



Australian Government

Department of the Environment

Threat abatement plan for competition and land degradation by unmanaged goats (2008)

Five yearly review 2013

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Conclusions on the threat abatement plan

The 2008 threat abatement plan for competition and land degradation by unmanaged goats has not achieved the goal of minimising the impacts of feral goats. The problem of the impact of feral goats is complex and as feral goat numbers rise the problem is increasing.

In 2008, when the threat abatement plan was released, much of the basic information required to manage feral goats was well known and published. Available techniques for feral goat management were publicised together with approved humane methods. There have been no significant developments in the management techniques of mustering, trapping and shooting since this time. There has been some research into the relative effectiveness of the different techniques and the numbers of goats necessary to remove to have any long-term change to the environment.

Some mustering and trapping techniques have been refined or modified for particular environments as programs have successes or failures. This is an ongoing process and it will continue to be important to disseminate this information to other land managers in similar situations.

Hunt (2012) is developing a goat feeding structure that will allow the specific delivery of toxins, where previously the use of toxins has been dismissed because of their likely non-target impacts on other species being too severe. Other goat control techniques of biological control or fertility control development have not been explored yet, probably because of the large research budgets that would be required.

The majority of land managers working on properties for conservation appreciate that it is not possible, or in many cases appropriate, to manage feral goats across their entire range in Australia. Therefore identifying high biodiversity (and cultural value) sites and working to protect these has been the focus for the land managers who are able to undertake feral goat control. Usually management will be undertaken for multiple pest species at the same time. Some research has been done since 2008 to inform management tools, especially related to the closure of water points to reduce the areas that can be accessed by feral goats and other herbivores or the strategic use of fencing between stock water points and conservation areas. This is being used in rangeland areas where natural water is usually a scarce resource.

Potentially the most important developments since 2008 in feral goat management have been in stakeholder management. These examples of land management practices have not necessarily been widely found but they emphasise the different methods needed to work together to achieve complementary outcomes as vital to success. Who to employ to muster or shoot your goats and under what conditions, the best way to close water points while still allowing adjoining properties to water stock, and how feral goat impacts can be monitored in semi-arid areas are important findings from management projects in the last five years. Studies have been undertaken that assess the total grazing pressure from livestock (including sheep and goats), kangaroos, rabbits and feral goats to assist rangeland farmers in identifying effective methods to utilise goats (managed or feral) and to understand the intertwined impacts of all the grazing animals.

Monitoring techniques to measure the specific impact on key native species have not been well developed. Neither has the relationship between feral goat density and damage in different ecosystems. It would be very useful for land managers to have clear guidance for their situation on the degree of intervention (culling of feral goats in some form) necessary and at what time, to keep threatened flora and fauna in an acceptable condition and promote their recovery. Monitoring of

outcomes from feral goat control is highly problematic because of the inter-relationships between goats and other species. Land managers often control multiple species at once to ensure unintended outcomes do not occur (e.g. rabbit management may provide more graze or browse for goats, or control of foxes may release goats from kid predation pressures). In these situations it can be hard to attribute the environmental changes just to the management of goats. Typically the monitoring of a management program is linked to the broader vegetation improvement.

It is concluded that the issues raised in the 2008 threat abatement plan and the objectives are still valid in 2012 and likely to be into the future. However, some of the actions under the objectives are not currently relevant or of the highest priority.

Introduction

The problem of feral or unmanaged goats and, in particular, how to abate the threat from competition and land degradation by feral goats is complex. As will be outlined in this review, the biodiversity impact of feral goats cannot be considered in isolation from primary production, cultural and social uses and impacts of goats. Goats were brought to Australia for their production value and are still an important species for meat, milk and fibre production. Their hardiness in arid environments including their wide range of grazing preferences makes them suitable as a production animal as well as having the characteristics that make a successful invasive species. In many parts of Australia, areas of production lie adjacent to, or are part of, areas that have high biodiversity value (for example the Stanthorpe Plateau region in NSW/Qld (Eco Logical Australia Pty Ltd, 2009)). This can create difficulties where the outcomes desired from the land and goat management (e.g. for biodiversity protection or primary production) are different. However, there are also examples where there is good cooperation between landholders to overcome these potentially conflicting objectives.

