

## **Conflict, Uncertainty and Risk in Feral Pig Management: ~~The~~ Australian Approach**

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In spite of its relatively long history, the regulatory approach to feral pig management adopted by Australia has not been successful.

Our first objective in this paper is to analyse the Australian regulatory approach to feral pig management. This is to determine how it addresses the issues of conflict, uncertainty, risk and complexity which characterize feral pig management and to identify the reasons for its lack of success. Our second objective is to point out some of the implications of this analysis for the management of feral pig populations in countries where feral pig issues are comparable to Australia's.

*Keywords:* Feral pigs, management, Australia, conflict.

### **1. Introduction**

Conflict, uncertainty, risk and complexity characterize the management problem posed to land administrators and environmental and wildlife managers by feral pig populations.‡ Conflicts of interest arise because the pigs create agricultural and environmental damage while also providing recreational and commercial benefits. The animals are thus perceived as a pest (for example, by primary producers and conservationists) as well as a valuable resource (for example, by recreational hunters and commercial harvesters). Clearly, pest management principles, the objective of which is to limit pest damage through pest population controls, can seriously conflict with wildlife management

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‡ Feral pigs are domestic pigs which have escaped captivity and have established permanent wild, or feral, populations.

principles, the goal of which is to maintain the size of an animal population above a threshold level.

There is considerable uncertainty about the values of the basic parameters of this management problem. For example, the size of a feral pig, or wild boar, population, the extent of feral pig damage, or the extent to which a feral pig population would be a vector for exotic diseases are rarely known with any degree of precision. However, these are critical variables since variations in their value across their range of uncertainty will have significant consequences for management decisions.

Risk is another component of feral pig management issues in countries free of some contagious animal diseases (e.g. foot-and-mouth disease in Australia). There is an uncertain risk of introduction and outbreak of such exotic diseases in these countries; and, in the event of an outbreak, there is an uncertain probability that feral pigs would be a vector for these diseases.

The complexity of feral pig management problems stems from the number of actors involved (individual landholders, local agencies, regional agencies, national agencies, outdoor recreationists), the interrelatedness which exists between the actions of these actors, and the conflicting values held by these actors. A principal implication of this complexity is that there is no obvious general criterion of rationality upon which to base society's feral pig management decisions.

Different countries manage their feral pig or wild boar populations with more or less success, depending upon prevailing social norms, technology and the size of their feral pig population. France provides an example of relatively successful control. The French government relies principally on recreational hunting to cull its wild boar populations, and combines this strategy with an insurance scheme where farmers receive monetary compensations for wild boar damages (Boulloire, 1984).

Australia, a country characterized by a high feral pig to human population ratio, a very low human population to land ratio (and thus relatively high management costs), and where feral pigs are generally not a socially acceptable source of meat for human consumption, has adopted a regulatory scheme and has mandated eradication in most of its states. In spite of its relatively long history, this approach has not been successful, since estimates of the current feral pig population vary between 500 000 and 11 million animals (see following section).

To date, feral pig research in Australia has concentrated on various technical aspects of feral pig ecology and control. Only one exploratory economic assessment of the feral pig population has been undertaken (Tisdell, 1982).

Our first objective in this paper is to analyse the Australian regulatory approach to feral pig management to determine how it addresses the issues of conflict, uncertainty, risk and complexity, and to identify the reasons for its lack of success. Our second objective is to point out some of the implications of this analysis for the management of feral pig populations in countries where feral pig issues are comparable to Australia's.

## **2. Australian feral pig legislation and policies and their results**

The historical background of contemporary feral pig issues exemplifies the lack of empathy for the specificity of Australian environmental conditions which has characterized the human use of most natural resources in Australia since European settlement.<sup>1</sup> The Australian feral pig population started to increase as early as 1870, when it was customary to let domestic pigs roam freely in the bush during the day and to attract them back to their pens with some feed at night (Pullar, 1953). Such herd management practices led to the escape of so many pigs into the wild that, by 1895, the animals started

to be regarded as a nuisance. A regulation was then passed legalizing the shooting of feral pigs wandering on private lands (Pullar, 1953). However, since it was still financially rewarding to let pig herds run loose, the authorities kept advising new settlers arriving in Australia to adopt this practice (Pullar, 1950). The feral pig population was thus provided with a steady flow of new recruits until the 1950s, when the fencing of rural holdings put an end to this procedure.

Contemporary feral pig legislation and policy making in Australia is the responsibility of each state government. The Federal government has the power to enact feral pig legislation and to implement policies only in relation to international trade issues (Commonwealth of Australia Constitution Act, 1901). It has been involved in two such issues.

The first, which has concerned the Federal government since the 1970s, is the loss of export markets for Australian meat products which would result from an outbreak in Australia of an exotic disease such as foot and mouth disease (FMD). Feral pigs are considered to be a potential vector for the spread of FMD, on the basis of the evidence available from other countries (e.g. Donaldson, 1979). As a consequence, the Federal government is elaborating contingency plans for exotic disease outbreaks involving wildlife, including feral pigs (Wilson and O'Brien, 1989). In addition, a Vertebrate Pests Committee was created in 1974 by an agreement between Federal and State governments. This committee is responsible for advising a ministerial agricultural council about pest control, and for co-ordinating pest control activities throughout Australia. However, at this point in time, neither this committee nor the Federal government has developed a formal feral pig management plan or policy.

The second international trade issue in which the Federal government has been active concerns the passage of legislation in 1978 legalizing game meat exports, including those of feral pig meat [Commonwealth Exports (Meat) Regulations and Meat Industry Act, 1978]. This Act stipulates that only wild animals, shot while in their habitats, and transported as carcasses by certified transportation firms, can be exported as game meat. Since the Act became operative in 1979, Australia has started to export feral pig meat, primarily to Europe (see following section).

