehicles. Most hunters work on their own and some believe that they have a useful role to play in feral pig control. Both public and private landholders have concerns about some aspects of the hunting of feral pigs. These include problems with trespassing and property damage by hunters, stock harassment, and dogs left behind after hunting that later become a problem.

Commercial harvesting operations are restricted to those areas of NSW, Queensland and the Northern Territory where feral pig populations persist despite harvesting and management programs conducted by landholders and government agencies. Factors such as product demand, distance to chillers and disease concerns affect the extent of the industry and its value can vary considerably from year to year (Ramsay, 1994). In 2001, the value of wild boar exports was $24 million, compared with the gross value of Australia's pig meat industry in 2001, which was $800 million (Australian Bureau of Statistics, 2003).

Attitudes to the commercialisation of feral animals can vary according to the economic circumstances of rural communities, individual landholders and the prices paid for their carcases. For example, in 1993 when feral goats were worth $10 a head, they were generally regarded as a pest and most pastoralists wanted to reduce them to low densities, and if possible, eliminate them. Two years later their price increased to $30 a head and the attitudes of some landholders subsequently changed to seeing them as a valuable resource.

3.2 Community attitudes

Feral pigs are variously regarded an agricultural pest, an endemic and exotic disease hazard, an environmental liability, an export commodity and a recreational resource (Choquenot *et. al.* 1996). The status of feral pigs in any of these categories can vary with location, time and observer perception, and this could lead to conflict in developing and implementing management plans designed to produce biodiversity outcomes.

3.2.1 Perceptions

One area that requires further work in relation to managing the known impacts of feral pigs on biodiversity and agricultural production is to better understand the attitudes and beliefs that key groups have toward feral pigs, the damage they cause and if and how it should be managed. This needs to be a two way process, not just driven by governments in order to achieve a particular outcome, but aimed at coming to a shared understanding of the issues, concerns and expectations of government, private land managers and other key groups toward feral pigs and their management. The end result of this process should be the development and dissemination of a communication strategy that will assist key groups and individuals to be aware of and understand the issues associated with feral pigs and what can and should be done to manage them.

It is possible to work with groups otherwise opposed to feral pig management, involving the key people and groups at the local level in discussing and planning feral pig management programs. An example might be demonstrating to concerned local conservation groups that a modified feral pig trap does not trap cassowaries.

3.2.2 Indigenous communities

Feral pigs are found on some lands owned or managed by Aboriginal and Torres Strait Islander people. As for other Australians, there is no one attitude held by all indigenous groups (Roberts et. al. 2001). Attitudes vary considerably across the country and are changing with time. It is important to first identify and understand the local attitudes and issues when planning feral pig

management in a given region. Some of the issues and concerns are (Roberts *et. al*. 2001):

- Hunting and commercial harvest of feral pigs is often used by elders to encourage younger members into the field to teach them traditional knowledge and as a way of helping to maintain the kinship system, provide employment and additional cash flow to indigenous communities
- Feral pigs are an important dietary supplement to indigenous people in some remote areas
- For some groups such as Torres Strait Islanders, pigs are a traditional feast animal for ceremony
- 'Too many' pigs are seen as a threat, especially from the perspective of disease outbreak, for groups that run pastoral operations
- The damage that pigs may cause to traditional food sources (roots and tubers), to totemic species and to the cultural landscape.

3.2.3 Animal welfare

Animal welfare groups aim to protect animals from cruelty and improper exploitation, and encourage considerate treatment of animals. While there is a range of views held by such groups, in general they oppose control practices that cause animals unnecessary pain or suffering. Most animal welfare groups regard some of the techniques used to kill feral pigs, for example yellow phosphorus, as inhumane. RSPCA Australia and Animals Australia (AA) are concerned that many current pest animal control programs are implemented without prior quantification of the impact on the pest animal, or without regard to the likely success of the program in reducing the pest population in the long term. If feral pigs are to be controlled, welfare groups such as RSPCA Australia and AA expect the need for control to be clearly justified and the most humane approach used, with the aim to achieve long-term control. In assessing the need for using techniques, these groups consider:

- What is the justification for the control program?
  - In other words what is the extent of the environmental and agricultural damage and do the benefits of preventing the damage outweigh the costs of control?
- How effective and efficient is the control method?
  - The need for undertaking control is questioned if it will not result in long-term reduction in pest density or environmental and agricultural damage.
- How target specific is the technique and strategy?
  - For example, are other wildlife or domestic pets at risk from the technique either directly or indirectly?
- Is the proposed technique humane?
  - If not, have alternative control methods been considered or the technique applied in an appropriate and humane manner?
  - Techniques should be frequently reviewed to ensure the most humane methods are used.

The need to consider the welfare of animals is now widely recognised and each state and territory has enacted comprehensive animal welfare legislation that pest animal controllers are required to adhere to. In addition there is a national animal welfare code of practice that applies to feral animals, *Feral Animals and Livestock. Destruction or Capture, Handling and Marketing* (SCAW, 1991). This code is currently being reviewed by the National Consultative Committee on Animal Welfare (NCCAW, 2003). The Department is also funding two projects to develop and agreed code of practice and standard operating procedures for (i) the humane capture, handling or destruction of feral animals in Australia and (ii) the humane care and use of pest animals in Australia for the purposes of scientific research.

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 techniques and strategies. However, there are instances where short-term management may be the most effective strategy, for example, reducing feral pig density just prior to lambing.

