FERAL GOAT

# Feral Goat (*Capra hircus*) in Queensland

**PEST STATUS REVIEW SERIES - LAND PROTECTION**

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# Contents

# 1.0 Summary

Feral goats (Capra hircus) are found in all states and territories (with the exception of mainland Northern Territory) of Australia. The majority of feral goats in Queensland are found in the pastoral areas of the south-west of the states. Feral goats are a declared pest in Queensland under the Rural Lands Protection Act 1985.

Feral goats can cause major agricultural and environmental damage. They compete with domestic stock for pasture, damage fences and reduce the profitability of pastoral and agricultural industries. Feral goats also cause environmental damage through competing with native fauna for food, enhancing soil degradation and overgrazing. Feral goats also pose a potentially serious disease risk to native and domestic animals.

Feral goats are harvested as a resource, primarily for meat, with benefits accrued to landholders and the associated meat industry. The export industry of live feral goats and feral goat meat has increased substantially throughout the 1990's.

The control methods used regularly in south-west Queensland are mustering, trapping and shooting. Exclusion and biological control are alternative methods but, depending on circumstances are difficult, inappropriate, expensive or yet to be fully investigated.

# 2.0 History

Goats, *Capra hircus*, have been part of the Australian landscape since 1788 when they were introduced from England with the First Fleet. These goats were used as a source of meat, milk and fibre (Rolls 1969).

Goats were introduced into Queensland when the State was colonised in the early 1800's.

Feral goat populations established after the deliberate release or escape of domestic stock. Many isolated properties kept goats for milk, meat and beasts of burden. Goats held on properties were often kept in a semi-feral state, being free to forage during the day and return to holding yards at night. This freedom allowed the domestic goats to mingle with or form feral populations (Ramsay 1994). Australia now supports the biggest feral oat population in the world.

The Australian feral goat population is composed of a mixture of Angora, Cashmere, Anglo-Nubian, British Alpine, Saanen and Toggenburg breeds. A significant number are Cashmere although the proportion varies between regions. The present feral population reflects the mixed origins of the fibre, meat and milk goat breeds (Agri-focus 1996).

Historically, feral goat numbers have increased on several occasions because of the collapse of the goat fibre industry (namely cashmere, angora and mohair). When this industry failed in the late 1800's, goats were abandoned leading to an increased feral population (Long 1988). The goat fibre industry experienced resurgence in the early 1900's only to decline around the same time as the wool crash in the 1960's. The 1990's have seen a shift back towards natural fibres (in preference to synthetic) and has caused the industry to increase again. This includes the export of feral goat stock for angora breeding stock.

Goat meat is the most commonly eaten meat in the world and the Australian feral goat industry has expanded significantly with both processed game meat and live exports becoming prominent in the 1990's. Australia is now the biggest exporter of goat meat in the world. The goat meat industry has also attracted renewed interest in goat farming. In 1990/91, Australia harvested and processed approximately 1 million feral goats. In Queensland, the numbers of feral goats captured live and processed through abattoirs was 166,264 head in 1990/91. In addition to this, about 100,000 feral goats are exported live each year to Muslim countries from Australia, although very few from Queensland (Parkes *et al*. 1996).

In some areas, commercial harvesting of feral goats has resulted in smaller feral populations. From about 1993 to 1998, up to 200 000 feral goats have been harvested annually in Queensland. Demand for feral goats remains strong despite the industry being seasonal and under the influence of religious activities in overseas markets. The high prices received encouraged the establishment of an abattoir at Charleville in 1996, which is primarily designed for processing feral goats. This may also have encouraged a greater number of goats being harvested in Queensland.

# 3.0 Current and Predicted Distribution

In 1993, Australia had an estimated 2.6 million feral goats distributed across all states and in the ACT.

Feral goats have been successful in areas where resources (food, water, shelter/cover) are adequate and dingoes are absent or heavily controlled. Most live in the pastoral areas of Queensland, New South Wales, South Australia and Western Australia (Parkes et al. 1996). In 1992/1993 New South Wales claimed the highest density of feral goats in known goat areas with 3.6 per km2, followed by South Australia with 2.2, Western Australia with 1.6, while Queensland had 1.5 feral goats per km2 (Parkes et al. 1996).

Estimates of feral goat numbers in Queensland vary from 240,000 (Southwell et al. 1993) to 400 000 (Parkes et al. 1996); however based on feral goat meat statistics (Ramsay 1994) these are considered to underestimate the population. Reithmuller (1998) reported a Department of Natural Resources and Mines aerial survey of 1995 that estimated 240,000 feral goats in south-west Queensland. The 1999 population levels are expected to have been reduced because the improved control methods and more significantly, the recent (1996-1999) high market price for goat meat that resulted in increased harvesting pressure.

In Queensland, the populations are widely distributed across the arid and semi-arid zones (see Map 1) with concentrations found mainly in the south-western and central-western areas of the state (Thompson et al. 1999). This equates to five bioregions: Mulga Lands, Mitchell Grass Downs, Brigalow Belt (South), Channel Country and Desert Uplands. The majority of feral goats are located within the area defined as the Mulga Lands with significant numbers in the rangeland country at the northern extremities of the Mulga Lands bordering the Mitchell Grass Downs (Thompson et al. 1999). Table 1 listed the reported densities of feral goats for various areas within south-west Queensland between 1995 and 1997.

Few feral goats are found in the northern regions of the State. It is speculated that this is due to disease, for example, melioidosis, which severely affects domestic goats in these areas (Seddon 1965). Dingoes prey heavily on goats and since dingoes and wild dogs are not controlled to the same extent in the northern areas as they are in the southern sheep country, this may also limit the density and distribution.

There are also small populations of feral goats on some off-shore islands (Parkes et al. 1996).

Feral goats still have the potential to expand their range (Biodiversity Group 1998) and many areas of Queensland that are presently goat-free, such as the Great Dividing Range, contain potentially suitable habitat for feral goats.

Table 1. Reported densities of feral goats for various districts and biogeographic regions in south-west Queensland 1995-1997.

| **DISTRICT** | **BIOGEOGRAPHIC REGION** | **DENSITY** | **REFERENCE** |
|---|---|---|---|
| Cunnamulla | Mitchell Grass | 10-24 /km$^2$ | Thompson *et al.* 1998 |
| Paroo River / Wyandra | Mulga Lands | 5-11 /km$^2$ | Thompson *et al.* 1998 |
| Ward River / Augathella | Mulga Lands | 1-10 /km$^2$ | Thompson *et al.* 1998 |
| Blackall | Mulga Lands | 6-20 /km$^2$ | Thompson *et al.* 1998 |
| Blackall | Mulga Lands | 5.1-23.5/km$^2$ | Pople *et al.* 1996 |
| South-West Queensland | Mulga Lands | 1.14 /km$^2$ | Lee and Cremasco 1995 |