This review provides an overview on what is currently known about feral goat populations in Australia, a little about the goat industry for context, and then considers progress towards objectives of the 2008 Threat abatement plan for competition and land degradation by unmanaged goats. While goat management is ongoing for many landholders, there has been limited research and other activities in the last five years. Hence, the review does not go exhaustively through all of the actions in the threat abatement plan but considers what activity has occurred at the objective level and how this may have assisted in the abatement of the threat.

For the purposes of this review, goats that do not require human assistance for their needs and predominantly are not fenced in are referred to as feral. In parts of rangeland Australia goats that are mustered and may be kept to 'finish off' in holding paddocks may be referred to as unmanaged goats or domesticated feral goats (for example see Farmnote 83/2000 Department of Agriculture and Food, Western Australia (Western Australian Department of Agriculture and Fisheries, Reviewed 2007)). There are advantages in the use of the term 'unmanaged' in that it does not have the connotations associated with the slang use of the word 'feral' and land managers who are not specifically managing their land for biodiversity outcomes may more easily recognise their role with unmanaged goats compared to feral goats and how these unmanaged goats fit into their total grazing regime with other livestock. Consumers in some markets may also associate the word 'feral' with undesirable aspects to the goat meat. However, for simplicity this review refers to all goats that are not kept in paddocks as feral.

Finally, the review, and associated options paper, will consider how threat abatement for competition and land degradation by feral goats could be undertaken in the next five years. It is clear from the rising numbers of feral goats that the threat from feral goats to biodiversity has not been abated and this is a problem that will be ongoing.

Feral goat management in Australia in 2013

Feral goat numbers have risen in Australia over the last two decades and are continuing to do so. Pople and Froese (2012) looked at aerial surveys of feral goat numbers in the rangelands from 1984 through to 2011. The surveys, undertaken as a secondary survey when aerial surveys for kangaroo management are done, have found an increase in the feral goat population in the rangelands from 1.4 million in 1997 to an estimated 3.3 million in 2010. There was a peak in 2008 of 4.1 million. Across Australia this equates to:

- 491,000 in 2010 in Queensland (no goat survey in 2011). There have been increases across the state particularly in the mulga lands where goats have increased nearly five-fold in the 20 years of data collection.
- 2.95 million in 2011 in New South Wales. Increases were the greatest in the Cobar peneplain and Murray Darling depression, including through the years of drought.
- 322,000 in 2011 in South Australia. This number has not varied to any great degree over the years.
- 150,000 in 2011 in Western Australia, declining from a peak of 1.1 million in 2005.

These estimates may also include managed goats in rangeland situations, as it is not possible to distinguish them from feral goats in an aerial survey. Pople and Froese (2012) only report on the numbers and do not speculate about the reasons for fluctuations in numbers.

Feral goats are most abundant in the rangelands of Australia. In NSW the wetter areas have feral goat populations that are sparser or in isolated pockets (Russell, et al., 2008).

Goat harvesting has also been increasing. Meat and Livestock Australia (2011) quote Australian Bureau of Statistics (ABS) data indicating slaughter of both domestic and feral/unmanaged goats in 2010-11 was around 1.7 million and 68,000 goats were exported live. Pople and Froese (2012) suggest this is an underestimate because of the survey blocks in which the ABS data has been collected and amalgamated.

Goat meat production from rangeland enterprises comprises about 95% of total production and goat meat or live export of goats is worth about \$125 million in 2010-11 (Meat and Livestock Australia, 2011). These figures on the goat livestock and meat industries illustrate that goats are important to primary production in the rangelands of Australia even though they are significantly smaller than sheep or beef production.