3.2.4 Agricultural producers

Feral pigs are viewed variously by the agricultural community. Many view them negatively because of the damage they cause to livestock and crop enterprises, and also because of their potential role in an outbreak of exotic disease, such as Foot-And-Mouth Disease (FMD). Feral pigs have been identified as potential efficient vectors and harbours of several exotic diseases should these diseases ever become established in Australia (Pullar, 1950; Keast *et. al*. 1963; Geering *et. al*. 1995; Wilson and Choquenot, 1996; AUSTVETPLAN 2002). This has led to a considerable amount of Australian Government funds being allocated to feral pig research through the Wildlife and Exotic Disease Preparedness Program, from the mid-1980s to the present. However, there is strong evidence from outbreaks overseas that pigs may not play a role in the maintenance of FMD in the environment and that spread to domestic livestock is unlikely except where feral pigs are in high density. Only in these cases is broad-scale control of feral pigs in the event of an FMD outbreak likely to be necessary (Black, *in press*). Some producers that see feral pigs as a potential resource, especially when the game meat price is high and/or the price of agricultural commodities is low.

Chapter 4 – Control techniques

There is a range of techniques and strategies for managing the damage due to feral pigs. For more detail see Choquenot *et. al.* (1996); McIlroy and Gifford (1997) and Bryant (*In press*). When strategically applied using well planned and appropriately resourced programs, they have been very effective in reducing the damage due to feral pigs, especially in managing the feral pig damage to crops and lamb producers. Environment ACT has shown that feral pig density can be reduced and maintained at an acceptable density in a national park over several years (Hone, 2002). The most effective techniques for large-scale management are poisoning and aerial shooting. However, these techniques are less effective for managing feral pig damage in areas such as closed tropical forest where access is difficult and aerial shooting is not feasible. There may be further restrictions on some techniques, for example where non-target animals are at risk from the technique or in areas close to human habitation due to the restrictions on the use of 1080 poison. Managers need to select the appropriate technique or combination of techniques that best suit the local situation and habitat. A discussion of issues associated with some techniques follows.

4.1 Poisons

Poisoning using bait stations or, less commonly, through aerial baiting, is a common and effective control technique. While some conservation and animal welfare groups have concerns about using poisons, their specificity to the target animal can be greatly enhanced by free-feeding with un-poisoned bait to attract the target animal, using a bait that is less attractive to non-target animals and using the minimum amount of poison per bait to kill the target animal. The Pest Animal Control CRC in cooperation with several agencies is investigating several strategies to improve the target specificity and effectiveness of feral pig poisoning including target-specific delivery systems, development of additional feral pig baits and control strategies, and an evaluation of alternative feral pig toxins (Steve Lapidge, Pest Animal Control CRC, *pers. comm.* 2003). While these developments are primarily aimed at managing the damage feral pigs cause to agriculture, the resulting benefits will be directly applicable to managing the environmental damage due to pigs. Several poisons have been used for pig control. These include:

- Compound 1080. This is the most commonly used poison for feral pigs. Currently, there is no nationally approved alternative to this poison for feral pig control. The Australian Pesticides and Veterinary Medicines Authority (APVMA) is reviewing the registration of products containing 1080. The review is considering factors such as the persistence in 1080 baits and poisoned animals, the impact on non-target animals as well as animal welfare concerns (APVMA, 2002).
- Warfarin. While the use of Warfarin is declining (and only under scientific permit), it has an advantage over acute poisons such as 1080 in that there is an antidote and several doses are required to be effective, allowing programs to be stopped or modified if non-target animals are seen to be at risk. However, there is some doubt about the humaneness of this poison (Bryant, *In Press*).
- Yellow phosphorus or CSSP. Concerns have been raised on its use based on animal welfare issues (Choquenot *et. al.* 1996; Bryant (*In Press*). The APVMA is reviewing the approval and registration of products containing carbon disulphide which includes CSSP (APVMA, 2003).

4.2 Traps

Trapping is an effective technique for controlling pigs in some situations. However, it needs to be expertly applied, as pigs quickly become trap-shy if they suffer a near miss. There are some new advances in trap application. NSW National Parks and Wildlife Service is using auto feed and satellite signal traps in remote areas so that animals can be removed when trapped. Animal welfare groups consider trapping to be humane only if the trap is positioned in a sheltered area, is checked frequently, and the pigs are killed humanely.

Other studies are investigating increasing the effectiveness of traps using attractants, better baits and more effective trap design (Dorrington *et. al.* 2001).

4.3 Shooting

4.3.1 Helicopter shooting

Helicopter shooting is a widely used and highly cost-effective technique for feral pig control in south-eastern Australia and is used opportunistically to take pigs as part of the feral donkey control program in the Kimberley District of WA. The effectiveness of this technique is influenced by factors such as type of terrain, the amount of vegetation cover and flying conditions (Choquenot *et. al.* 1996). Most states have a detailed code of practice for feral pig control by aerial shooting that requires shooters to reach and maintain a high standard of accuracy and to use the appropriate grade of ammunition to minimise suffering to the target animal. For example, NSW requires all shooters participating in state supported aerial control programs to be trained and accredited under the Feral Animal Accredited Shooting Team (Bryant, *In Press*).

4.3.2 Ground shooting

Animal welfare groups consider a 'brain shot' by an experienced marksman to be one of the most humane techniques for killing feral pigs. However, except in special circumstances, ground shooting is not considered to be an effective technique for control of feral pigs because it is labour intensive and can be used only to target small groups of pigs. Shooting, especially where dogs are used, can be counter-productive to other techniques in that it can disperse pigs or make them more wary (Choquenot *et. al.* 1996).

4.4 Fencing

Fencing may be of value in some areas but it is expensive to erect and maintain. It is considered favourably on animal welfare grounds. 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.

4.5 Habitat manipulation

There is limited opportunity to manage feral pigs by manipulating the habitat. One area that may be useful is to take strategic advantage of the need for feral pigs to have access to water and cover from the direct sun in dry areas. For example, preventing access to dams, closing off open bore drains and removing essential cover. There is also the potential to restrict access of pigs to essential 'out-of-season' food sources such as crops when natural food is depleted.