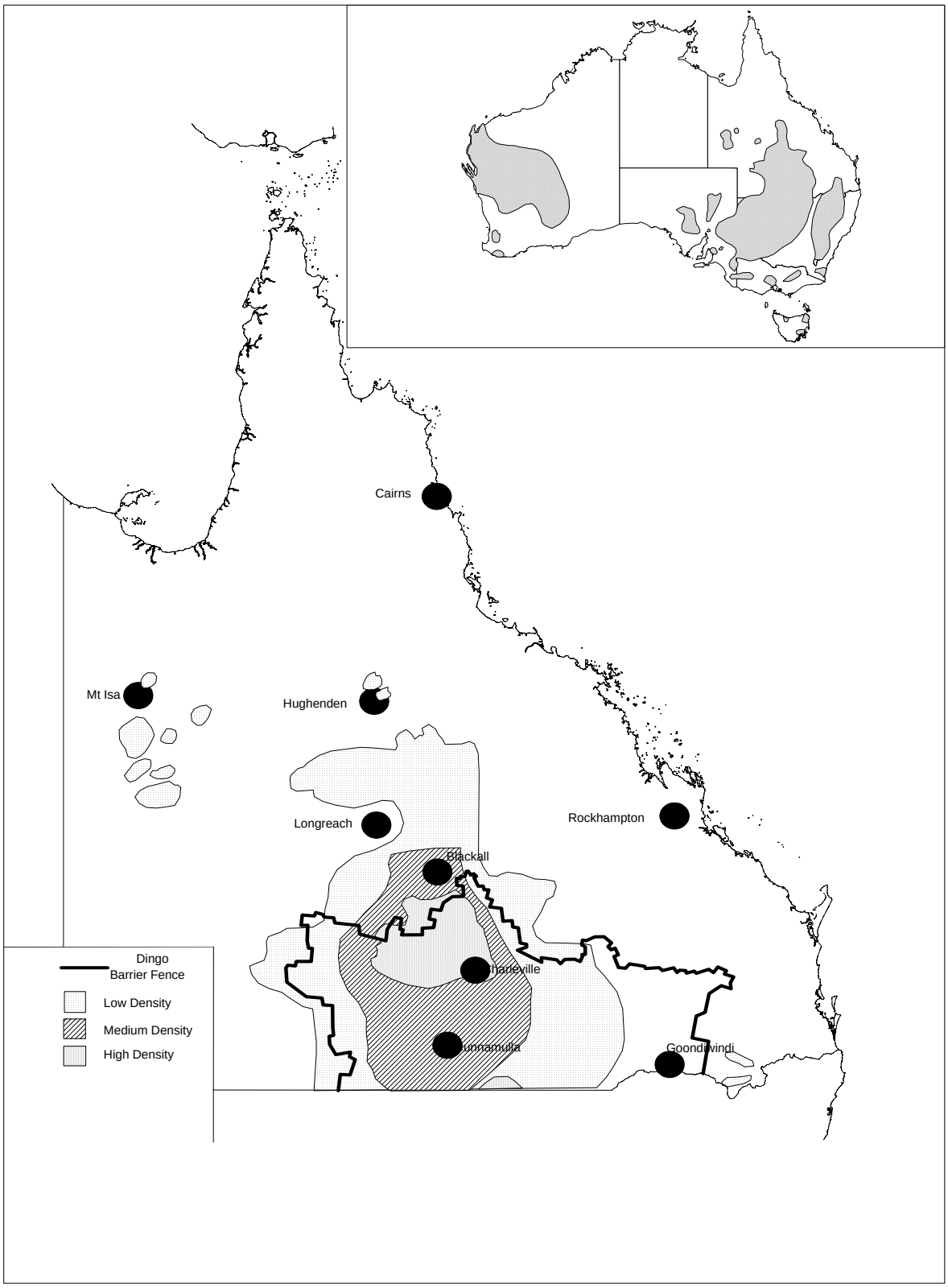



**Fig 1** Feral goat distribution in Queensland. Inset approximate feral goat distribution in Australia

# 4.0 Estimates of Current and Potential Impact

Feral goats cause economic losses of approximately $25 million annually in Australia through reduced stock production, threat of exotic disease and government control operation costs (Parkes *et al.* 1996). This estimate does not include the uncosted environmental impacts of land degradation including soil erosion, pasture degradation, vegetation degradation and costs to native fauna (Agri-focus 1996).

## 4.1 Impact on Primary Production

The two main negative impacts on primary production attributed to feral goats are grazing competition with domestic stock and damage to fences. In 1993, lost livestock production attributed to feral goats was estimated at $17.8 million per year (Parkes *et al.* 1996), however by 1999, the high prices being received for goats and relatively low gross margins for sheep would significantly offset these costs (E. Miller *pers. comm*.). This cost includes all aspects of feral goat damage such as, the competition between feral goats and domestic stock for pasture, wool contamination and fence damage. Feral goats also contribute to uncosted impacts on primary production by causing long-term changes to the perennial vegetation which pastoralism is based (Parkes *et al.* 1996).

Feral goats impact on both primary production and the environment that affects total grazing pressure. Total grazing pressure is the combined grazing pressure of native, domestic and feral herbivores (Thompson *et al.* 1999). It is dependent upon stocking rates, environmental factors (which effects food and water availability) and disturbance. A Western Australia study has found feral goats contribute approximately 10% (Parkes *et al.* 1996) to 20% (Pickles 1992) to total grazing pressure of all large herbivores. Total grazing pressure needs to be kept to levels where sustainable use of the land is possible (Thompson *et al.* 1999).

Feral goats and domestic stock compete directly for pasture, water and shelter. In areas where feral goat numbers are high, or where food is scarce, competition leads to losses in productivity of domestic stock through starvation, inability to raise young and reducing the survival of stock during drought.

A South Australian study found the dietary overlap between feral goats and sheep can be as high as 80% (Henzell 1989) however, this is dependent upon the stocking rate, number of feral goats, forage composition and environmental conditions. In a good season, dietary overlap will have minimal impact on productivity as there is sufficient food available for all grazing and foraging herbivores. In drier periods, competition is more intense and losses to productivity are more noticeable (Thompson *et al.* 1999). Goats have a reputation for being 'first to the best feed' after any rain, and thereby decrease sheep production (Parkes *et al.* 1996). Dietary overlap between feral goats and sheep is often high in poplar box (*Eucalyptus populnea*) areas (Harrington 1986), while low in belah (*Casuarina cristata*) and rosewood (*Heterodendrum oleifolius*) woodland (Wilson *et al.* 1975).

Feral goats can contaminate wool with goat fibres in areas where sheep and goats water together and in yards that are used for handling and loading goats and sheep. The annual cost this impact has on the wool industry is unknown, however, careful management of stock can reduce this risk to negligible levels (Thompson *et al.* 1999).

Feral goats can cause considerable damage to fences but it is difficult to determine exact costs involved. In south-west Queensland, landholders have estimated feral goats cause $800 - $1300 damage annually (average $1000 per property) (Thompson *et al.* 1999).

It is estimated that government agencies spend $1.2 million per annum directly spent on feral goat control (Parkes *et al.* 1996). The Queensland government spent about $175,000 on control methods and related activities in 1994, while South Australia spent $170,000 in 1992 and Western Australia spent $800,000 between 1991/92 and 1994/95 (Parkes *et al.* 1996). These amounts only indicate government expenditure but it is estimated that landholders across Australia spent $2 million on mustering goats in 1996 (Parkes *et al.* 1996).

### 4.2 Impact on the Environment

Feral goats have been responsible for severe or even catastrophic environmental damage to ecosystems that evolved without browsing mammals (Parkes 1990) although in ecosystems adapted to some browsing their effect is variable (Parkes *et al.* 1996). Feral goats impact upon the soil, vegetation (trees, shrubs, grasses and herbs), woody weeds and native fauna in the areas they occupy.

High densities of feral goats can rapidly deplete an area of its vegetation and lead to an increased chance of soil erosion. The characteristic pawing of the ground by male goats and the hard hooves of the herd, breaks the soil crust and exposes the soil to erosive forces of water and wind. This reduces soil stability resulting in wind or water erosion. Typical soils of the Mulga Lands are stable when protected by vegetation but following fire or overgrazing, sheet erosion seriously reduces nutrient levels (Dawson and Ahern 1974). In steep country, similar erosion patterns have lead to land slips (Parkes *et al.* 1996).

Feral goats can have a signficant effect on vegetation composition (Henzell 1992). Browsing by feral goats can kill most plants under 2 metres high by defoliation or by debarking the tree (Parkes *et al.* 1996). Goats stand on their hind legs to browse 1.8 metres high or higher if they can climb the plant. In large numbers, feral goats have a devastating effect on all plant growth but even if present in low numbers, their impact on palatable species was still very noticeable in South Australia (Henzell 1992).