An examination of early State feral pig acts shows that legislation for controlling rabbits has been extended to encompass feral pigs without significant amendments. The differences and similarities in the current feral pig state legislations are summarized in Table 1. This table shows that feral pigs have the legal status of a pest in all but one state (Tasmania) and one territory (the Australian Capital Territory). In Tasmania, feral pigs occur only on one offshore island (Flinders Island), where they are held to provide good hunting opportunities for recreational hunters (Tasmanian Lands Department, pers. comm., 1987). The situation is very different in the Australian Capital Territory where the Department of Territories has considered feral pigs as a pest since the mid-1970s, in spite of the absence of regulations (Australian Capital Territory Department of Territories, pers. comm., 1987).

The two states where feral pigs have been declared a pest for the longest period of time, New South Wales and Queensland, are, not unexpectedly, those where pigs have

† This lack of empathy has been expressed thus: "... rare conservatory plants were commonplace, the appearance of light-green meadows lured squatters into swamps where their sheep contracted rot, trees retained their leaves and shed their bark instead, the more frequent the trees, the more sterile the soil, the birds did not sing, the swans were black, the eagles white, the bees were stingless, some mammals had pockets, others laid eggs, it was warmest on the hills and coolest in the valleys, even the blackberries were red, and to crown it all the greatest rogue may be converted into the most useful citizen: such is *Terra Australis*." (Martin, 1838, as quoted in Powell, 1976, pp. 13-14).

TABLE 1. Feral pig legislation in Australia

State	Earliest act; current act; feral pig (FP) status	Government authority administering the act	Responsibilities of landholders under the act	Policies of other relevant government agencies
Queensland	Stock Routes and Rural Lands Protection Acts 1930 Rural Lands Protection Act 1985 FP gazetted as vermin in 1945	Queensland Rural Lands Protection Board	Must eradicate FP on their lands	National Parks and Wildlife Service (NPWS): small attempt at controlling FP; acknowledges limited value of this attempt Forestry Department: attempts to eradicate
New South Wales	Pastures Protection Act 1902 Pastures Protection Act 1934 FP declared noxious in 1955	Department of Agriculture, plus 57 Pasture Protection Boards	Must eradicate FP; cannot have live FP in their possession; FP cannot be introduced in the state	Dept. of Environment and Planning: states that FP are not a concern of theirs Meat Industry Authority: considers that other departments are too lax in implementing the Act
South Australia	Vertebrate Pest Act 1975 Animal and Plant Control (Agricultural Protection and Other Purposes) Act 1986 FP "declared" in 1986	Animal and Plant Control Commission	Must control FP on their lands	Dept. of Environment and Planning and NPWS: controls by shooting. FP are not a serious problem Woods and Forests Dept: no policy

Western Australia	Vermin Act 1918-1973 Agriculture and related Resources Protection Act 1976 FP declared vermin in 1964	Agriculture Protection Board	Must eradicate FP; cannot have live FP in their possession; FP cannot be introduced in the State	Dept. of Conservation and Land Management: control SFP in public forests
Victoria	Vermin Destruction Act 1890 Vermin and Noxious Weeds Act 1958 FP declared vermin in 1973	Department of Conservation Forests and Lands	Must destroy FP if ordered to do so	Dept. of Agriculture and Rural Affairs and Dept. of Planning and Environment: no policy
Tasmania	Vermin Destruction Act 1950 FP are <i>not</i> declared under this Act	Department of Agriculture	None	Dept. of Environment; Forestry Commission: no policy NPWS: works with Department of Agriculture Lands Dept: No policy (FP provide "good hunting" and are "tolerated")
Northern Territory	Territory Parks and Wildlife Conservation Act 1984 FP declared pest in 1987	Conservation Commission	May be ordered to control or eradicate FP	None
Australian Capital Territory	Rabbit Destruction Ordinance 1919 FP are <i>not</i> declared under this Act	Department of Territories	None	Forestry Dept. no policy

Sources: Acts shown in second column and information obtained from a 1987 survey of relevant government agencies conducted for the purposes of this study.

been the most numerous. Feral pigs were first declared a “noxious animal” in two districts of New South Wales in 1936. More districts were progressively added to this list until 1955, when the animals were declared noxious throughout the state. A similar evolution took place in Queensland where feral pigs were first declared vermin in one district, in 1931 (see Table 1). By 1973, they were declared vermin over the whole state. In the other states, feral pigs were given the status of pests more recently. But, in these cases as well, pigs were first proclaimed a pest in the areas deemed most infected, then the legislation was extended over time to other districts, as infestation was perceived to spread, to finally cover an entire state (see Table 1).

Proclamation of “pest” (or “vermin”, or “noxious animal”) status has different legal implications in different states and has had different legal meanings over time. In Queensland, New South Wales, and Western Australia, proclamation means that the eradication of feral pigs is mandated by the relevant act (Table 1). In addition to eradication, it signifies that it is illegal to introduce feral pigs into Queensland and Western Australia, illegal to “keep” the animals in Western Australia, and that feral pigs can be kept and sold in Queensland only under prescribed conditions. In the Northern Territory and in Victoria, pest or vermin status means that pigs must be controlled, instead of eradicated (Table 1). Landholders in these states are required to destroy feral pigs on their lands, when so instructed by the relevant government authorities, and for a stipulated period of time. In South Australia, where feral pigs are not deemed to constitute a widespread problem, proclamation simply implies that landholders must, “as far as is reasonably achievable”, destroy feral pigs in order to decrease their numbers (Animal and Plant Control Act, 1986). (“Reasonably achievable” is not further defined in the Act).