4.6 Bio-control techniques

The Pest Animal Control CRC investigated the potential for the biological control of feral pigs, using an immuno-sterility approach similar to that being developed for rabbits and house mice, but concluded that it was not feasible, primarily because of the unacceptable risk that such a technique would pose to the domestic pig industry (Peacock, 2003).

Fertility control using bait-delivered fertility agents is also not viable for wide-scale control of feral pigs, primarily because of the cost and difficulty of delivering the fertility agent to such a widely dispersed and highly productive animal (Choquenot *et. al.* 1996).

4.7 Use of Dogs

Hunting with dogs is commonly used by recreational pig hunters. However, studies have shown that it is of limited value in reducing feral pig density on a large scale, (McIlroy and Saillard, 1989) although dogs may be of value in removing solitary animals after application of a broad-scale management program (Caley and Ottley, 1995). The success of hunting seems to vary with the amount of vegetation cover, the previous history of the pigs with dogs and hunters, and the skill and experience of the hunters. Also, there are animal welfare concerns with the use of dogs, not

only for the pig, but also for the injuries that dogs incur during hunting. There is also the risk that unrestricted use of dogs will disturb non-target species and simply scatter pigs, and hence be counter productive with respect to control. In addition, many landholders distrust volunteers and their value for pest control.

4.7.1 Wild dogs

It has been suggested that wild dogs may help to prevent a build up of feral pig numbers following an effective pig control program when pig density is low (Newsome *pers. comm.* 2001). However, the level of interaction is not known. Corbett (cited in Fleming *et. al.* 2001) found that dingo predation alone did not limit feral pig populations in the Northern Territory.

4.8 Coordination with commercial harvesters

Usually, commercial harvesters of feral pigs operate where it is most profitable. Factors that affect the economic viability of harvesting include pig density, distance to abattoirs, ease of access for harvesters and chillers, disease 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. In developing a management program, managers may consider commercial harvesters as one component of an integrated program.

Chapter 5 – Integrated & coordinated approach to management

5.1 Need for coordinated action

The damage that feral pigs cause is rarely confined to national parks. Approximately 70% of Australia's biodiversity is on non-reserved land, often on private land (Commonwealth of Australia, 1996). This coupled with the high mobility of feral pigs and their high reproductive potential means that managing the environmental damage due to feral pigs requires an integrated and coordinated approach, often across a variety of land uses. With the possible exception where management can be undertaken solely within a conservation area, plans to manage the environmental impact of feral pigs need to consider the concerns and needs of agricultural neighbours. Relevant stakeholders concerned with feral pigs need to be identified early and be actively involved in the planning and implementation of the program. Identifying the range of issues and concerns about feral pigs and their management, including those who use feral pigs as a resource, is an integral part of the process.

Without an inclusive, cooperative approach, there is unlikely to be ownership of the problem and the solution and hence effective management of the damage due to feral pigs is unlikely. Dorrington (2001) discusses the effectiveness of a cooperative approach in a community-based feral pig trapping program in the Queensland Wet Tropics.

There are several groups and agencies that are concerned with, or have responsibility for, feral pig management. Relevant stakeholders will vary with the location and will need to be identified for each proposed management program.

5.2 Range of planning documents

Ultimately, action to conserve or protect a species or community is developed and implemented at the local/regional level. However, feral pigs are but one factor that might be threatening native species and communities. Managing the impact of pests needs to integrated into the broader context of the strategies and policies for conserving Australia's natural biodiversity. Failure by pest managers to identify the full range of stakeholders and the relevant issues, restrictions and priorities that are operating at the national, state and local/regional level, can block or inhibit effective management of feral pigs and other threatening processes. A non-exhaustive list showing the range of planning and policy documents is shown in Table 1. Once the broader context for natural resource management has been determined, the documents and guides relevant to managing feral pigs can be used to plan and implement a locally developed and owned strategy that is consistent with and integrated into other local and regional programs.

Table 1: Range of Planning and Policy documents associated with Natural Resource Management and Feral Pig Management

Scale and scope	Natural Resource Management	Feral Pig Management
National	National Strategy for Ecologically Sustainable Development, National Resource Management Strategy; National Strategy for the Conservation of Australia's Biodiversity; national species recovery plans	Managing Vertebrate Pests: Feral Pigs; Threat Abatement Plan for Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
State/ territory	State/territory Sustainable Resource Management Strategy; Biodiversity strategies; species recovery plans	State/territory pest animal technique manuals; Threat Abatement Plans, and animal welfare legislation.
Regional Catchment	Regional management plans/catchment management plans	PESTPLAN

Local Government	Regional management plans	Vertebrate Pest Management Plan
Local Property	Property management plans/nature reserve management plans	As above

5.3 Setting priorities

There are unlikely to be sufficient financial and other resources to simultaneously and effectively manage the damage due to feral pigs across the whole area where they are considered to be a threat to native species. Managers therefore need to decide where to direct resources to get the most cost-effective return. Different approaches have been used for this process. For example, in the NSW *Threat Abatement Plan Predation by the red fox* (NSW NPWS, 2001a), those species that are most likely to be threatened by fox predation have been identified. Body mass, habitat use, spacing and anti-predator behaviour, mobility, and fecundity of threatened fauna species are used to rank the likelihood of fox impact; placing threatened species into categories (high, medium and low priority) to facilitate planning of control programs.

This approach to priority setting can be extended to feral pig management planning. Braysher and Saunders (2003) provide a structured guide that addresses the complex questions and issues to be considered about pests and pest-related problems. Management of the impact of the pest is set within the broader social and economic land management context. Their guide takes account of the conservation status and likely threat due to the pest, in an approach similar to that used for foxes in NSW. The guide may be a useful tool for planning feral pig control programs.