Some farmers, predominantly in the rangelands, use feral goats to supplement their other livestock grazing when the prices for goats are high enough. The feral goats are mustered or trapped and the goats that are saleable are sent off. The remainder are either kept in goat proof paddocks until they have reached a suitable sale size (>25 kg live weight) or they are released again to grow to a suitable size. Both of these methods are advantageous to the farmer as there is significantly less need for fencing and other livestock infrastructure. The small amount of infrastructure required for feral goats can then be used for sheep or other production while not being used for goats.

This utilisation of feral goats can contradict biodiversity outcomes where the grazing and land degradation by feral goats impacts on native species or ecological communities. For example the malleefowl (*Leipoa ocellata*) is threatened by goat browsing in the Lachlan River catchment. Isolated breeding groups of malleefowl occur within highly specific mallee vegetation patches that are rare in the general mallee woodlands of the western Lachlan catchment (poster by Lewis et al. (2012) for the Australian Rangeland Society 17th Biennial Conference Kununurra, Western Australia). Lewis et al. (2012) outline the difficult dilemma in balancing conservation outcomes and maintaining an income

for landholders. A landscape scale fencing method to passively remove feral goats from critical breeding habitat is being utilised. Initial results have shown a positive vegetation outcome for the fenced sites and the fencing is now attempting to “control traffic” to direct the goats to lower value areas.

These contradictions in biodiversity versus primary productivity outcomes can occur on both private and public land, particularly in the rangelands where there may be tracts of land that have not been modified to any extent. The current threat abatement plan, and other documents, acknowledge that there is a tension between the resource utilisation of feral goats by farmers and the need for an abatement of the threat to biodiversity from feral goats.

Conflicts or difficulties can arise where adjoining landholders have different views on the value of feral goats. Conservation areas, such as national parks, have a need to manage feral goats on their lands, whereas some farmers see the goats as an asset waiting to be harvested. There are some examples in rangeland areas where a cooperative approach with landholders is used such as modifications on boundary fencing around water-points instead of closure, opportunities to retrieve domestic goats that have strayed into conservation areas and improvements on boundary fencing. Conservation areas in the rangelands, particularly those that have joint management with Indigenous people or with a station owner, are likely to use harvesting of feral goats to supplement other income. Care needs to be taken to ensure that reduction targets for the biodiversity outcomes are being met.

There is also a difficulty with goat farming in that they will challenge fences and fences that are appropriate for other livestock such as sheep and cattle are insufficient for goats (Parkes, et al., 1996). Goats will also quickly utilise breaches of fences by native wildlife such as wombat or kangaroo holes. The construction and maintenance of suitable fences is both expensive and time consuming.

While not the subject of the threat abatement plan, a third element of the problem of feral goat management is with cultural values. Heritage sites, particularly unprotected Indigenous art sites, are increasingly being damaged by feral goats as their numbers build up. Some tourist or camping destinations are being compromised by feral goats in western NSW (e.g. ABC report from Mutawintji National Park NSW 3 October 2012 (Australian Broadcasting Corporation (ABC News), 2012).

With the increase in feral goat numbers, which has not been kept in check by an increased rate of harvesting, these conflicts are likely to increase. It will be important for all concerned to appreciate the reproduction rate of feral goats has a theoretical maximum of doubling every year, and a likely rate of a bit lower (Pople & Froese, 2012). With current rates of harvesting this still results in an increase in feral goat numbers. The fluctuations in numbers of feral goats in response to drought appears variable with a reduction in numbers since 2005 in Western Australia being attributed to drought but in New South Wales there have been few fluctuations and a general increase over time (Pople & Froese, 2012).

Feral goats are predated on by wild dogs, foxes (main predator of kids in eastern Australia), wedge-tailed eagles and feral pigs. The NSW Department of Primary Industries has observed that large numbers of goats do not occur in areas where dingoes are abundant. Goats are rarely present in northern Australia unless wild dogs are absent or controlled to low densities (New South Wales Department of Primary Industries, 2012).