As goats can consume many species of plant normally unavailable or not palatable to sheep and cattle, feral goats have the potential to be more damaging than domestic animals to arid zone perennial vegetation. Feral goats can cause long-term changes by eating established plants and by preventing regeneration of seedlings (Parkes *et al.* 1996).

Although goats consume some weeds (spear thistle, etc.) it has been suggested that the abundance of woody weeds has increased due to the presence of feral goats (Parkes *et al.* 1996). Goats have been used to control more palatable species of weeds, for example *Rubus* spp. - blackberry (Parkes *et al.* 1996); however, very high stocking rates and goat-proof fences are necessary for it to be effective. Goats will only be of benefit in these circumstances if preferred dietary species are not present or are in low volumes. Use of goats for wed control also risks complete removal of the vegetation cover, subsequent exposure of soil and possibly the establishment of other weed species after the goats are removed.

Feral goats have indirect impacts on native fauna through alteration of habitat such as by changing the composition and quantity of vegetation and subsequent degradation of soils (Parkes *et al.* 1996). Feral goats compete directly with native fauna for resources such as food, water and shelter. Goats eat many of the same plants as native herbivores and although goats are rarely the dominant introduced herbivore, this competition is considered to affect native populations depending on 'goat-favoured' species of plants.

The feral goat has been implicated in the decline of some native animals, although it is most likely that feral goats alone are not responsible for the decline in populations. Feral goats have been implicated in the decline of populations of yellow-footed rock-wallabies, brush-tailed rock-wallabies, mallee fowl and the thick-billed grasswren (Biodiversity Group 1998). In Queensland, the distribution of the yellow-footed rock-wallabies and feral goats overlap, but the impact of feral goats on the wallaby population has not been quantified.

### 4.3 Disease

Goats can suffer from a number of potentially debilitating parasites and diseases (Parkes *et al.* 1996) but it is unlikely that these have a major impact on the density or distribution of feral goats in southern pastoral areas of Queensland.

Feral goats have been found to carry 22 nematode, 2 cestode, 2 trematode, 4 arthropod and 3 protozoan parasites (Parkes *et al.* 1996). Parasites can be a problem in well-watered pastures where intensive stocking occurs, and in these areas, feral goat numbers are generally low (Parkes *et al.* 1996). Goats can also carry lice and a variety of bacterial and viral diseases, for example *Coxiella burnetii*, the cause of Q fever. It has been noted, however, that feral goats in arid areas are relatively free from parasites and disease (Henzell 1992).
The feral goat poses a serious threat to Queensland's livestock industries and human health through being a potential carrier, or amplifier, of these exotic diseases (Parkes *et al.* 1996). Exotic diseases of livestock are known to be carried by feral goats overseas, but have not been reported in Australia. Of these diseases, foot-and-mouth disease (FMD) poses the greatest threat if it was to enter Australia and establish in feral goat herds. Other exotic diseases include bluetongue, rinderpest, screw-worm fly, capripox, Rift Valley fever, vesicular stomatitis and scrapie (Henzell 1996).

The Agriculture and Resource Management Council of Australia and New Zealand have published national management responses for exotic disease outbreaks in the Australian Veterinary Emergency Plan (AUSVETPLAN) Wild Animal Management Manual (ARMCANZ 1998).

The presence of feral goats in Australia increases the contingent cost of insuring livestock against the outbreak of exotic diseases (Parkes *et al.* 1996). The estimated cost of a FMD outbreak was $12.5 million per year prior to the Commonwealth's Wildlife and Exotic Disease Preparedness Program (CWEDPP). This estimate has decreased to around $6 million per year as a result of the control operations and overall management of feral goat populations as recommended by (CWEDPP) (Parkes *et al.* 1996).

### 4.4 The Goat as a Resource

Feral goats are seen by landholders in Queensland as either a pest or a resource or sometimes both, depending on the price being offered at the time (Thompson *et al.*

1999). During the 1990's, feral goats became an important resource for the meat, fibre, leather and livestock industries in some rural areas. In 1996/7, export of goat products from Australia accounted for about $21 million of which the majority was for goat meat but also included signficant exports of skins and live goats (Twyford-Jones 1998). The goat skin and leather industry is a by-product of the goat meat industry (Ramsay 1994). Skins are generally exported as salted skins principally to Italy (Agri-focus 1996) although, Spain, Sweden and Germany are important buyers of goat skins (Ramsay 1994). The majority of goat skins are used for leather as the fibre on the skin is of no value. The skins are often marked by wounds, disease or poor preservation and cannot be sold. A steady demand exists for the live export trade to the Middle East and Asia. An additional 100 000-250 000 feral goats are exported live to Muslim countries each year (Parkes *et al.* 1996).

Australia began exporting goat meat in 1952 (Standing Committee on Agriculture 1982) and is now the world's largest supplier of chilled and frozen goat meat. Australian goat meat exports accounted fro about 60 per cent of the world goat export market in 1996 (Twyford-Jones 1998). He principal export market is Taiwan but signficant markets also exists in Malaysia, Korea, Singapore, the United States and Canada. Australia goat meat exports are principally supplied from New South Wales but signficant volumes are contributed by Western Australia, South Australia and Queensland.

Approximately one million feral goats were processed in abattoirs in 1991/92 and a further 40,000 shot in the field for game meat (Parkes *et al.* 1996). About 95 per cent of these goats are exported as carcasses. Since 1992, total exports of goat meats have remained steady at around 12,000 tonnes, but peaked in 1994 with 14,000 tonnes (Meat and Livestock Resources 1998 in Twyford-Jones 1998). The high demand and increasing prices being received since 1993 have maintained the pressure on the feral goat population and also increased the value of the export market.

The volume of goat meat exported from Queensland has declined by 70 per cent, from 2,400 tonne in 1992 to 714 in 1996, although it increased again in 1997. Feral goat populations have been subject to increased harvesting pressure for several years and the decline in Queensland's exports is partly attributed to a reduction in supply of goats. There is also considerable interstate trade, between NSW and Queensland, in live feral goats depending on the opening and closing o abattoirs, which may also explain the decline in Queensland goat meat exports.

In 1998, an estimated 150,000-160,000 feral goats from south-east Queensland were slaughtered for export (Thompson *et al.* 1999). Approximately 20,000 of these were processed through chiller boxes distributed throughout Queensland, however, in previous years up to 60,000 carcasses were processed in this manner (J. Riethmuller *pers. comm*.).

The goat meat industry is now heavily dependent on export markets and any shift in general international trade agreements and exchange rates will strongly impact on the industry. Since the volume of goat meat traded on world markets is small compared to the world production, relatively small changes in supply and demand could upset the market for Australia (Twyford Jones 1998). Although international demand for feral goat meat has increased steadily, the demand is seasonal, depending upon the trading partner and the timing of their religious ceremonies.

The development of a large, domestic market could help offset any negative impacts of international price fluctuations on the export industry (Twyford-Jones 1998). There

are three distinct goat meat markets in Australia. There are two main markets; the retail of fresh goat meat or 'chevon' in butchers or delicatessens and wholesaling to small goods industry for manufacturing (Ramsay 1994). The third is a small market within the food service industry supplying specialty restaurants and hotels (Ramsay 1994).

The goat industry is suggested to play an important role in the control of feral goats as feral goat harvesting provides income for landholders while decreasing the feral goat population. However there are also arguments that commercial utilization of pest species leads to their sustained harvesting (Williams *et al.* 1995). The sale of feral goats can provide a signficant proportion of some farmers' incomes (Parkes *et al.* 1996) and the high market prices offered in 1998 ($30/head and up to $45/head for good breading stock), was incentive to muster many goats. In 1992, landholder profits from feral goat harvesting was about $6m, however by 1998, south-west Queensland graziers were receiving $3-5 m per annum. There appears to be considerable opportunity for landholders to increase their feral goat control and still make a profit as goat harvesting requires relatively minimal time commitment (Thompson *et al.* 1999).