The implications of declared pest status have also changed over time, as feral pig populations were perceived to increase and spread to new areas. In Queensland, the responsibilities of landholders have changed from having to control feral pigs on public roads and stock routes passing through a property (1930 Act), to having to keep one’s property free from feral pigs to such an extent as was “reasonably and economically possible” (1944 Act), to having to eradicate the pigs (1985 Act). The State of Victoria is currently considering enacting a bill (proposed Land Protection Bill, 1987) in which pest status will imply that public and private landholders must eradicate feral pigs on their lands, instead of controlling them. This proposed bill also makes provisions for the organization of pest destruction schemes by government authorities. The relatively recent proclamation of feral pigs as pests in Western Australia (in 1964), South Australia (in 1986) and the Northern Territory (in 1987) further illustrates the increasing reliance of state governments on mandated control or eradication as the principal, if not the only means of managing feral pig populations.

In all States and Territories, the legislation requires landholders to bear the financial burden of eradication or control activities. However, in three states and one territory, some financial assistance may be provided to landholders, at the discretion of the relevant government authorities. The Northern Territory may provide help with materials, equipment or labour to landholders. Loans at no interest can be granted to land users who are not financially able to destroy feral pigs in Victoria. In Queensland, free poisonous baits can be distributed to landholders, and the Western Australian government may offer financial help to private land users (the relevant acts are shown in Table 1).

In most states, the authorities which administer feral pig legislation have the power to prosecute non-compliers, or to undertake pig control activities on a non-complier’s

land, and to charge the non-complier for the costs of these activities. These authorities have also conducted a substantial amount, perhaps most, of the Australian feral pig research and offer extension services for feral pig control to landholders (e.g. advice about the technically best eradication strategy for a given property). In addition, most of these agencies undertake their own feral pig control operations, including regular helicopter shooting, poisoning, or pilot control schemes.

In spite of this broad range of activities and responsibilities, these authorities have not developed feral pig management or eradication plans. That is, they have not produced detailed guidelines concerning the strategies which can best be used in various locations under their jurisdiction for implementing specific feral pig management objectives. Furthermore, in some states, there are discrepancies between the broad management objectives adopted by feral pig management authorities and the relevant legislation. In Queensland and Western Australia, where eradication is mandated, the tacit management objective of the relevant authorities is to control feral pig populations rather than to eradicate them (pers. comm. with Western Australia Department of Conservation and Land Management and Queensland Rural Lands Protection Board, 1987). In the Australian Capital Territory, by contrast, the Department of Territories attempts to decrease pig populations down to "acceptable" levels, in spite of the absence of any feral pig legislation to that effect.

Government agencies which own land and manage the various land resources of each state (e.g. forestry departments, national parks and wildlife services) generally do not have feral pig management plans or policies for these lands. Some of these agencies unofficially acknowledge that the objective of their pig control efforts is to placate lobbying pressures.

Finally, it must be noted that, in most states, various acts focusing on other matters contain sections relevant to feral pigs. (The acts listed in Table 1 are thus the principal, but not the only, acts dealing with feral pigs). These acts are not always consistent in their treatment of feral pigs. For example, in Queensland feral pigs are simultaneously "non-protected fauna" (Fauna Conservation Act, 1974–1985), a "cane pest" (Sugar Experiment Stations Act, 1900–1983), "stock" (Stock Act, 1915–1986) and a "category A2 declared animal" (Rural Lands Protection Act, 1985). Each classification has a differing legal meaning. Such diverse terminology reflects the *ad hoc* development of the legislation and creates confusion about the intent of legislators. This confusion is increased by the fact that the legislation does not specifically address the issues of relevance to the feral pig meat industry (e.g. keeping, marketing, ownership of dead and live feral pigs), or recreational hunters, or exotic disease control problems.

It is impossible to quantify the effects of this purely regulatory approach to feral pig management. Estimates of past feral pig populations are not available, and recent estimates of the total feral pig population in Australia vary greatly. The lowest estimate is 500 000 pigs (McKnight, 1976) and the highest is 11 million (Flynn, 1980); this figure compares with a human population of 16 million inhabitants. Most researchers concur that the current feral pig population consists of several million animals (see Tisdell, 1982), which indicates that eradication has obviously not been achieved.

Figures 1 and 2 show 1953 and 1987 estimates of feral pig population density distributions. The notable increase in the geographical distribution of feral pigs between 1953 and 1987 is very likely to reflect an increase in pig numbers. (During that period, legislators and government authorities certainly perceived that such an increase was occurring.) Thus, not only has eradication been unsuccessful in the states where it has been mandated for decades, but also feral pig distribution and numbers have almost