Chapter 6 – Increasing awareness and understanding

The wide range of perceptions and attitudes to feral pigs has been outlined above. A clear awareness and understanding of the problems that feral pigs cause, and what can and should be done about them, is essential to the effective management of damage due to feral pigs, although the extent and the depth of understanding required will vary. This not only applies to researchers and state and territory agencies, but to landholders and others concerned with natural resource management. It should not be a top down or a bottom up approach but a combination of the two.

6.1 Practitioners

State and Territory land management decision makers, pest management agencies, and managers of private and public land need to have an up-to-date knowledge on feral pigs and how best to manage them. This requires sharing relevant knowledge, including extensive but often unpublished knowledge gained through the experience of private and public land managers. The resulting information needs to be collated and made available to those that are involved with feral pigs and their management. There are several national initiatives in this area including:

- the strategies and principles for managing pest animal damage developed under the National Bushcare Program
- the Bureau of Resource Sciences feral pig guidelines, *Managing Vertebrate Pests: Feral Pigs* (1996)
- National Training Authority's Conservation and Land Management Training Package incorporating core competencies (skills and knowledge) for pest animal managers, developed under the auspices of the National Vertebrate Pests Committee
- computer–based education and planning guides for pest animal managers
- PESTPLAN, guidelines for setting priorities and developing management plans for pest animals.

This Plan is another important addition to this list along with complementary pest management strategies, plans, training manuals and programs that have been, or are being, developed at the state and territory level.

Relevant information needs to be packaged and disseminated in a format appropriate to the needs of the planners and managers. It also needs to be regularly evaluated and updated with new information.

6.2 The wider community

The wider community does not need to have the same depth of understanding of feral pigs and their management as practitioners. However, inaccurate or a poor understanding of the problems and issues can lead to unrealistic and inappropriate perceptions and expectations about feral pigs and their management. The resulting lack of support and pressures can detract from effective management. Governments at all levels have a major role in developing community understanding and awareness through appropriately packaged and targeted information. Non-government groups such as Landcare, industry groups and associations, animal welfare societies, hunting groups and conservation societies can also play an important role, 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 in areas where pigs could establish.

Chapter 7 – Roles and responsibilities

7.1 Australian Government

Under the EPBC Act the Australian Government has responsibility for implementing the Plan in Commonwealth areas, and for seeking the co-operation of states and territories for implementing the Plan outside Commonwealth areas. In addition to resources spent on feral pig management on Commonwealth managed land, the Australian Government also provides funding through the Natural Heritage Trust toward research and management of the environmental damage due to feral pigs. It has also funded studies to better understand the biology and ecology of feral pigs and to develop and demonstrate techniques and strategies to manage the economic damage due to feral pigs.

7.2 State and territory governments

State and territory governments can use the following strategies to help reduce the environmental impacts of feral pigs in the following ways:

- where appropriate, ensure that state and territory and regional biodiversity management plans include relevant actions on feral pigs
- provide 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
- contribute to national, state, and territory committees on managing pest animal damage
- set priorities for natural assets for protection from feral pigs
- implement and demonstrate best practice management of the environmental damage due to feral pigs
- liaise with local management groups such as Rural Lands Protection Boards (NSW) and their equivalents in other states and territories
- conduct relevant studies into the quantification of the environmental damage due to feral pigs
- update and modify feral pig management strategies as appropriate
- ensure that all control techniques used to manage feral pigs comply with state/territory or national codes of practice and regulations
- coordinate state and territory databases on nationally and state/territory listed threatened species and ecological communities and the effectiveness of management programs. This should include distribution and relative abundance of feral pigs and other key pest animal threats.

7.3 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 control developments, and 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 governments into on-ground actions (Australian Local Government Association, 2002).

Local governments can help reduce the environmental impacts of feral pigs by:

- ensuring that pest management programs, where appropriate, include strategic management of the environmental damage due to feral pigs

- participating in relevant state and regional natural resource planning and management committees
- liaising with, and advising, local landholders and community groups on best practice management of feral pigs
- coordinating local/regional information on feral pig distribution and abundance and the effectiveness of management programs in reducing feral pig environmental damage.

7.4 Community groups

The role of community groups in helping reduce the environmental impacts of feral pigs can include:

- ensuring that projects managing the impact on local biodiversity are consistent with the Plan and, where appropriate, include best practice management of the environmental damage due to feral pigs
- cooperating and coordinating with government managers and other agencies and groups in strategic, coordinated programs to manage the damage due to feral pigs and other pests
- once identified, implementing best practice management of feral pig impact in high priority natural areas.

7.5 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 priority areas for protection of nationally-listed threatened species and ecological communities
- cooperating with local/regional strategic programs to manage the damage due to feral pigs
- providing input into local regional databases on feral pig distribution and abundance.

Chapter 8 – Threat abatement objectives and actions

Goals

The Plan has two broad goals:

- to protect nationally listed threatened species and ecological communities from predation, habitat degradation, competition and disease transmission by feral pigs *and*
- to prevent further species and ecological communities from becoming nationally threatened or extinct due to predation, habitat degradation, competition and disease transmission by feral pigs.

These goals can be achieved by improving understanding of the threatening process and its effects on native species and ecological communities and strategic implementation of currently available management techniques (see Table 2 for a summary of objectives, actions and performance indicators for the Plan). A critical performance indicator will be the degree of security achieved for species and ecological communities that are currently or potentially threatened by feral pigs.