Feral goat populations also provide landholders with a source of goats suitable for cross-breeding with Boer goats for meat production. Good breeding stock attracts a premium of $10-$15 per head above the abattoir price (Thompson *et al.* 1999). Utilisation of feral populations may allow a more rapid expansion of the domestic goat herd and the ability to meet export demand for consistent supply.

Some estimates of the costs and benefits of feral goats are identified in Table 2, however, there are many aspects of feral goat management that cannot be costed and a cost-benefit analysis would be misleading and incomplete without their consideration.

Uncosted impacts include;

- environmental damage (impacts on biodiversity, land degradation),
- wool contamination and
- production losses associated with between feral goats with domestic stock.

Similarly, the uncosted benefits to feral goat include;

- Considerable flow-on effects to small rural communities associated with mustering, fencing, transport, slaughter and other services,
- the opportunity of diversification of landholder income,
- uncertain potential for weed control and,
- the availability of breeding stock feral goats provide for their domestic herds.

**Table 2** Costs and benefits associated with feral goats (Thompson et al. 1999 and Parkes et al. 1996).

| **Costs** | **($)** |
|---|---|
| Mustering costs | $1.59 - $3.55/head |
| Trapping costs | $1.15 - $3.87/head |
| Damage to fences per property | $800 – $1300 pa |
| Potential disease risk to the nation | $6 million pa |
| **Benefits** | |
| Total revenue from sale of feral goats | $3-5 million pa |

# 5.0 Biology and Ecology

## 5.1 Morphology

In south-west Queensland, goats are predominantly mixed colours of black, white and brown (J. Reithmuller *pers. comm.*). The head and body length of male goats range from 120 - 162 cm, with an average of 150 cm for males. Female head and body length range from 114 – 147 cm, with an average of 133 cm. Adult males (over three years of age) can weigh up to 60 kg while the female feral goats weigh up to 45 kg. Female goats become sexually mature at 15 kg and offspring have an average birth weight of 2.6 kg. The range of colours and the variation in goat body size reflect the mixed origins of the original stock (Ramsay 1994).

## 5.2 Habitat Requirements

There are four minimum requirements for survival: permanent water, adequate food, cover and few (or no) dingoes. Other limiting factors include diseases (e.g. melioidosis, caseous lymphadentis) and parasites (e.g. protozoan, nematodes, cestodes).

Feral goats prefer areas of rough ridges or dense trees, shrubs and logs to which they can escape. In south-west Queensland, the highest densities of feral goats occur in hilly terrain with tree or shrub cover that permits evasion of predators and human control activities. Feral goats are often found in conservation areas because these areas often provide extensive cover from predators and human control.

In the pastoral zone, permanent watering points are available and dingo control is often carried out to protect domestic stock particularly in sheep grazing areas. The control of dingoes inside the Dingo Barrier Fence is provided a safer environment for feral goats and has contributed to the development of a high population inside the fence.

Another predator, the red fox (*Vulpes vulpes*), is known to kill domestic goat kids (Long *et al.* 1988), but the role of foxes in limiting feral goat populations has not been established (Ramsay 1994).

## 5.3 Diet

Feral goats are opportunistic forages, with a diet varying seasonally according to forage quality and availability (O'Brien 1984). They are described as a generalist herbivores (Harrington 1986) that both graze and browse, consuming the following extensive range of foods: foliage, forbs, grasses, plant litter, twigs, bark, stems, herbs, seeds, flowers, fruit, roots; and fungi. In general, trees and shrubs are favoured over grasses, and ephemerals are eaten when available (Henzell 1992). Goats also show a marked selectivity among tree and shrub species. Preferred species found in Queensland include a number of trees and shrubs; ironwood (*Acacia excelsa*), poplar box (*Eucalyptus populnea*), mulga (*Acacia aneura*) and belah (*Casuarina cristata*), herbs; wild turnip (*Brassica tournefortii*), milk thistle (*Lactuca serriola*) and lucerne (*Medicago sativa*) and grasses; nutgrasses (*Cyperus* spp.), and speargrass (*Stipa* spp.). Feral goats also eat gidgee (*Acacia cambagei*) and brigalow (*Acacia harpophylla*) suckers.

The dietary overlap of sheep and goats is high (Harrington 1986), however, goats tend to eat more browse and less forbs than sheep in dry times.

In pastoral areas, goats are able to eat many less palatable species often avoided by domestic stock, such as *Cirsium vulgare* - spear thistle (A. Mills *pers. comm.*), *Dodonaea attenuata* - narrow-leaf hopbush and many poisonous or bitter plants (Parkes *et al.* 1996). They will only turn to these plants after exhausting preferred species. Feral goats are generally not suited to controlling woody weeds in south west Queensland, such as budda, *Eremophila mitchellii*, turpentine, *Eremophila sturtii* and hop bush, *Dodonaea viscose*, are not preferred species (Grice and Korn 1992) and the high stocking rates needed to force a change in diet are destructive to range or pasture condition.

### 5.4 Social Structure and Behaviour

The basic social units are groups of adult females and their recent offspring (Parkes *et al.* 1996). The young males leave these matriarchal groups and form loose affiliations with similar aged males or larger mixed-aged groups. The male group's home range overlaps with the female's home range during the breeding season, but may range over larger areas at other times (Rudge 1990). Although the females tend to stay together in groups, they will frequently share resources with male groups.

Group size can range from solitary animals to large herds and varies frequently with age, sex, disturbance, vegetation and water availability (J. Riethmuller *pers. comm.*). A common range of group size for Queensland is 1-20 goats (Thompson *et al.* 1999). Larger groups of up to 200 goats do occur, especially in times of drought. Other States have recorded larger herds of up to 800, however in Queensland these numbers have not been recorded.

The group size can also change on both a daily and seasonal basis. If palatable vegetation and water is readily available, group size will decrease and many small groups will scatter across an area to feed and drink. If vegetation and water is limited to certain areas, feral goats will 'mob up' leading to an increase in group size. Disturbance such as mustering cause higher numbers of smaller groups as goats break from the herd and scatter to increase their chances of evasion.

The home range of goats vary in size, depending on shelter, food and water availability. In areas where these requirements are freely available, the home range is small, often about 1km$^2$ (Parkes *et al.* 1996). In arid and semi-arid pastoral areas, the home range of feral goats may extend to cover much larger areas. The home range of rangeland feral goats can extend up to 600km$^2$ (Parkes *et al.* 1996). Ranges are smaller in drier periods, presumably because the goats have to visit water more frequently (King 1992). Pastoral zone fences are typically not goat proof and hence goats can move freely from property to property (Elliott and Woodford 1995). Feral goat territories often include trails, shelter, feeding and watering areas that can also be used by sheep and cattle. Even though they are habitual in their use of such areas, there is no evidence that feral goats actively defend territories.

Feral goats are most active in the early mornings and in the late afternoon or in times of disturbance. Predators and control programs (mustering, shooting, etc) cause goats to alter the utilisation of their existing ranges or can cause them to move to new areas (J. Riethmuller *pers. comm.*).

### 5.5 Reproduction and Population Dynamics

Female goats can potentially commence breeding as young as three months of age although six months is more likely, and generally weigh at least 15 kg. Sexually

mature female goats usually come into oestrus at about the same time. Oestrus is thought to be synchronised by male sexual activity (Shelton 1960).