The increasing goat numbers provides an increasing challenge in the attempt to abate the threat of competition and land degradation by feral goats. It will be important, as the current threat abatement

plan has highlighted in its first objective, to continue to identify high priority areas in Australia where feral goats are having the biggest impact on threatened species and ecological communities or other elements of biodiversity deemed to be important.

Objectives of the threat abatement plan

The first section has provided an overview of the issues surrounding feral goats. Their specific impact on biodiversity is outlined in the 2008 threat abatement plan and background document – the nature of this impact has not changed. This section of the review considers each of the objectives of the threat abatement plan and what work or management has occurred in each of the areas since 2008.

The goal of the threat abatement plan is to minimise the impact of feral goat competition and land degradation on biodiversity in Australia and its territories. Each objective has subsidiary actions. In this review, the actions are not analysed in depth as this is likely to lead to significant repetition and gaps in the review, but rather there is a discussion of progress made towards each objective.

OBJECTIVE ONE – ‘island’ management

Prevent unmanaged goats occupying new areas in Australia and eradicate them from high-conservation-value ‘islands’.

Performance indicators

- No further establishments of unmanaged goats in goat-free areas of high conservation value.
- Successful eradication of isolated populations of unmanaged goats where this is attempted.
- Increased populations of affected native species in areas from which unmanaged goats, and other invasive species, have been eradicated.

This objective is focused on determining where goats are causing an impact on environmentally sensitive areas and where the relevant land manager can undertake a management action to eliminate or reduce the impact. There is a focus on islands within the objective, be it an offshore island or isolated area of the mainland, because long term benefits can more easily be obtained from areas where feral goats are not going to reinvade as soon as the control action is completed.

Offshore islands

Offshore islands are a good target for goat eradication because, while initially expensive, it is an extremely cost-effective undertaking because there is no long-term immigration that needs to be managed. It is also easy in comparison to many other feral animals to keep goats from invading other close-by offshore islands as they are reluctant swimmers (Parkes, et al., 1996).

Mainland “islands” or isolated areas are also worth considering where there are no immediately adjoining areas with feral goat populations because the chances of immigration are reduced and, potentially, handled more easily if they arise. The threat abatement plan outlines an example of the removal of isolated populations from the late 1980’s and early 1990’s where feral goats north and northeast of Alice Springs in the Northern Territory were eradicated.

During the life of the threat abatement plan (since 2008) three island eradications for feral goats have been attempted. The first of these has been from Kangaroo Island in South Australia. A case study of this eradication program is below. The second is the commencement of a goat eradication program on Dirk Hartog Island in Western Australia. This island was purchased by the WA Government in 2010 as an important biodiversity site and eradication of goats is part of a larger plan to remove all the feral animals from the island. Further detail on this eradication attempt is provided under the Australian Government funding section on page 28.

Case Study 1: Attempted eradication of feral goats on Kangaroo Island, South Australia

Kangaroo Island Natural Resources Management Board South Australia in association with the Invasive Animals Cooperative Research Centre, the SA Department of Environment and Heritage and the SA Department of Water, Land and Biodiversity Conservation commenced an eradication program in 2006 (South Australian Kangaroo Island Natural Resources Management Board, 2011) (South Australian Kangaroo Island Natural Resources Management Board, 2010)(pers. comm. Pip Masters, South Australian Kangaroo Island Natural Resources Management Board, email 19 October 2012) (Markopoulos, et al., 2009). In late 2012 it was believed that all feral goats have been removed but monitoring is still ongoing.

The island was identified as a significant national biodiversity hotspot and the management, and eradication where possible, of feral animals such as goats is crucial for conservation of vegetation at threat by their browsing. Their exact impacts were not clearly understood as goats have been on the island for nearly 200 years.