The Plan has five key objectives:

1. to prevent feral pigs from establishing in areas where they currently do not occur or are in low eradicable numbers, and where they are likely to pose a threat to biodiversity; especially where they would impact on nationally listed threatened species and ecological communities
2. to integrate feral pig management plans and their implementation into natural resource planning and investment at the regional, state and territory, and national level through consultation and liaison with key stakeholders
3. to increase awareness and understanding of land managers and the general community about the damage that feral pigs cause and management options
4. to quantify the impacts feral pigs have on biodiversity (especially nationally listed threatened species and ecological communities) and determine the relationship between feral pig density and the level of damage
5. to improve the effectiveness, efficiency and humaneness of techniques and strategies for managing the environmental damage due to feral pigs.

This plan represents a framework for feral pig management in Australia. Both government and non-government agencies will be involved with the implementation of objectives and actions in the plan and a threat abatement team (or equivalent) will be responsible for priority setting and recommending priorities for funding through the Natural Heritage Trust.

8.1 Preventing the establishment of feral pigs in new areas

Climate matching indicates that there are extensive areas that feral pigs could occupy, but they are currently absent or in low density (Braysher, 2000). This includes large parts of central and eastern Tasmania, Eyre Peninsula and south-eastern South Australia.

Objective 1.

To prevent feral pigs from establishing in areas where they currently do not occur or are in low eradicable numbers, and where they are likely to pose a threat to biodiversity, especially where they would impact on nationally listed threatened species and ecological communities.

Actions

- Identify those areas currently free from feral pigs or where they are eradicable, and where these areas overlay priority areas for nationally listed threatened species and ecological communities, and which are feasible to maintain free of pigs.

- Relevant agencies to verify, as far as is practicable, the presence or absence of feral pigs in priority areas.
- Relevant agencies to develop and implement strategies including surveillance monitoring and contingency plans to remove any pigs found in these priority areas. Where practicable, monitoring should be integrated into other monitoring programs where they exist.
- Awareness programs to be developed and implemented for key target groups (recreational hunters, bushwalkers and land managers) to ensure that they understand the risk should feral pigs establish in these priority areas.
- Review the adequacy and effectiveness of existing legislation and its implementation that aims to control the release, transport and keeping of feral pigs. Relevant jurisdictions to make appropriate amendments and develop best practice strategies to implement it where the review identifies inadequacies.

Performance indicators

- Where feral pigs are not currently a threat, but where there is potential for them to invade, the presence or absence of feral pigs has been verified.
- Key strategies to prevent the establishment of new populations developed and implemented.
- Feral pigs have not established in priority areas currently free from feral pigs.
- Priority small and isolated eradicable populations of feral pigs have been removed.
- Awareness programs developed in conjunction with relevant stakeholders and key target groups informed of the potential risks and what can and should be done.
- Adequacy and effectiveness of existing controls reviewed.
- Where found inadequate, amendments to legislation on the keeping, transport and release of feral pigs made by relevant jurisdictions.
- National best practice to control illegal movement and release developed.

8.2 Ensuring a coordinated and integrated approach

As discussed above, feral pig management needs to be integrated at the regional and local levels into the hierarchy of natural resource policy and planning programs through a process that includes identifying all relevant stakeholders concerned with feral pigs and actively involving them in the planning and implementation of the program.

Objective 2.

To integrate feral pig management plans and their implementation into natural resource planning and investment at the regional, state and territory, and national level through consultation and liaison with key stakeholders.

Actions

- The Department and relevant state and territory agencies to set out key concerns and issues to be included in Natural Resource Management plans.
- The Department and relevant state and territory agencies to establish protocols and use funding and other relevant mechanisms to improve the consistency and coordination of actions across tenures and jurisdictions.

Performance indicators

Feral pig management programs:

- integrated into relevant natural resource planning and management activities

- adopt a strategic, consultative and cooperative approach
- specifically address the impact on nationally listed threatened species and ecological communities in priority areas
- address other environmental threats in a strategic, coordinated and integrated manner.

8.3 Increasing awareness and understanding

Targeted and timely information about feral pigs, their impact and how best to manage them, needs to be provided to practitioners, including decision- and policy-makers in government agencies, to enhance their skills and effectiveness in planning and managing the environmental damage due to feral pigs. This information should include new research findings, management approaches and community views and attitudes towards feral pigs and their management.

Raising awareness and support of the broader community is essential to the effective management of the environmental damage due to feral pigs.

Objective 3.

To increase awareness and understanding of land managers and the general community about the damage that feral pigs cause and management options.

Actions

- Relevant government agencies to assess the adequacy of the available information and the needs of key groups concerned about feral pigs and their management.
- Government agencies to arrange the preparation, packaging and dissemination of appropriate material to target groups to promote awareness and understanding of feral pig damage and how best to manage it.
- Support the completion, dissemination and adoption of the pest management component of the Conservation and Land Management Training Package being developed by the National Training Authority.

Performance indicators

- Key groups and the information required identified.
- Information appropriately packaged and disseminated.
- Surveys show that key feral pig manager groups are aware and understand the biology and damage due to feral pigs. These groups should understand how to develop and implement effective plans to manage feral pig environmental impacts.
- The pest animal component of the National Training Authority Conservation and Land Managers Training Package adopted and disseminated.

8.4 Quantifying feral pig impacts on nationally-listed threatened species and ecological communities

While a number of studies point to the damage that feral pigs cause to nationally listed threatened species and communities, additional work is needed in this area to provide an improved understanding of the relationship between feral pig density and the level of environmental damage. Inadequate information is seen to be a major inhibitor to effective management of pest animal damage (English and Chapple, 2002). Examples of listed threatened species that are known or perceived to be threatened by feral pigs are listed in Appendix 1. Other animals threatened by feral pigs include some species of earthworms, endemic snails, frogs and some ground dwelling birds and mammals.

Objective 4.