Feral goats have an average of three pregnancies in a two year period, with an average of 1.59 embryos per pregnancy (Parkes *et al.* 1996). The gestation period is 150 days (Henzell 1992). The first birth is likely to be a single kid, although twins and triplets are common thereafter.

The young are born away from the herd and left in a protected area while the mother grazes for food nearby. When the kids are approximately 5 days old, they will accompany the females as they feed and continue to be suckled for up to 60 days. Females with a kid at foot are often pregnant (Henzell 1998).

The availability of food, water and shelter will determine the length, timing and success of the breeding season. Under favourable conditions, feral goats can breed all year round. In arid-temperate areas, the breeding season is usually between January and June, with the peak starting in February. In areas where resources are seasonal there appears to be no defined breeding season (Department of Lands 1995). In south-west Queensland, kidding peaks can occur throughout the year.

Mortality of feral goats can be natural or human-induced. Natural mortality (predation, starvation, disease or mismothering of kids) can be up to 45 per cent in Australia and 19 per cent in New Zealand (Parkes *et al.* 1996). Predation from dingoes or other animals, lack of water and food during droughts, toxic plants and various diseases also contribute to higher rates of mortality. Adult mortality is estimated at 10% and is mostly attributed to old age and misadventure. Mortalities induced by human activities, such as mustering or culling also decrease populations. A South Australian study found mortality rates (combination of natural and human-induced factors) equal to 38 per cent (Henzell 1983).

Feral goats have the potential to increase their numbers in a relatively short period given favourable conditions (Parkes *et al.* 1996). The potential for feral goat populations to grow is estimated by their instantaneous exponential rate of increase. Using a base population of 100 feral goats, the potential rate of increase predicts that within one year the population will expand by 53 per cent i.e. to a population of 153 goats, and after 2 years with compounding effects, produce a population of 234 feral goats (Parkes *et. al.* 1996)

Very few of populations in Australia are not affected by harvesting. In order to prevent a population from increasing, it has been estimated that around 35 per cent of the population needs to be removed either through control programs and / or predation (Parkes *et al.* 1996). This number is variable depending on environmental conditions and when control is undertaken.

# 6.0 Efficacy of Current Control Methods

There are a number of different methods that can be used to control feral goat populations. In Queensland mustering, trapping and shooting are regularly used. Sometimes judas goats are used in conjunction with shooting, although this method is rarely used in Queensland. Other techniques include exclusion by fencing, poisoning and biological control (natural control agent - the dingo). At present, there are no registered poisons for use in Queensland.

## 6.1 Mustering

Mustering is the most widely used control technique in Queensland. It is an effective and very target specific technique with efficiencies sometimes around 80 per cent although commonly much les (Henzell 1994). The effectiveness and efficiency of feral goat mustering depends on 4 factors (Thompson *et al.* 1999): ruggedness of the terrain, experience of the operators, equipment used and group size of the feral goats.

Timing of mustering is important because high temperatures influence the efficiency of a muster. Mustering and handling of goats in the heat of the day should be avoided as hot weather reduces the distance that feral goats will travel. Nannies that are heavily pregnant or nannies with kids at foot are even less likely to travel long distances in hot conditions (Thompson *et al.* 1999).

Mustering of feral goats using motorbikes and dogs is the common practice but the additional use of light aircraft (Cessna 172/182's, gyrocopters and ultralights) has proven to be an extremely effective and efficient method, particularly from range country. The aircraft is usually aided by a combination of motorbikes and dogs that muster the goats into yards where they can be loaded onto trucks for transport to abattoirs. Radio communications between mustering units and strategically sited yards can help improve mustering efficiencies.

Most landholders muster opportunistically, or muster when they notice a large herd on their property (Parkes *et al.* 1996). The growing commercial market for the sale of feral goats to overseas countries acts as an incentive for landholders to muster. The high 1998 market price offered for feral goats made it worthwhile for landholders to muster small mobs, even as small as individuals and pairs.

Mustering becomes uneconomic once populations are reduced to densities below about one goat per square kilometre (Henzell 1984) but this figure fluctuates with the prices received for feral goats (Fig 2.). The average cost of mustering feral goats in south-west Queensland in 1995/97 was $1.93 per head (Thompson *et. al.* 1999) but based on higher prices it may prove economical to muster at even lower densities (e. Miller pers. comm.)

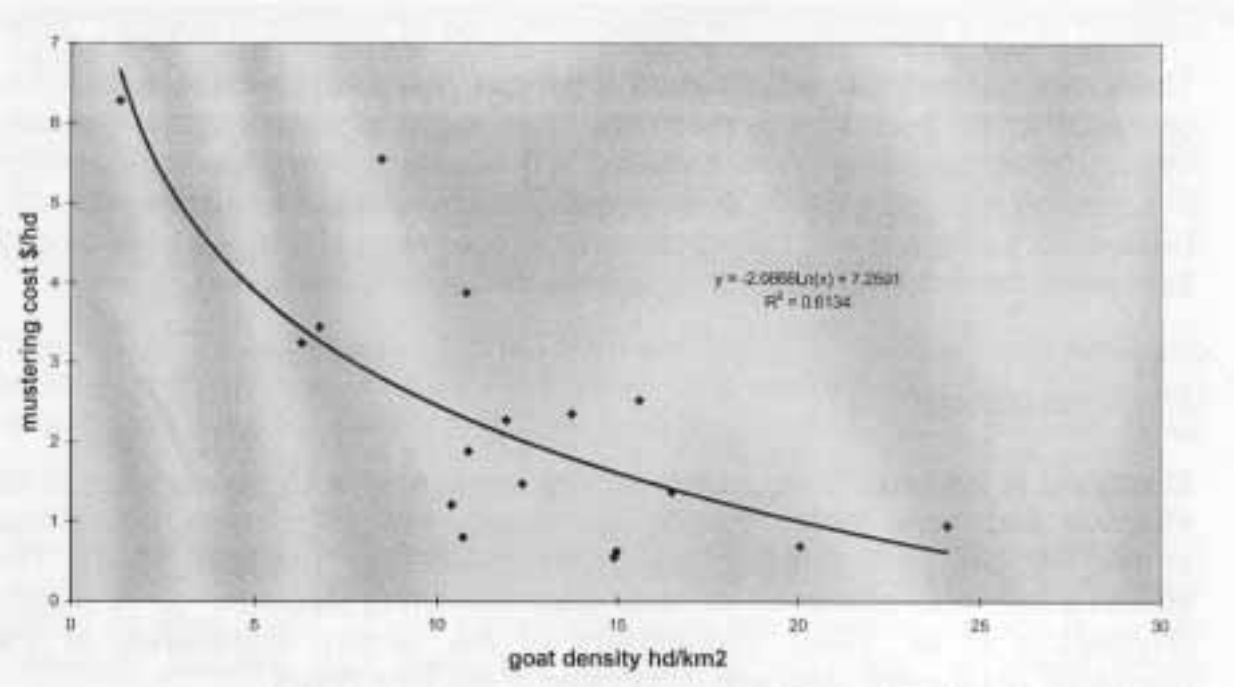



**Figure 2.** Relationship between mustering cost and goat density (Thompson *et. al.* 1999)

### 6.2 Trapping

Traps are goat-proof fences surrounding a watering point with a variety of one-way gates or ramps that permit goats to enter, but not to exit, the enclosure (Parkes *et al.* 1996).

Trapping, or self-mustering, can be used to reduce mustering costs and the stress on the animals (O'Dempsey 1993) and is a successful control method in dry times, when feral goats congregate around watering points. It is less efficient and often impractical during periods of wet weather when water is plentiful. As little as 5 mm of rain may result in quite substantial pools of water, particularly in rocky range country, reducing the need for goats to water at the trapped points (Thompson *et al.* 1999).