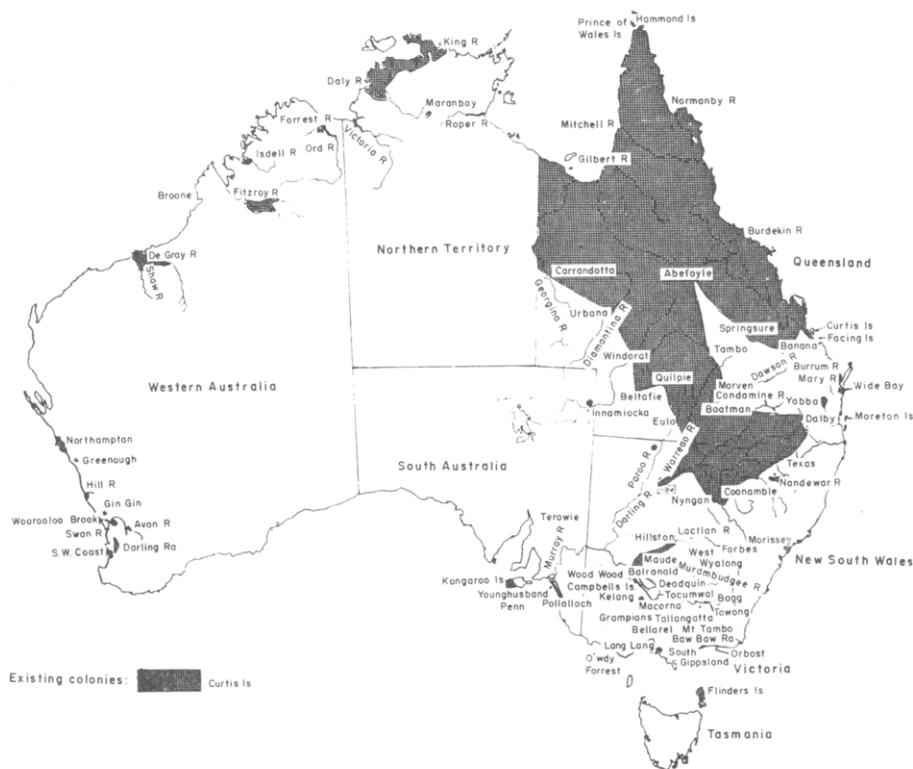


Figure 1. Distribution of feral pigs in 1953. Source: Pullar, 1953.

surely increased throughout Australia (with the exception of Tasmania) since the enactment of control legislation. The evidence indicates that prosecution of landholders who do not comply with mandated eradication is extremely rare, even though the government authorities which administer the legislation have prosecuting powers (Korn, 1987). There is, therefore, an obvious inconsistency between the stated objective of the Australian feral pig legislation and the way in which this legislation is implemented by governmental agencies. To determine why this is the case, and why this legislation has been ineffective, we now examine the technical and economic feasibility of feral pig eradication in the Australian environment.

### 3. Technical and economic feasibility of eradication from a social welfare perspective

To be successful and to be warranted from a social welfare perspective (i.e. from the viewpoint of society's welfare or well-being) eradication must be both technically and economically feasible. That is, it must be possible to eradicate feral pigs, given the available technology, and the benefits of doing so for society must outweigh the costs.

Just as technical feasibility is a relative concept, defined in relation to available technology, economic feasibility is a relative concept, defined in terms of the existing institutional structure. The costs and benefits of eradication for society will vary with changes in institutions and regulations. Our intent here is to survey these costs within the existing institutional framework only.



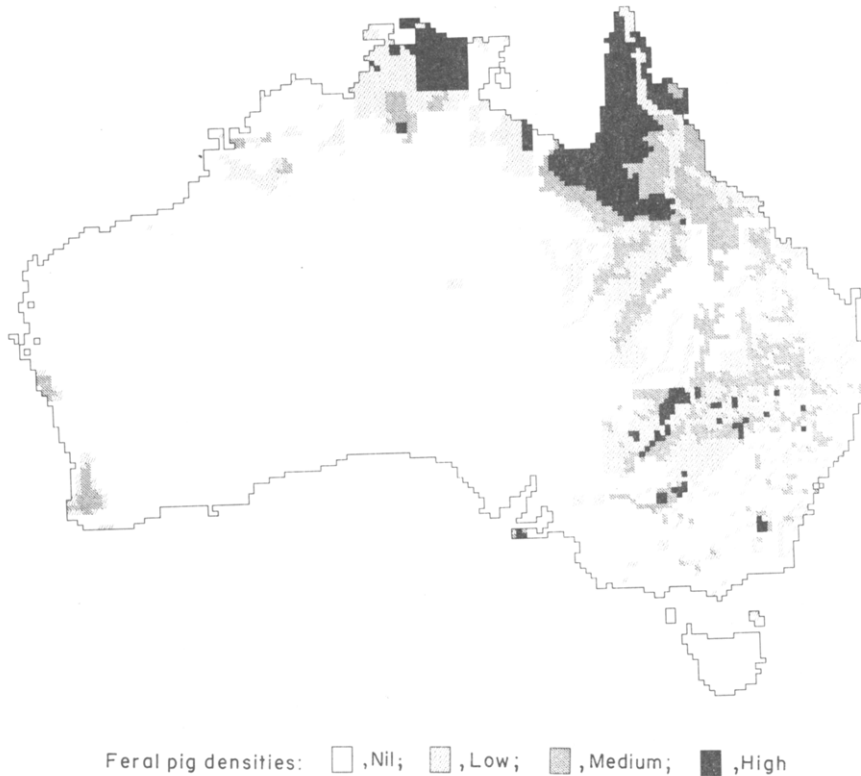


Figure 2. Distribution of feral pigs in 1987. Source: Bureau of Rural Resources, Canberra.

Past experiences with animal and disease eradication campaigns indicate that the technical feasibility of a feral pig eradication programme is determined by three principal factors. First, basic biological information regarding the size of the feral pig population, its geographical distribution, its intrinsic rate of growth, and the rate of offtake associated with various methods of removal must be available (Caughley, 1977). Second, there needs to be a method of removal of the animals which is completely effective (Yekutieli, 1980). Third, in the advanced stages of the eradication programme, the detection and surveillance of surviving feral pigs must also be entirely effective (Yekutieli, 1980).

None of these criteria of technical feasibility are met in Australia. The necessary biological information is not available; as already mentioned, even the total feral pig population is not known with certainty. Research regarding the effectiveness of various techniques for eradicating feral pigs has been undertaken for a number of years. However, no completely effectual removal technique has yet been developed. Likewise, no entirely efficient means of surveillance and removal of surviving feral pigs has been found. The vastness of the land area over which feral pig populations occur in Australia, its remoteness and low human population densities partly explain why this is the case.

Feral pig eradication is thus not technically feasible in Australia at this point in time, on the basis of the three criteria of technical feasibility just discussed. (This is probably why some government authorities have adopted a feral pig management objective different from eradication, even if eradication is mandated in their state). It is conceivable that changes in technology and/or increased investments in feral pig

research could render eradication technically feasible in the future. However, to be socially warranted, eradication must also be economically feasible, viz. its total benefits to society must be greater than its total costs.