To *quantify the impacts feral pigs have on biodiversity (especially nationally listed threatened species and ecological communities) and determine the relationship between feral pig density and the level of damage.*

Actions

- Relevant government agencies to identify priority areas where nationally listed threatened species or ecological communities are known or perceived to be under threat from feral pigs (as per species listed in Appendix 1).
- Develop and implement appropriate studies that aim to determine the impact of feral pigs on nationally listed threatened species and the level of feral pig control required to reduce the impact to an acceptable level. This is best undertaken through an adaptive experimental approach to management (see Box 1).

Performance indicators

- Identification of priority areas where listed threatened species or ecological communities are under threat from feral pigs.
- Impacts of predation, habitat degradation, competition and disease transmission from feral pigs on listed threatened species and ecological communities determined.

Adaptive approach to management

The damage that most pests cause and how best to manage them is poorly understood. For most pests, there is no 'sure-fire' approach for each situation and often there are limited resources and time to research the problem. In these cases the best management approach is to use each pest management program as an ongoing experiment from which to share, learn and build on existing knowledge held by all key stakeholders including private and public land managers as well as researchers. This is called adaptive management or 'learning by doing'. The key is to be specific about what each program is meant to achieve, to monitor progress and to evaluate results. In doing so it is important to realise that knowledge and insights can come from programs that fail to meet the desired result as well as from those that succeed. Adaptive management is particularly important given the diversity of situations that require control of the damage due to pest animals to be controlled. Flexibility is also important, that is, recognising the different circumstances and restrictions at each site and the need to adapt to changing circumstances or conditions.

Where practicable, an adaptive management approach should underpin the overall outcomes and objectives of management plans for pest animal control.

Adaptive management addresses the need to:

- accept that knowledge of the system being managed is always incomplete – not only is the science imperfect, but the system itself is a moving target, evolving due to the impacts of management and the expansion of the scale of other human activities
- develop an integrated experimental design that allows clear separation of the effects of as many factors as possible, so that a sensible balance of management tools and policies can be developed
- explore creative ways to set priorities for investing in research, monitoring and management.

If the adaptive management approach is to be used as the basis of a management plan, advice should be sought from groups or individuals with appropriate knowledge and experience in its use.

8.5 Improving techniques and strategies for managing feral pigs

Current procedures for feral pig control can achieve local control, especially in areas outside the tropics. Poisoning, if used properly and responsibly, can be highly effective in achieving a rapid population knockdown. There are concerns, however, about the potential non-target losses from pig poisoning programs, as well as animal welfare concerns. Other techniques such as aerial shooting and trapping can also be cost-effective, but not in all situations. For example, shooting from helicopters is limited to relatively open country. Similarly, trapping can be effective but its effectiveness is often highly variable. Season, trap type, site, and the type of bait lure used all affect trap-success. However, despite this plethora of approaches, current methods cannot effectively control the damage that feral pigs can cause to native wildlife in some areas such as remote, dense, closed tropical forest.

NSW Agriculture (Bryant *in press*) recently reviewed current and future options for broad-scale control of feral pigs in NSW. In addition, there are several studies aimed at improving the cost-effectiveness, target specificity and humaneness of techniques and strategies, primarily for managing the economic damage due to feral pigs (See section 4.1). These studies are very valuable and, along with the NSW review, provide an excellent basis for setting priorities for further studies on techniques to manage the damage due to feral pigs.

Objective 5.

To improve the effectiveness, efficiency and humaneness of techniques and strategies for managing the environmental damage due to feral pigs.

Actions

- In collaboration with private and government stakeholders, investigate and collate a list of current options for managing feral pigs, and assess the need for the development of more effective and humane techniques and strategies with special emphasis on managing feral pigs in priority areas for the protection of nationally listed threatened species and ecological communities.
- Relevant government agencies to assess techniques and strategies of feral pig control using these new approaches through an analysis of costs and benefits, safety, potential impact on non-target species, legal issues and any other practical considerations, and formulate a regional best-practice approach.

Performance indicators

- Available information collated and reviewed and inadequacies in effectiveness and humaneness identified.
- Innovative and humane techniques and strategies to control damage by feral pigs in priority areas for the protection of nationally listed threatened species and ecological communities developed.
- Appropriate management studies demonstrate the effectiveness and humaneness of new techniques and strategies.

Table 2. Summary of Objectives/Actions/Performance Indicators in the Pig TAP

Objective	Actions	Performance indicators
1.To prevent feral pigs from establishing in areas where they currently do not occur or are in low eradicable numbers, and where they are likely to pose a threat to biodiversity; especially where they would impact on nationally listed threatened species and ecological communities.	• Identify those areas currently free from feral pigs or in low eradicable numbers, and where these areas overlay priority areas for nationally listed threatened species and ecological communities, and which are feasible to maintain free of pigs.	• Where feral pigs are not currently a threat, but where there is potential for them to invade or establish, the presence or absence of feral pigs has been verified.
	• Relevant agencies to verify as far as is practicable, the presence or absence of feral pigs in priority areas.	
	• Relevant agencies to develop and implement strategies including surveillance monitoring and contingency plans to remove any pigs found in these priority areas. Where practicable, monitoring should be integrated into other programs where they exist.	• Key strategies to prevent the establishment of new populations identified and implemented. • Feral pigs do not establish in priority areas currently free from feral pigs • Priority small and isolated eradicable populations of feral pigs have been removed.
	• Awareness programs to be developed and implemented for key target groups (recreational hunters, bush walkers and land managers) to ensure that they understand the risk should feral pigs establish in these priority areas.	• Awareness programs developed in conjunction with relevant stakeholders and key target groups informed of the potential risks and what can and should be done.
	• Review the adequacy and effectiveness of existing legislation and its implementation that aims to control the release, transport and keeping of feral pigs. Relevant jurisdictions to make appropriate amendments to develop best practice strategies to implement it where the review identifies inadequacies.	• Adequacy and effectiveness of existing controls reviewed. • Where found inadequate, amendments to legislation on the keeping, transport and release of feral pigs made by relevant jurisdictions. • National best practice developed to control illegal movement and release.