For successful trapping:

- goats must initially be trained to accept the traps. Trap gates are left open when the trap is not in use to allow animals to pass in and out and to encourage goats to use the traps (King 1991);
- when traps are set, they must be checked daily to avoid stress to the goats and to clear the trap of any domestic stock which may have been caught;
- traps should always be approached from the direction of the gate as this is the weakest point in the trap and usually the lowest point in the fence; so when going to check the trap, goats should not be forced towards it if possible;
- trap during day times to avoid catching macropods (Parkes *et al.* 1996); and
- alternative watering points should be fenced off, forcing goats to water at the trapped points (Thompson *et al.* 1999).

The trap fence is usually constructed from prefabricated 8/90/15 hinged joint wire with pain wire along the top and the bottom to tie the hinged section together. The fence needs to be kept as close to the ground as possible (within a few centimeters) to keep the goats from crawling under it. The prefabricated sections of fence stand

90 cm tall and two strands of wire are added to the top of the trap extending the height of the fence to approximately 120 cm.

Good trap designs:

- include trees and logs within the boundaries to provide goats with protection from the elements:
- enclose the entire water point and any back waters:
- keep the trap fences as close to the ground as possible. Once goats find a depression under a fence, they'll force their way through very small gaps:
- do not use sloping, wooded stays in the corners of the yard, as the goats can walk up them:
- site the trap gates on established goat trails coming in to the water so that they encounter them on their normal path and are more likely to use them and,
- give the goats enough space to avoid social stress (J. Riethmuller *pers. comm.*):

Three of the main trap gate designs used in Queensland are: 'jump down' ramp gates, Bettini trap gates and the Charleville sheep trap gate.

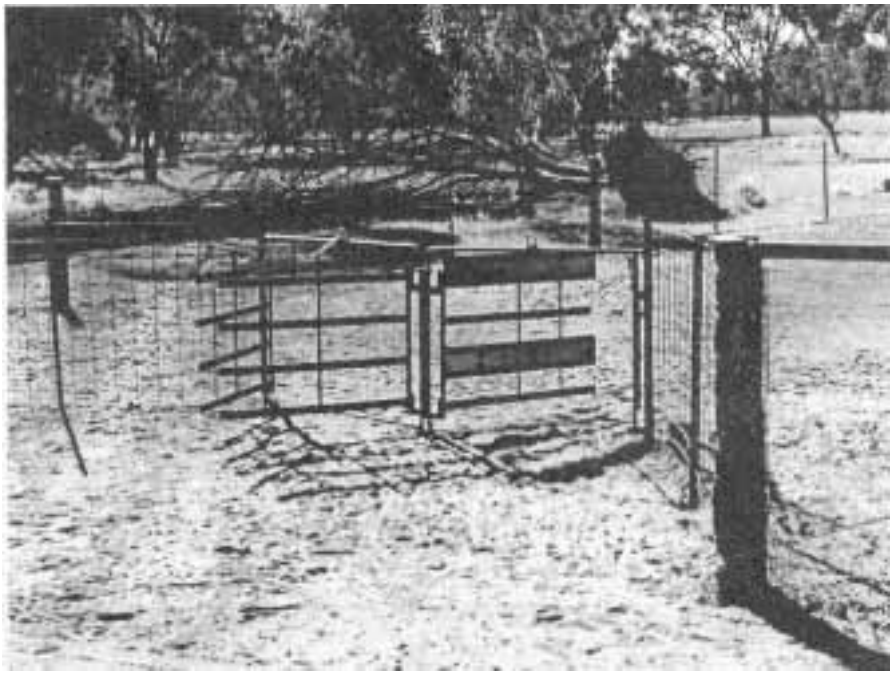
The 'jump down' ramps consisted of earth ramps at least 1 metre high that allow the goats to walk up and jump in, but not out (Fig. 3). A heavy gauge wire extends above this by approximately 30 cm, to prevent the goats escaping. A gate is placed next to the ramp and is closed when trapping. The width of the ramp depends on the number of goats in the area. This particular design is low in cost for materials (soil, boards/logs), durable and billies with large horns can get in easily. This design is not suitable for sheep and particularly lambs, which may suffer injuries when jumping from the ramp into the trap.

Source: J. Riethmuller, NR&M

**Figure 3**. Jump-down trap, jump and gate

The Bettini trap gate uses a v-shaped four-barred gate with flexible spears (Fig. 4). The spears may need to be strengthened because goats can bend them while trying to escape. The Bettini gates requires goats to be trained to walk through the in and out gates by progressively closing the spears to get them used to squeezing in and

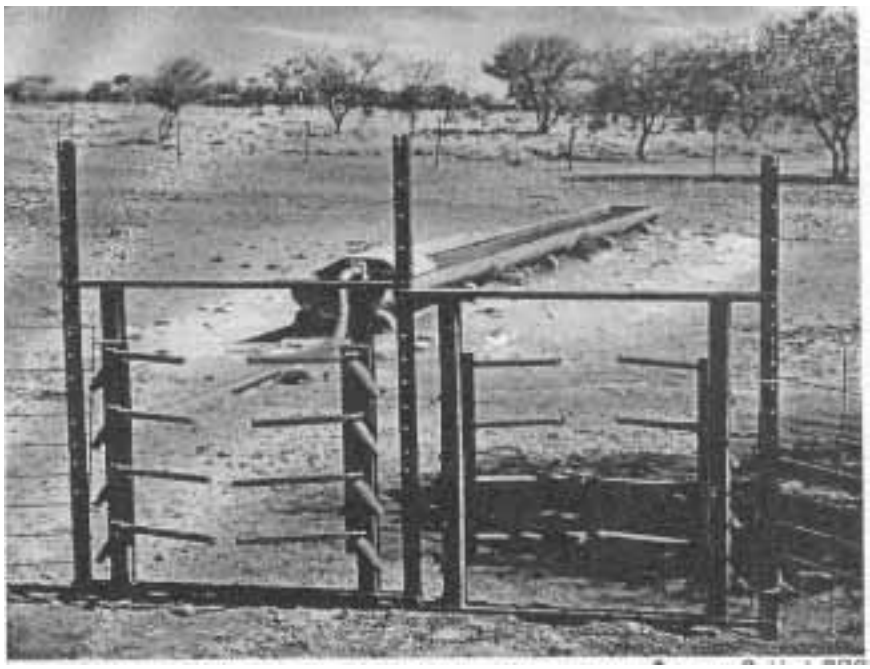
out. When trapping commences the 'out' gate is closed. Big billies, or goats with large horns, can find it difficult to go through the gate and some landholders overcome this problem by adding a few sloping logs near the gate to allow them to walk up and jump in over the top of the fence. This type of gate can be used when soil is too hard, too scarce, or too soft to construct 'jump-down' ramps.



Source: J. Riethmuller, NR&M

**Figure 4.** Bettini trap gates

The Charleville sheep trap gate (Fig. 5) has been used in Queensland with some success (J. Riethmuller *pers. comm.*). The spears used on this trap are robust and may be lower maintenance than the Bettini trap.