The distribution of feral goats on Kangaroo Island (KI) was restricted to the north and west coastal areas. The area was divided into seven eradication management units. The key to this eradication program was the use of Judas goats to locate the feral herds. Judas goats were obtained by capturing some island feral goats using a yard trap and others brought in from two mainland locations. A jump-down trap was constructed around a watering point but this was unsuccessful due to disturbance of the herd by human presence while building the trap and subsequent rainfall. The Judas goats were sterilised (either a vasectomy or fallopian tubular transaction) in a way that mean the animals maintained sexual motivation and other behaviours associated with intact animals. Both the male and female Judas goats were successful in finding feral goats in both high and low densities.

On-ground shooting teams of two to three skilled people proved to be manageable and safe for herds of up to 16 using .308 calibre firearms. An aerial shoot was also undertaken following a large bushfire. The aerial shoot was held in difficult flying conditions often experienced on KI.

Estimates of the control cost for one of the larger management units in the Finders Chase National Park were \$71.71 per goat for the first 164 goats (strategic ground shooting only); and \$237.75 per goat for the last 18 goats (ground shooting and Judas goats). The aerial shoot shot 111 goats for a cost of \$363 per goat.

Key elements of the program were:

- a zero escape policy for herds found by the ground shooting teams
- professional ground shooting teams of two and three people for herds of up to 18 goats. The calibre of firearm (.308) allowed quick kills, minimised the risk of injured animal escapes, allowed destruction at close range as well as longer shots, and had good wind bucking ability for a windy site.
- in the management units that did not require park closures opportunistic control activities were frequently used. Every time the team went out they took a firearm. In this management control unit it only took 10 months to remove all the feral goats.

- systematic walks in the management areas requiring closure to find where the herds were located. They were then left undisturbed until a park closure was approved for hunting.
- aerial shooting was conducted after a bushfire and when the upper vegetation had dropped its leaves. Strong winds made the shoot less successful and, for Kangaroo Island, the skilled ground shooting teams were more cost-effective.

All goats destroyed during the program were recorded for their key statistics and stomach samples collected from some to indicate the vegetation being consumed. This has provided the Kangaroo Island NRM Board with good information about their feral goats including size, reproductive information and the plant species being impacted. This information as it was collected informed the ongoing eradication program.

Important points in getting community support for the eradication program and access to local property was employing two locals who were already hunting and had the contact with local landholders and the community (through sporting clubs). Pip Masters (Department of Natural Resources and Environment) said "...we really underestimate the value of trust which is difficult when you are new to an area. Before the program begun, one of the larger landholders basically said he would not allow anyone with a gun on his property with the exception of 4 people, two of whom we employed." The eradication program really focused on the community relations and found that face to face discussions were the best method of getting people on side, some of whom liked the goats. The program actively chose to work first in the national park, second in the supportive landholder areas and finally in the areas where landholders were initially not supportive to counter arguments and provide a demonstration that the program was working.

A key to the ongoing success of the eradication program on Kangaroo Island will be the security of the domestic goat herds on the island. Public support for the eradication was high. Public information has been produced about ensuring the security of domestic goat herds. The significant challenge for the island will be compliance by the non-resident owners.

The third is Faure Island in the Shark Bay World Heritage Area where the last goats were killed in 2010 (pers. com. Fay Lewis, Australian Wildlife Conservancy, 5 December 2012). The eradication of feral goats together with other management actions followed the purchase of the island by the Australian Wildlife Conservancy. The Australian Wildlife Conservancy have not been able to ascertain the impact of removing goats from the island in monitoring vertebrate and vegetation changes because it took place at the same time as other management actions including the removal of sheep. The removal of goats and sheep has allowed the reintroduction of small native mammals.

Ecosure (2009) undertook a desktop analysis of Australian Government offshore island databases of feral animals and threatened species. This study prioritised islands that showed greater biodiversity value and identified where feral animals were a problem, including goats. Ten islands out of the top 100 islands greater than 200 hectares have goats present (refer Appendix A). The department is not able to make an assessment of the level of uptake of this information or whether land managers are using it to identify islands of high biodiversity value. However, the information is freely available and the department has promoted the report/information to island managers (e.g. Island Arks Symposium II (7-9 February 2012)).