The total costs to the community of a feral pig eradication campaign are equal to harvesting costs, campaign administration costs, surveillance and monitoring costs, the non-target environmental costs of the harvesting techniques employed, plus all the foregone benefits which are associated with the current feral pig population. These costs and benefits are discussed below.

The first three categories of costs include the direct financial costs of the chosen harvesting techniques and labour and equipment costs incurred by individual landholders, by the relevant government authorities (e.g. Pastures Protection Boards) and by the government agencies which manage public lands. These costs are difficult to measure, are not systematically recorded, and have never been evaluated.

Non-target environmental costs of eradication are principally those associated with the use of the poison 1080 (Sodium monofluoroacetate). The potential adverse impact of 1080 on wildlife has received some scientific attention, but once again no quantitative valuation has been attempted (e.g. Hone, 1983; McIlroy, 1983).

The other costs of eradication are equal to the benefits which recreational hunters and game meat exporters would have to forego if eradication were successfully completed. Only one investigation of recreational hunters of feral pigs has been undertaken. Tisdell evaluated the expenditures incurred by feral pig amateur hunters through surveys, and he concluded that annual gross expenditure by about 100 000 amateur pig-hunters are likely to be between A\$5 and A\$15m (Tisdell, 1982).

As mentioned in the previous section, the commercial harvesting of feral pigs is a relatively new export industry in Australia. During 1985, 123 566 feral pigs were harvested in New South Wales and Queensland; their estimated export value was A\$12m (G. Wilson, pers. comm.). There has been no systematic economic study of the industry, apart from Tisdell's preliminary study.

The total benefits of eradication to Australian society are equal to all the expected and potential damages avoided through eradication. That is, they are equal to the sum of all the agricultural, environmental and potential disease costs associated with the current feral pig population.

Although the adverse effects of feral pigs on the environment and on agriculture have long been known (e.g. Pullar 1950, 1953), they have been the subject of surprisingly little quantification or systematic study. As shown in Table 2, there have been very few studies of the physical damages caused by feral pigs to the agricultural sector, and only one of these studies resulted in a quantification of the damage, studied (viz. lamb predation and wheat crop losses). Tisdell (1982) has provided the only rough estimate of the financial cost of all agricultural damages due to feral pigs.

Environmental damages are even less well documented and quantified. European and North American studies have shown that feral pigs and wild boars have significant adverse environmental impacts (e.g. Jeziński and Myrcha, 1975; Singer *et al.*, 1981). However, only two, non-quantitative, studies have been conducted on the impact of feral pigs on the Australian flora and fauna (Hone, 1980; Alexiou, 1983). The various environmental damages which land administrators suspect to be caused by feral pigs include native flora and habitat destruction, competition for food with native fauna, predation on native fauna, soil erosion, weed and flora disease dispersal (such as dispersal of fungal dieback on trees).

Australia feral pigs have been found to carry several endemic diseases, viz.

TABLE 2. Evaluations of agricultural damages caused by feral pigs

Damage	Authors and area studied	Damage estimate
Lamb predation	Benson (1980) for Western New South Wales	7% reduction in marking
Adult sheep predation	Various anecdotal reports (Pullar, 1953; Moule, 1954; Rowley, 1970)	None
Pasture degradation through rooting	Hone (1980) for Tenterfield, New South Wales	None
Damage to fences and watering facilities through wallowing	No study (unquantified reports by land holders)	None
Sheep predation leading to mis-mothering	Pavlov and Hone (1982), site specific study	None
Damage to crops (wheat, oats, sorghum, maize, oilseeds, sugar cane, potatoes, rice, cotton, fodder crops)	Benson (1980) for Western New South Wales	5.6% reduction in wheat crop
All agricultural damages	Tisdell (1982), entire country	Rough estimate of \$75 million per year

leptospirosis, Q Fever, tuberculosis and echinococcus (Letts, 1964; Keast *et al.*, 1963; Corner *et al.*, 1980). However, the specific role played by feral pig populations in transmitting these diseases, and the consequent social costs, have not been determined.

The risks of exotic disease transmission which are associated with feral pigs and their related costs for the community are also poorly documented. Pigs are highly susceptible to a number of diseases which are not present in Australia, viz., FMD, classical swine fever, African swine fever, and rinderpest.

FMD is currently deemed to pose the greatest problem to Federal animal health agencies (G. Wilson, pers. comm. 1989). In the event of an outbreak stamped out immediately, foregone export earnings and related losses in revenues for the community would amount to about A\$3 billion (Johnston, 1982). Because they are abundant and widely distributed, feral pigs could play a major role in such an outbreak by delaying disease detection, increasing the rate and extent of disease spread, and complicating eradication. These factors would contribute to increasing the cost of an outbreak, and would delay international trade re-accreditation. Johnston (1982) estimated that an outbreak followed by a prolonged eradication campaign could result in a social cost of A\$4.1 billion.

Outbreaks of FMD have occurred in Australia over the past 100 years (Gee, 1982). A probability of occurrence of an outbreak could thus be estimated on the basis of this historical pattern. However, the likelihood of the disease affecting feral pig populations is not known (though it is likely to be relatively high because feral pigs are widely distributed in areas where contact with a FMD agent could easily occur and because the animals frequently live in close proximity to domestic livestock). It is thus impossible to evaluate the expected FMD costs imposed by the current feral pig population onto Australian society.

On the basis of the sparse and incomplete empirical evidence currently available, it is impossible to determine whether feral pig eradication is economically feasible in Australia. The total costs of eradication have not been evaluated and the corresponding total benefits are not known with certainty.