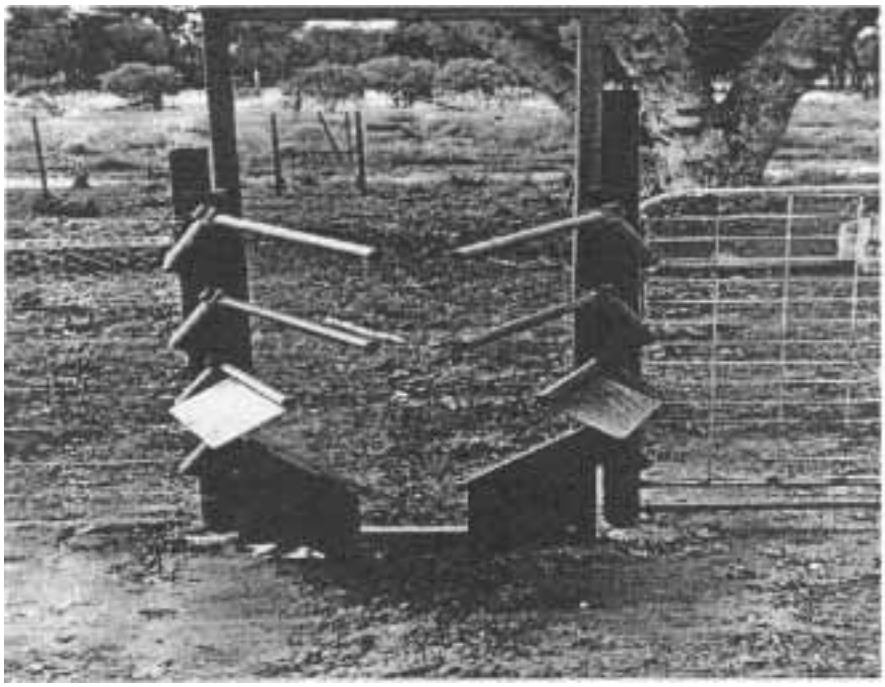
Source: Q. Hart, BRS

**Figure 5.** Charleville sheep trap gates

In areas where cattle graze, the Cattle/sheep trap gate (Fig. 6) should be used. The design of the cattle/sheep trap gate is the same as the Charleville sheep trap gate, however, the bottom spears have a 'plate' hanging down to the ground. It is important that the bottom spears and the plate are close to the ground to prevent the goats crawling out under them.

The initial outlay to construct a trap can be high. When weighed against the sale of goats caught and the life of the trap (usually a number of years), the trap is relatively inexpensive. Properly designed traps can also be used to trap sheep at water. They can thus have a dual purpose, sharing the costs of constructing the trap between domestic and feral animal capture.

For south-west Queensland, the total trapping costs (labour, construction and maintenance) range between $1.15 and $3.87 per head (Thompson et al. 1999). This was calculated on a trap costing between $2000 and $5000, with an average trap life of 10 years or 10 000 goats. Based on 1999 prices this requires between 100-200 goats to be trapped to achieve full cost recovery.



Source: N O'Dempsey

**Figure 6.** Cattle/sheep trap

### 6.3 Shooting

If properly carried out, shooting is often the most humane method of destroying feral goats and a supporting code of practice for the capture and destruction of feral animals is available from CSIRO Publishing (SCA 1992). When prices for feral goats are high, shooting as control method is rarely undertaken because the animal is too valuable and other management methods are used.

#### 6.3.1 Shooting from the Ground

Ground based shooting is very labour intensive and is often not an effective option if there are large numbers of goats present over large areas. Since herd numbers can recover rapidly if any goats remain, or if immigration of goats from adjacent

properties occurs (King 1991), ground shooting must be conducted on a regular basis if low numbers are to be maintained.

Small numbers of goats are shot from the ground in forested areas, usually with the aid of dogs to indicate, track and bail-up the goats (Parkes 1990). Professional shooters who sell feral goat carcasses to local chiller boxes for export as game meat are also ground based operations.

In the pastoral zone, ground shooting is most successful when used in conjunction with other control methods such as following a muster or trapping program (Thompson *et al.* 1998).

### 6.3.2 Shooting from Helicopters

Aerial shooting is widely recognised as an effective method of feral goat control at low and high densities. It is a particularly useful method in areas that are inaccessible to ground hunters, where mustering is difficult or impossible and where there is no requirement or desire to sell the animals (Thompson *et al.* 1998). Integrated management o feral goats often uses techniques such as mustering and trapping followed by aerial shooting to mop-up isolated and scattered populations. The advantage of helicopter shooting is the aircraft can cover large areas quickly however the over-riding factor is the cost of helicopter hire per hour that can be expensive. Experienced helicopter pilots and skilled marksmen contribute to the humane kill of feral goats.

## 6.4 Judas goats

Radio-collared 'Judas' goats can be used to locate groups of feral goats that are difficult to find by other methods (Parkes *et al.* 1996). The collared goats are used to track down and 'mob up' with other goats, thereby allowing small or hard to find goats to be found and destroyed.

Judas goats are usually used in particularly rough country where other control methods are unavailable or where the goats are in low densities. They are used in follow-up control programs after other methods have already reduced the population to low numbers. Judas goats have been successfully used in eradicating feral goats off Woody Island (Fig. 1) off the coast of Queensland but the method has not yet been used in the pastoral zone where the majority of feral goats are found.

Goats are particularly suited to the 'Judas' method as they are a highly social species. Local feral goats as useful Judas animals because they are familiar with the area and are already part of the social structure of the target population. This creates less stress and minimises the risk of Judas animals leaving the target area (Parkes *et al.* 1996).

## 6.5 Exclusion by Fencing

Fences will not generally stop the movement of feral goats (Parkes 1990), however, there are advantages in using fencing (Parkes *et al.* 1996). Fences can limit the dispersal of goats, break up large areas into manageable blocks, exclude goats from watering points forcing them to drink at trapped points and when built effectively, can constrain captured feral goats.

There are several designs for conventional boundary and electric fences for normal Australian conditions (Lund and May 1990); however, the construction and

maintenance of such fences can be expensive. Conventional boundary fences are made out of prefabricated material (7/90/30 or 8/90/30) standing at 1070 millimetres and topped with a single strand of plain or barbed wire (Parkes *et al.* 1996). An electric fence consisting of three energised wires set alternatively with earthed wires is the recommended design for excluding feral goats (Parkes *et al.* 1996). For south-west Queensland, a typical electric fence designed to contain goats can cost up to $1800/km for materials at 1999 prices (J. Reithmuller *pers. comm*).

### 6.6 Poisoning

Poisoning is not suited to most Australian conditions because of risk to non-target animals (Parkes *et al.* 1996). There is no registered pesticide available for poisoning feral goats in Queensland.

### 6.7 Biological Control

Biological control methods have inherently high environmental and commercial risks that require strict procedures to regulate their development and use. For biological control programs to be successful, the introduced agents must be host specific. Unfortunately, it would be difficult to stop any introduced goat pathogen, or disease-borne immuno-contraception agent, spreading from feral goats to domestic goats and sheep if it was introduced.

Acceptable examples of biological control for mammals are rare, and no natural pathogen to manage feral goats in Australia is available and acceptable (Parkes *et al.* 1996). Indirectly however, dingoes present an available method. Feral goat populations are generally absent, or maintained at low densities if dingoes or feral dogs are present (Parkes *et al.* 1996*).* Dingoes have been successfully used on Townsend Island (Fig. 1) to reduce feral goat populations from over 2000 animals in 1992 to 4 in 1997 (Allen *et al.* 1998). The remaining 4 feral goats have since been shot (Allen *et al.* 1998)

### 6.7 Control During Exotic Disease Outbreaks

If feral goat populations are kept to a minimum through control programs the risk of exotic disease transmission is reduced.

In the event of an exotic disease outbreak, financial and legal control constraints take on less importance and the amount of control required is increased. The procedure for an exotic disease outbreak involving feral goats (as set out in the draft Wild Animal Management Manual, ARMCANZ 1998) requires the containment of the disease within a geographic area and then the reduction of the host (feral goat) population as quickly as possible. Monitoring of the adjoining host populations (including domestic goats) for disease incidence is essential to assess containment of the disease.

# 7.0 Animal Welfare Considerations

In Queensland, the *Animals Protection Act* 1925 gives no protection to any feral animal but does provide, in broad terms, that procedures to destroy declared animals must not constitute 'unreasonable, unnecessary or unjustifiable ill-treatment'. Ill-treat is defined as: "wound, mutilate, overdrive, override, overwork, abuse, worry, torment and cause any animal unnecessary pain or suffering; also overload or overdrive when loaded, and overcrowd, and unreasonably beat or kick". Ignorance is no excuse for inappropriate handling of goats (SCARM 1995).