Objective	Actions	Performance indicators
2.To integrate feral pig management plans and their implementation into natural resource planning and investment at the regional, state and territory, and national level through consultation and liaison with key stakeholders	The Department and relevant state and territory agencies to: • set out key concerns and issues to be included in Natural Resource Management planning/programs. • establish protocols and use funding and other relevant mechanisms to improve the consistency and coordination of actions across tenures and jurisdictions.	Feral pig management programs: • integrated into relevant natural resource planning and management activities; • adopt a strategic, consultative and cooperative approach; • specifically address the impact on nationally listed threatened species and ecological communities in priority areas; and • address other environmental threats in a strategic, coordinated and integrated manner.
3.To increase awareness and understanding of land managers and the general community about the damage that feral pigs cause and management options	• Relevant government agencies to assess the adequacy of available information and the needs of key groups concerned about feral pigs and their management.	• Key groups and the information required identified.
	• Government agencies to arrange the preparation, packaging and dissemination of appropriate material to target groups to promote awareness and understanding of feral pig damage and how best to manage it.	• Information appropriately packaged and disseminated. • Surveys show that key feral pig manager groups are aware and understand the biology and damage due to feral pigs. These groups should understand how to develop and implement effective plans to manage feral pig environmental impacts.
	• Support the dissemination and adoption of the pest management component of the Conservation and Land Management Training Package being developed by the National Training Authority.	• The pest animal component of the National Training Authority Conservation and Land Managers Training package disseminated and adopted.

Objective	Actions	Performance indicators
4. To quantify the impacts feral pigs have on biodiversity (especially nationally listed threatened species and ecological communities) and determine the relationship between feral pig density and the level of damage.	• Relevant government agencies to identify priority areas where nationally listed threatened species or ecological communities are known or perceived to be under threat from feral pigs as per species listed in Appendix 1. • Develop and implement appropriate studies that aim to determine the impact of feral pigs on nationally listed threatened species and the level of feral pig control required to reduce the impact to an acceptable level. This is best undertaken through an adaptive experimental approach to management (see Box 1)	• Identification of priority areas where nationally listed threatened species or ecological communities are under threat from feral pigs. • Impacts for predation, habitat degradation, competition and disease transmission from feral pigs on nationally listed threatened species and ecological communities determined.
5. To improve the effectiveness, efficiency and humaneness of techniques and strategies for managing the environmental damage due to feral pigs.	• In collaboration with private and government stakeholders, investigate and collate a list of current options for managing feral pigs, and assess the need for the development of more effective and humane techniques and strategies with special emphasis on managing feral pigs in priority areas for the protection of nationally listed threatened species and ecological communities.	• Available information collated and reviewed and inadequacies in effectiveness and humaneness identified. • Innovative and humane techniques and strategies to control damage by feral pigs in priority areas for the protection of nationally listed threatened species and ecological communities developed.
	• Relevant government agencies to assess techniques and strategies of feral pig control using these new approaches through an analysis of costs and benefits, safety, potential impact on non-target species, legal issues and any other practical considerations, and formulate a regional best practice approach.	• Appropriate management studies demonstrate the effectiveness and humaneness of new techniques and strategies.

Chapter 9 – Implementation, evaluation and review

The Department will facilitate implementation of the plan, encouraging involvement of key stakeholders and expertise. The Australian Government will implement the Plan as it applies to Commonwealth areas and act in accordance with the provisions of the Plan. The Australian Government will also seek the cooperation of the states and territories and other stakeholders in implementing the plan. Funds are available under the Natural Heritage Trust for the implementation of key national environmental priorities, such as the actions listed under this Plan, including for the on-ground implementation of actions identified in regional natural resource management plans.

The making of this plan does not necessarily indicate the commitment of individual stakeholders to undertaking any specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

The duration of the plan is initially for a five year period, but the duration of the threat abatement process is likely to be ongoing, as there is no currently feasible means of nationally eradicating feral pigs. In addition, the costs of many of the actions, such as regional control, will be determined by the level of resources that stakeholders commit to control of a pest that it appears can not at this stage be eradicated. The total cost of implementation of the plan over its lifetime therefore can not be quantified at the time of making.

Section 279 of the *Environment Protection and Biodiversity Conservation Act 1999* provides for a review of the Plan at anytime and requires that the Plan be reviewed at intervals of no longer than five years (see Appendix 2).

If evidence is found that the practices recommended in the Plan need to be updated or modified to prevent species becoming endangered or extinct, the Department will recommend to the Minister that the revision of the Plan is desirable earlier than five years.

Before the end of the five-year period, the Department will commission an independent person to review the Plan, the available technical information and the achievements of the recommended management actions undertaken. This review will also be conducted with close reference to key stakeholders, as identified in the development of this plan.

Recommendations from the review will be used to revise the plan for the next five-year phase.

Glossary

Ecological community	As defined in and listed under the EPBC Act. Means an assemblage of native species that: (a) inhabits a particular area in nature (b) meets the additional criteria specified in the regulations (if any) made for the purposes of this definition.
Endangered species	As defined in and listed under the EPBC Act. A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
Regional management plan	A strategic document that details species and ecological communities that are currently under threat or potentially under threat and the areas and high-level actions required to manage those threats.
The Department	The Australian Government Department of the Environment and Heritage
Threatened ecological communities	Refers to the Commonwealth list of threatened ecological communities divided into the following categories as per the EPBC Act: critically endangered; endangered; vulnerable.
Threatened species	Refers to the Commonwealth list of threatened native species divided into the following categories as per the EPBC Act: critically endangered; endangered; vulnerable; conservation dependent.
Vulnerable species	As defined in and listed under the EPBC Act. A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Weeds of National Significance	Twenty species form the Weeds of National Significance. Species that made the list were nationally prioritised on a detailed analysis of their level of invasiveness, current impact, potential for spread and socioeconomic and environmental aspects.