The lasting perception of feral pigs as a significant agricultural pest by some groups in society is probably accurate, but is not founded on any quantitative evidence of the damages caused by the pigs. Even the basic data needed to implement the legislation (e.g. feral pig population dynamics) have not been collected. The government authorities in charge of the implementation of Australian feral pig legislation (e.g. rural land protection boards, forestry departments, national parks and wildlife services) are partly responsible for this absence of information. These agencies have not attempted systematically to build up a body of information upon which to draw for implementing the feral pig legislation (e.g. evaluation of agricultural damages). As a result, the feral pig research and control activities which have been conducted and/or financed by these government agencies have been undertaken entirely *ad hoc*.

This poor data base can also be partly explained by the high costs of feral pig data collection in Australia. These costs have not been evaluated but it can be surmised that they are very high. This is because of the vast geographical distances, the very low human population densities, the extensiveness of agricultural activities, and the extreme remoteness of many environments which characterize Australia. In such conditions, operations such as pig counts, for example, become major and costly undertakings. In addition, some of these factors (e.g. low human population densities, extensive agriculture) also partly explain why the landholders who do not comply with the legislation are not prosecuted. Lack of compliance is very difficult (and thus very costly) to demonstrate in the Australian environment.

We have argued in this section that feral pig eradication is not presently technically feasible in Australia and that it is impossible to determine whether it is economically feasible from a societal point of view. Furthermore, we stressed that uncertainty about the social costs and benefits of eradication, and about the physical extent of damage and benefits associated with feral pigs is an intrinsic characteristic of feral pig issues in Australia. In the following section we examine whether eradication is economically feasible for, and therefore acceptable to, individual landholders.

#### 4. Economic acceptability of eradication from an individual perspective

The Australian feral pig legislation requires landholders to bear almost all the costs of their eradication or control activities. Both economic logic and the evidence available indicate that it is unlikely that such activities are financially viable for many, if not most, landholders.

Agricultural damages will probably increase at a decreasing rate as pig numbers increase on a given holding and at a given point in time, as carrying capacity is reached. This relationship can be represented graphically by the total damage curve  $OO'$  on Figure 3. Since the benefits of destroying feral pigs for a landholder are equal to the present and future (discounted) pig damages avoided, the total benefits of destroying pigs for this individual are  $O'O$  on Figure 3, where  $O'$  is now the origin of the axes.

The total costs of destroying pigs are likely to be an exponential function of the number of pigs destroyed. This is because as the population declines, the surviving pigs become more difficult to remove.

A landholder can then face one of the following four scenarios. First, the total costs of pig harvesting can be always greater than the corresponding total benefits, as shown

in Figure 4(a). In such a case, the best course of action for the landholder is to do nothing. Second, total benefits may be always greater than total costs [Figure 4(b)]. The best strategy is then to eradicate pigs on the property. Third, total costs and total benefits may intersect, as shown in Figure 4(c). In such a case destroying a small percentage of a population costs more than it benefits the farmer, and eradication is the

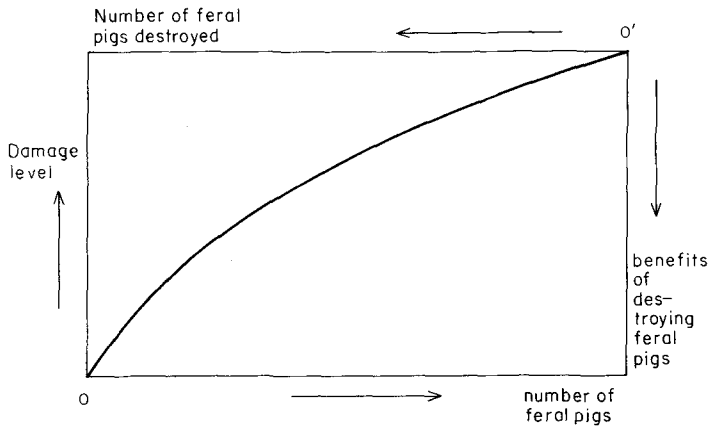


Figure 3. Total feral pig damage and total benefit of control curves for a landholder.

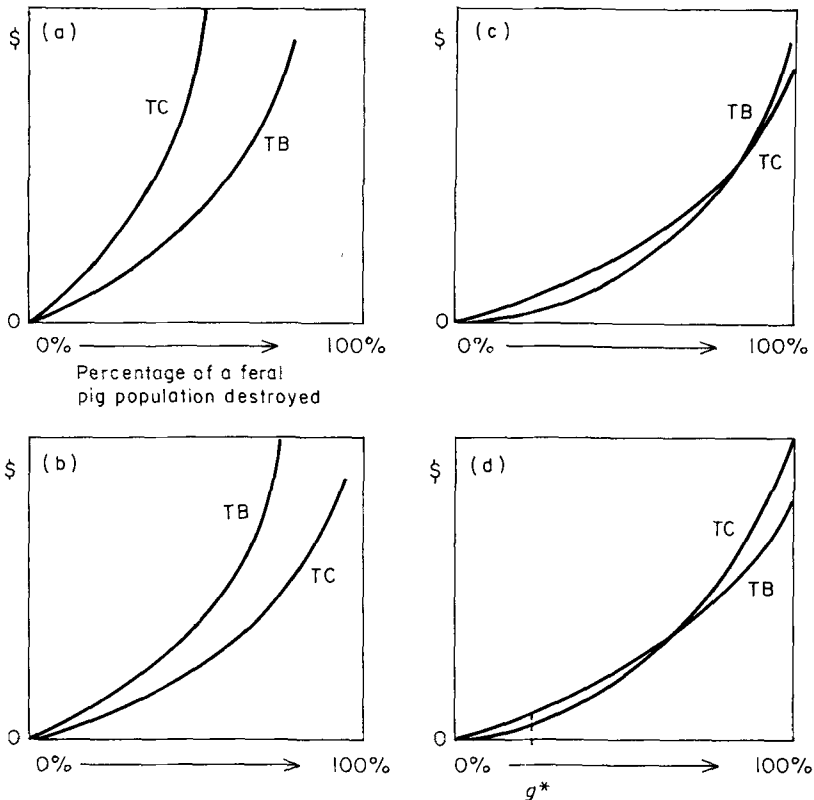


Figure 4. Total costs (TC) and total benefits (TB) of eradication: four scenarios.