Mainland islands

A desktop study of Australian Government databases containing species lists of islands by Eco Logical (2009) identified high biodiversity value mainland 'islands'. Part of this analysis included feral goats. This report identifies islands where goats are present and the potential impacts of goats on threatened species (e.g. Armidale plateau has goats potentially impacting on *Bertya ingramii*, *Petrogale penicillata*, *Hakea fraseri*, *Underwoodisaurus sphyrurus*). Appendix A has a list of 34 mainland island areas where goats are identified. Seven of these areas have management plans that specifically identify goats as an issue and some identify specific management actions that are required. Of the other 27 islands either an appropriate management plan has not been found or other management issues are identified instead of feral goats. As with the offshore islands report, the department is unable to assess the level of use of this report by land managers.

In NSW, Russell et al. (2008) have proposed the division of management for feral goats into three broad management zones. The Eastern feral goat management zone covering the higher rainfall coast and ranges where food and water tend not to be limiting; the Central feral goat management zone covering the wheat/sheep belt where goats tend to occur in islands of native vegetation with little immigration; and the Western feral goat management zone that covers the arid and semi-arid rangelands. These broad categorisations of zones based on landscape are likely to be similar for other parts of Australia. In particular the isolation of goat populations in the central zone is particularly applicable for applying an "island" style of management where the population is reduced or, where possible, removed from an area and immigration from other areas is prevented. The resident population can then be managed to prevent build-up through breeding. Many of the sites identified in the Eco Logical (2009) report are either in this central feral goat management zone or the eastern zone where again the populations are typically isolated (a significant challenge with the eastern zone can be the rugged terrain).

It should be noted that, at least in NSW (pers. comm. B Russell, 25 March 2013), feral goats are causing significant problems in conservation areas in the western feral goat management zone or the rangeland areas of NSW. The population of goats in the rangelands is essentially contiguous with the provision of artificial watering points and the nomadic nature of feral goats when conditions are very dry (Russell, et al., 2008). Any control of goats to protect values in national parks or nature reserves requires constantly high levels of culling, trapping and harvesting to keep pace with the high levels of immigration. For example, on one park dung counts (see (Mitchell & Balogh, 2007)) indicated there were approximately 3000 goats. A contractor harvested approximately 2500 feral goats to significantly reduce the population. However, a month later the same contractor was able to harvest a similar number indicating a very high level of immigration. The ongoing dung counts confirmed immigration was the problem as dung levels fluctuated in accordance with the harvest (i.e. it was not an incorrect estimation of population) (pers. comm. B Russell, 25 March 2013). Therefore, in these continuous rangeland areas the concept of being able to manage a high biodiversity area as a mainland 'island' in isolation from surrounding populations is unworkable.

Conclusion

The premise of this objective is that it is not possible to control goats everywhere across Australia. However, it is not clear that, even where goats are identified as being present in an area of high biodiversity value, the necessary management of the population is occurring.

The situation for offshore islands appears comparatively simple with only a few islands where they have been identified as present and the island has a high biodiversity value. Two of these have been targeted for goat eradication – Kangaroo Island and Dirk Hartog Island. Faure Island has completed eradication and some of the others have some goat management in place.

There are areas in the Australian landscape where feral goat populations are relatively isolated from each other such as throughout the wheat-sheep belts of intensive farming where there are parks and reserves that may contain isolated populations. These areas are good for treating as a mainland island, and this is recognised in NSW, and possibly elsewhere.

With mainland islands there may not be recognition of either the high value of a particular region or the threat that feral goats may pose to vegetation loss and land degradation. The impacts may have been occurring over a long period and the slow build-up in feral goat numbers over the last two decades will have only gradually changed the flora present or the appearance of the land. If so, it may be easy for land managers to overlook the problem of goats until it reaches a critical threshold.

Another reason for a lack of goat management is that the resources of the land manager may not be sufficient for consistent longer-term in management of feral goats to allow the recovery of native flora and fauna. In areas where feral goats are affecting biodiversity there are often other problems such as major weed infestations or fire management that may require the more immediate attention of land managers.