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Appendix 1 – Species threatened by feral pigs

Threatened species listed under the EPBC Act for which feral pigs are a known or perceived threat, as identified in a survey of recovery plans (note that recovery plans have not been prepared for all nationally-listed threatened species).

	Known Threat	
Scientific Name	**Common Name**	**Reference**
Mammals		
Zyzomys palatalis	Carpentarian Rock-rat	(Churchill, S. 1996)
Birds		
Casuarius casuarius johnsonii	Southern Cassowary	(Qld Parks & Wildlife Service 2001)
Dasyornis brachypterus	Eastern Bristlebird	(NSW NPWS 2001b)
Amphibians		
Geocrinia alba	White-bellied Frog, Creek Frog	(Wardell-Johnson, G *et al.* 1995)
Geocrinia vitellina	Orange-bellied Frog	(Wardell-Johnson, G., *et al.* 1995)
Mixophyes fleayi	Fleay's Frog	(Hines, H., *et al*. 1999)
Mixophyes iteratus	Southern Barred Frog, Giant Barred Frog	(Hines, H. 2001, *pers comm.*)
Rheobatrachus silus	Gastric-brooding Frog	(Hines, H., *et al.* 1999)
Taudactylus pleione	Kroombit Tinker Frog	(Hines, H. 2002)
Reptiles		
Caretta caretta	Loggerhead Turtle	(Env. Aus., 1998)
Eretmochelys imbricata	Hawksbill Turtle	(Env. Aus., 1998)
Natator depressus	Flatback Turtle	(Threatened Species Scientific Committee 2001)
Fish		
Scaturiginichthys vermeilipinnis	Red-finned Blue-eye	(Wagner, R. & Jackson, P. 1993)
Invertebrates		
Paralucia spinifera	Copper butterfly, purple	(NSW NPWS, 2001c)
Plants		
Ballantinia antipoda	Southern Shepherd's Purse	(Alexander, J.K 1999)
Burmannia sp (Melville Island)		(Liddle, D. pers comm. 1998)
Calonemorchis elegans	Elegant Spider Orchid	(Phillimore, R. *et al.* 2000)
Caladenia winfieldii	Majestic Spider Orchid	(Holland, E. *et al.* 1996)
Phaius australis	Lesser Swamp-orchid	(Benwell, A. 1994)
Phaius tancarvilleae	Swamp Lily, Greater Swamp-orchid	(Benwell, A. 1994)
Pterostylis sp Northampton.	Northampton Midget Greenhood	(Papenfus, D. *et al.* 1996)
Thelymitra manginii	Cinnamon Sun Orchid	(Phillimore, R. *et al.* 1999)
Cynanchum elegans	White-flowered Wax plant	(Matthes, M., & Nash, S. 1993)

Eriocaulon carsonii	Salt Pipewort; Button Grass	(Pickard, J. 1992)
Ptychosperma bleeseri	palm	(Conservation Commission of the Northern Territory 1994)

	Perceived Threat	
Mammals		
Lasiorhinus krefftii	Northern Hairy-nosed Wombat	(Threatened Species Scientific Committee, 2001)
Potorous longipes	Long-footed Potoroo	(Threatened Species Scientific Committee, 2001)
Bettongia tropica	Northern Bettong	(Threatened Species Scientific Committee, 2001)
Birds		
Turnix melanogaster	Black-breasted Button-quail	(Threatened Species Scientific Committee, 2001)
Amphibians		
Litoria lorica	Armoured Mistfrog	(Richards, S. *et al.* 1993)
Litoria nannotis	Waterfall Frog, Torrent Tree Frog	(Richards, S. *et al.* 1993)
Litoria nyakalensis	Mountian Mistfrog	(Richards, S. *et al.* 1993)
Litoria rheocola	Common Mistfrog	(Richards, S. *et al.* 1993)
Nyctimystes dayi	Lace-eyed Tree Frog, Australian Lacelid	(Richards, S. *et al.* 1993)
Spicospina flammocaerulea	Sunset Frog	(Roberts, D. *et al.* 1999)
Taudactylus rheophilus	Tinkling Frog	(Richards, S. *et al.* 1993)
Taudactylus acutirostris	Sharp-snouted Day Frog	(Richards, S. *et al.* 1993)
Pseudophryne corroboree	Southern Corroboree Frog	(Osborne, W. 1996)
Invertebrates		
Engaeus martigener	Furneaux burrowing crayfish	(Doran, N. 1999)
Plants		
Cullen parvum	Small Scurf-pea	(Muir, A., Victorian Recovery Plan 1992)

The New South Wales Government also identified the following threatened species and ecological communities as possibly impacted by feral pigs:

Boronia deanei, Goodenia Macabaronii, Lepidium monoplocoides, Pterostylis saxicola, Stemmacantha australis, Tetratheca juncea, Trachymene saniculifolia, Pseuodphryne pengilleye, Grassy White Box Woodlands, and Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions.

Appendix 2 – Threat abatement plan requirements

Relevant extracts from the EPBC Act 1999 relating to the requirements for developing Threat Abatement Plans.

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 maximize 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 the criteria against which achievement of the objectives is to be measured;and
(c) specify the actions needed to achieve the objectives and
(d) state the estimated duration and cost of the threat abatement process and
(e) identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan and
(f) specify the 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 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 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.

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 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 co-operation 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.

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