strategy which maximizes net benefits to this individual. Finally, total costs and total benefits may intersect in such a way that benefits are greater than costs only during the initial period of harvest [Figure 4(d)]. In such a case, the best strategy is to destroy a percentage  $g^*$  of the pig population (at  $g^*$  net benefits are maximized).

Surveys of farmers and graziers in different pig infested areas show that pig damage on individual properties is universally perceived to be "extremely" high (though it is not quantified), but that landholders are generally not willing to undertake systematic eradication or exclusion (fencing) activities, because these are deemed to be too costly (Bryant *et al.*, 1984; South Australian Vertebrate Pest Control Authority, pers. comm. 1987). Even though these farmers could not estimate the amount of feral pig damage they incurred, they are nevertheless likely to have behaved rationally, in view of Figure 4, by refusing to carry out eradication activities.

These benefit and cost curves will change over time with changes in environmental and socio-economic conditions. For example, scenario 4(b) may be followed by scenario 4(d) on a given property if the damage created by feral pigs decreases during a dry season. Furthermore, the specific scenario confronting a farmer is also dependent upon the feral pig management strategies used by his neighbours. This is because feral pigs, as all wildlife, are a fugitive resource and are the object of non-exclusive, or common property rights. The fugitive and common property nature of feral pigs has two specific consequences.

First, the feral pig control level adopted on a property is affected through pig population dynamics by the management strategies chosen by adjacent landholders. Even if eradication (or  $g^*$  level of control on Figure 4) is in theory warranted on a property, it may not be rational to carry it out if adjacent landholders, over an area related to the home range of the pigs, do not also carry out the same strategy. If some adjacent landholders fail to eradicate their pigs, the eradication (control) efforts of an individual land user will not be successful. Pigs from adjacent properties will roam over the pig free property and cause damage, and may re-colonize it. Landholders who do not control their pig population thus generate a cost for other landholders who wish to eradicate (control) pigs on their lands in a given area, at a given point in time. Vice versa, landholders who do control pig numbers generate a benefit for their neighbours (Tisdell, 1982, makes a similar point). These costs and benefits are called here control externalities. As a result of control externalities, the level of feral pig control undertaken by individuals is likely to be sub-optimal from a social welfare perspective.

These control externalities mean, in addition, that individual land users have no financial incentive to engage in long-term feral pig control strategies. A landholder has some control over the feral pig numbers present on his property in the current time period. Local or regional eradication may even be attained by a few landholders at one point in time. However, because of control externalities, feral pig population dynamics and immigration, such localized eradication will be unstable over time. The smaller a feral pig population, the greater is its natural rate of increase until environmental carrying capacity is reached. Consequently, each individual landholder has little control over the total feral pig population present in an area over time. Thus, rational individuals will adopt a myopic, or short-term perspective when deciding upon a feral pig control strategy (see Feder and Regev, 1975, for a similar argument in the context of insect pest control).

In the presence of such intra and intertemporal externalities, voluntary collaboration among landholders, which is conceivably one way of overcoming regional pig control problems, is difficult to initiate and unlikely to persist. There are two reasons for this.

First, different properties are likely to have different feral pig damage functions, and therefore different “best” pig strategies, as shown on Figure 4, so that it will not be in the best interest of all landholders in an area to collaborate in a unified regional control effort. Second, different categories of landholders are likely to have conflicting pig strategies because their land use objectives are different. Landholders who are not primary producers, for example, may value highly the benefits of feral pig hunting, and may therefore use their lands as hunting reserves. In these conditions, it is not surprising to observe that, in general, landholders do not carry out their pig control strategies in a concerted manner, even if strongly encouraged to do so by feral pig control authorities (Bryant *et al.*, 1984, provide empirical evidence).

Another relevant consequence of control externalities is that it is difficult and costly for state governments to implement mandated eradication. It is almost impossible to determine if the presence of feral pigs on a property is due to poor control efforts on the part of the landholder or to intra- or inter-temporal control externalities. This fact partly explains why prosecution of landholders who do not comply with the legislation is so rare.

The second consequence of feral pigs being a fugitive common property resource is that it is very unlikely that individual landholders will take exotic disease risks and environmental damage into account when deciding upon their feral pig strategy. Individual evaluations of the total benefits of eradication are likely to exclude the benefits which a decreased exotic disease risk will generate for the livestock industries and the ecological benefits of foregone environmental damage. This is because the benefits associated with a decreased exotic disease risk and lower environmental damages are collective, and very difficult to estimate, whereas the costs of eradication or control which must be incurred to bring about such decreases are privately borne. Total benefit curves in Figure 4 will thus probably be undervalued by individual landholders, and the resulting level of feral pig control will be inferior to the level which is warranted from the viewpoint of society.