This legislation is currently being reviewed and a Bill is expected to be tabled in 1999. In addition, a series of Model Codes of Practice for the Welfare of Animals has been coordinated by the Animal Health Committee, Sub-Committee on Animal Welfare for the Standing Committee on Agriculture and Resource Management (SCARM). Two publications in this series deal with goats; *The Goat* (SCA 1991), and *Feral Livestock Animals - Destruction or Capture, Handling and Marketing* (SCA 1992). A third, *Land Transport of Goats*, is proposed to cover the minimization of stress and injury during land transport

Animal suffering must be reduced to a minimum and consistent with the effective control practice. Good culling, mustering and trapping practices include:

- trapping at points where water is available;
- moving goats steadily at the rate of the slowest animal;
- not using dogs to attack and bring down animals;
- mustering in cool or mild conditions to decrease the chances of dehydration;
- not using electric prods on feral goats and
- careful and quiet drafting and loading (SCA 1992).

# 8.0 Management and Control Practices

### 8.1.1 Legislative Status in Queensland

The declaration of pest species is based on the impact, or potential impact, that species could have on the environment and rural economies. The feral goat is a declared animal under Section 69 and 70 of the *Rural Lands Protection Act* 1985 (Qld). It is classed as a A2, A4 and A6 animal for the State of Queensland, which requires that feral goats be destroyed and only kept, sold and transported under permit. Section 80 of the Act describes the responsibility 'of occupiers of any private land to control declared animals'. Non-compliance is an offence and subject to penalties (Table 3).

**Table 3.** Offences and penalties applicable to feral goats in Queensland under the provisions of the *Rural Lands Protection Act* 1985.

| OFFENCE | MAXIMUM FIRST OFFENCE | MAXIMUM SECOND OFFENCE |
|---|---|---|
| Failure to control | $ 375 | $ 1,500 |
| Failure to comply with direction | $ 1,500 | $ 3,750 |
| Introduction of Category A4 animals without a permit | $ 7,500 | - |
| Restrictions on keeping and selling A6 animals | $ 3,750 | - |
| Liberating declared animals | $ 7,500 | - |

Since feral goats can be perceived as either a pest or resource, their status is largely determined by the owners or managers of the land that shelters the animals. Pastoral zone fences are typically not goat proof and feral goats can move freely from property to property (Elliott and Woodford 1995). There is no legislation detailing to whom feral goats belong but landholders control the access to feral goats and whoever has rightful access has the right to destroy or capture them (Elliott and Woodford 1995). A dispute can arrive as neighbouring properties lay claim to the same feral goat population. This can lead to what is known as 'duffing' (stealing of feral goats) between properties but may also involve residents from rural towns opportunistically harvesting goats. Incidents of 'duffing' are more frequent with the high market price offered for feral goats.

The distinction between feral goats and domestic goats is not always clear as there are no morphological differences between them. Thee is no legal requirement to identify domestic goats by ear tags or other forms of marking (Elliot and Woodford 1995) but in order to protect property a registered brand or earmark is necessary. In Queensland, a registered brand or ear mark confers ownership of an animal (*Brands Act 1915*), however, pest status is independent of ownership. Branded animals can still behave as feral animals through lack of husbandry routine. To change the status of a feral goat to a domestic goat under the Department of Natural Resources and Mines policy, a mark of ownership needs to be supported by husbandry practices and infrastructure which demonstrates that the goat is now domesticated and no longer feral.

## 8.2 Queensland Department of Natural Resources and Mines Policy

The Queensland Department of Natural Resources and Mines 'Feral Goat Management' policy (March 1998) aims to 'minimise the impact of feral goats through providing technical advice on the control and management of feral goats. The most appropriate method which will be determined in each case by the actual damage being caused, land type, suitability of control methods, and potential for commercial utilisation.

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

> *Sustained control as 'the implementation of control on a regular basis to keep population at or below a threshold density at which the benefit of control is equal to or greater than the cost of control. Sustained control requires the development of pest animal management plans that include regular and integrated control options. (Integrated control is the use and combination of multiple control techniques).'*
>
> *Commercial utilisation (harvesting and hunting) as 'utilising animal pests as a resource is particularly appropriate for some species such as the feral horse, feral pig, feral goat and rabbit. Commercial utilisation can be integrated with other control methods to regulate pest animal numbers and should be incorporated in management plans.'*

To prevent the introduction of a feral goat problem to new areas the QNR&M policy is that 'harvesting of feral goats should have one or two conclusions, either a direct sale to abattoirs or, suitable containment and domestication so as to prevent goats returning to a feral or semi-feral state'.

## 8.3 Management Strategies in Queensland

The management of feral goats requires the development of appropriate strategies by major interest groups, including landholders, animal welfare groups and government (NR&M 1998). Flexible feral goat management combines the strategic management of pest impacts with ongoing evaluation of the techniques used. Flexible management strategies will also be able to reflect any changing circumstances such as drought, threats to neighbouring conservation areas, and rises and falls in goat prices.

### 8.3.1 Pastoral Zone

The main management methods used in the Queensland pastoral zone are mustering and trapping. Mustering is the most widely with many landholders mustering opportunistically. In times of high prices, good profits can be made by harvesting goats. Most landholders muster sheep or cattle in their day to day property management and the mustering of feral goats is merely and extension of this technique (Thompson *et al.* 1998). An advantage of mustering is that the costs can be offset by the sale of captured goats (Parkes *et al.* 1996).
Commercialisation is important in the overall management of feral goats. Between 1996 and 1998 the high price per head paid for feral goats has actively encouraged the management of the pest animal and some landholders have developed

appropriate infrastructure to contain the herds and undertake a breeding program as part of business diversification.

High prices also encourage 'goat framing' which occurs where landholders anticipate future economic returns by releasing some feral goats following capture to sustain a base population for harvesting at some time in the future. This type of 'farming' does not confer a change of status from feral to domestic and is an offence under the *Rural Lands Protection Act* (the release of a declared animal is subject t a penalty).

### 8.3.2 National Parks and Conservation Areas

The majority of National Parks and Conservation Areas in Queensland do not have a feral goat problem however, ones that do are found within the pastoral zone (e.g. Currawinya National Park) or on offshore islands. Management strategies include mustering, trapping and shooting with the aim to achieve significant decline in the population and if possible, to eradicate them. Shooting and trapping are used in areas that are inaccessible and difficult to muster because of thick vegetation. Eradication has been successful using dingoes on some offshore island parks e.g. Townshend Island.

### 8.3.3 Property Management Strategies

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

**1. Problem definition**: The problem, real or perceived, is defined and identifies the problem feral goats cause (e.g. soil loss, and loss or decline of vegetation) and compares it to the factors that can influence these impacts (other pests, weeds, climate, soil fertility). Once these boundaries are set, the economic damage and environmental damage can be assessed.

**2. Developing a management plan**: Clear objectives must be set to determine the production or conservation outcome. The available management options are considered and weighed accordingly. Several options are available for feral goat management including local eradication, strategic management, commercial management, and no management. The chosen management option needs to be determined through a process based upon the objectives and performance criteria. Flexibility and the ability to change in response to conditions and experience are a feature of the plan.

**3. Implementation**: Broad support for the plan is essential for implementation. Stakeholders should be identified and their involvement and 'ownership' of the plan should be encouraged from the outset.

**4. Monitoring and evaluating progress**: Monitoring of both the operational and performance components of the plan is essential if changes are to be made and deficiencies rectified.

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

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## Pest Status Reviews

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