## 5. Summary and conclusions

Australia has dealt with conflicts, uncertainty, risk and complexity in feral pig management decisions by relying upon regulations. Since the enactment of the first feral pig acts, the animals have consistently been considered as agricultural pests by legislators who have largely ignored the recreational and commercial attributes of feral pig populations. The premise on which both past and present legislation have been based is that, the greater the number of feral pigs in a locality, the more landholders must be made responsible for controlling and eventually eradicating feral pigs. Government authorities responsible for feral pig issues have not developed feral pig management plans to facilitate the implementation of this legislation, nor have they given the legislation “teeth” by prosecuting landholders who are non-compliers. In the physical context of vast geographical distances, low human population, and high feral pig population densities, this reliance on regulations may *a priori* seem pragmatic. However, this approach has not been successful. Not only have feral pig populations not been eradicated, but the evidence also suggests that feral pig numbers have increased throughout the country, and particularly in the states where eradication was first mandated, some 40 years ago.

We identified various causes for the failure of this regulatory approach. First, we argued that eradication is currently not technically feasible in the Australian environ-

ment. It is impossible to determine whether eradication is economically feasible, from a social welfare perspective, because the relevant data are not available. We noted that uncertainty about this information is a characteristic of feral pig issues in Australia. Second, we showed that the likely relationships between the benefits and costs of eradication for individual landholders are such that eradication cannot always be financially justified for these individuals. We showed that intra- and inter-temporal control externalities result in local or regional eradication being unstable. This further reduces the likelihood of eradication being economically rational on an individual property. Furthermore, these externalities mean that co-operative eradication or control programs among landholders will be unlikely to be successful over time, and that landholders will probably adopt a short-term outlook when planning their individual feral pig management strategies. Finally, we demonstrated that the fugitive and common property nature of feral pig populations implies that individual landholders are likely to underestimate the benefits of the feral pig management activities they undertake.

The individual underestimation of the social benefits of control, the short-term planning horizon of most landholders and inter- and intra-temporal control externalities result in an individual level of feral pig control which is socially sub-optimal.

The different categories of agricultural and environmental damages caused by feral pigs and the exotic disease risk associated with feral pigs which are described in the contemporary literature were already acknowledged to be costs to the community several decades ago (Pullar, 1950, 1953). Likewise, the recreational and commercial attributes of feral pig populations have been recognized for many years (Pullar, 1953). However, the relative importance attributed to each one of these factors by various groups in society has changed over time. For example, there is probably more concern now among land administrators about the environmental degradation caused by feral pigs than there was some 40 years ago. Likewise, the potential export earning capacity of feral pig meat has recently received more attention from some federal agencies than it did in the past.

The regulatory approach to feral pig management chosen by Australia does not reflect this change in perceptions. Legislators have shaped the feral pig legislation in a way which only addresses the concerns of primary producers. (This is probably due to the facts that the agricultural sector has a relatively strong bargaining power, because of its high contribution to export earnings, and that mandated eradication is an inexpensive policy for the government since landholders are to bear most of the costs of the successful implementation of the policy). At best, this legislation may have fulfilled the goal of placating the demands of the farming community, at least in the short-term. However, the disregard for conflicting interests, the lack of recognition of the uncertainties which pervade the problem, the prosaic, and biologically naive attempt at abolishing feral pig related FMD risks, and the extreme oversimplification of the problem which all characterize the Australian legislation have led to its failure. This failure, in turn, when coupled with changing perceptions regarding feral pigs, has exacerbated conflicts between primary producers, recreational hunters and commercial harvesters, thereby bringing the vicious circle to a close.

In the words of two well-known analysts of institutions:

“The role of the legal system, including both common and constitutional law, is to provide a framework or process for conflict resolution and the development of legal rights. . . . Law is in fact both a mechanism for sanctifying what is perceived or advocated as tradition and a resource for facilitating what is perceived or advocated as desirable change” (Samuels and Mercuro, 1981, p. 219).



To ensure that the conflict resolution role of the Australian feral pig legislation is fulfilled, substantial changes need to be introduced in these regulations. The function of these changes would be to create congruity between socially desirable feral pig management goals and the actual results of the implementation of these management goals. We have shown that eradication is not an attainable goal within the current legislative framework. Under democratic ethics, new feral pig management goals would need to take into account the interests of all protagonists in feral pig issues, namely, primary producers, conservationists, recreational and commercial harvesters and relevant governmental agencies. This could be done, for example, through the identification of several geographically separated areas which would each be managed to accommodate the interests of a different group of protagonists (O'Brien, 1987). This concept of "separate facilities" has been used successfully to provide for the conflicting demands of diverse groups of outdoor recreationists (e.g., Izac and Ditwiler, 1985).

To be socially desirable, feral pig management goals should also lead to a socially acceptable distribution of the costs and benefits of management activities. The current regulatory approach requires landholders to bear almost all the costs of management, whereas the resulting benefits are borne by other groups in society as well (e.g. conservationists). Some cost sharing principle could be developed, for example, to ensure the acceptability (and economic feasibility from an individual perspective) of the new feral pig management goals.

Mechanisms for the implementation of such goals would need to take into account inter- and intra-temporal control externalities and uncertainties regarding the value of basic economic and biological parameters. This implies that the management plans adopted should be flexible, in order to enable decision-makers to systematically and regularly review the content of feral pig regulations in the light of their results. An iterative decision-making algorithm based on bounded rationality and on trial and error could be used fruitfully to develop such management plans. By explicitly taking into account the conflicts, uncertainty, risk and complexity of feral pig management, this approach would be more likely to result in the effective management of Australian feral pig populations than the current trend towards increasing reliance on mandated eradication. For as Bertrand Russell noted:

"Science tells us what we can know, but what we can know is little, and if we forget how much we cannot know we become insensitive to many things of great importance. Theology, on the other hand, induces a dogmatic belief that we have knowledge where in fact we have ignorance, and by doing so generates a kind of impertinent insolence towards the universe. Uncertainty, in the presence of vivid hopes and fears, is painful, but must be endured if we wish to live without the support of comforting fairy tales" (Russell (1945) *Introduction to a History of Western Philosophy*, as quoted in Whipple, 1987, p. 529).

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