It is concluded that progress is being made towards achieving this objective but, as feral goats will always be a problem on the mainland, the prioritisation of where management action is required to protect areas of high biodiversity will also be an ongoing task. However, the recognition of areas of high value biodiversity that are threatened by feral goats in combination with the availability of appropriate techniques for managing feral goats may assist land managers in obtaining resources.

OBJECTIVE TWO – recovery of native species

Promote the maintenance and recovery of native species and ecological communities that are affected by competition and land degradation by unmanaged goats.

Performance indicators

- Priority areas, where goat control is required to protect important affected flora and fauna, have been identified and are a focus for unmanaged goat control programs.
- The effectiveness of programs to control unmanaged goats is measured through pre and post-control monitoring of unmanaged goat populations and of key native species.

The biggest challenge to achieving effective management of feral goats in priority areas has been the availability of ongoing funding to conduct and monitor regional goat control. The level of funding required for ongoing control is significant to prevent repopulation through breeding or immigration.

Contracts for harvesting are another common treatment for feral goat populations, especially in the rangelands, as this can be a viable industry for musterers. However, mustering is only viable in the long term in rangeland areas during dry spells where water is scarce and the feral goats mob together, and the mustering contractors are able to profit from the work. For mustering to be successful in achieving threat abatement, all feral goats mustered or trapped must be removed from the landscape. Mustering only the goats of saleable weight (approx. >25 kg) (Jones, 2012) and releasing the rest to grow means further damage by those animals and breeding stock (females can breed at 15 kg weight/6 months of age) (Queensland Government Department of Agriculture, Fisheries and Forestry, 2010).

Conservation areas such as national parks and private reserves are able to identify when feral goats are causing a significant impact and this is reflected in their plans of management. For example, in South Australia goats are identified in management plans where their grazing is impacting on the vegetation. The closure of unnecessary water points (in rangeland areas) is a common treatment proposed where surface water is scarce to create large tracts of land without easy access to water for goats and other feral animals. Russell et al. (2010) found in a study that manipulated feral goat access to water in a rangeland area, that goats are rare greater than 4 km from water (also see Figure 1 under objective 4). As expected, Russell et al. (2010) also found that by closing water-points leaf litter improved within 12 months and vegetation cover was anticipated to improve as well. This distance from water can be utilised by reserve areas that are bounded by neighbouring properties where the water points are required for stock. A goat-proof fence (8-90-30 hinge joint with a barbed wire strung 20 cm above the top of the hinge joint) extending 4 km in either direction from the water point will prevent the feral goats from entering the reserve. By not making the goat-proof (and hence animal proof) fence fully enclose the reserve area, native species with a greater range such as macropods retain the freedom to move (Russell, et al., 2010).

The plans of management for the conservation areas acknowledge the need to have some sort of arrangement in place with neighbours (such as participation in water point closure, fencing, ensuring managed stock that stray have ear tags so they can be identified) to prevent or manage re-invasion from neighbouring properties.

In rangeland areas feral goats need to be managed to prevent over-grazing/browsing of the groundcover and prevent surface soil erosion. In a series of six reports prepared for the NSW Western Catchment Management Authority feral goat management in the rangelands is investigated. Kimball

and Chuck (2011) observe that the commercial harvesting industry is very much divorced from any moves to manage goats for environmental or natural resource management reasons. Ferguson (2012) identifies the specific problem of land degradation, especially soil erosion problems, caused by large numbers of harvested underweight goats being held within total grazing pressure paddocks to grow to a size suitable for the market. Because of the goats' ability to utilise both the grazing grasses and herbs and the browsing shrubs there can be a tendency for grazing mismanagement. Both of these reports go beyond discussion of the threat abatement plan objective of promoting the maintenance and recovery of affected native species and ecological communities to discuss the broader issue of vegetation in the rangelands. However, if the natural resources of the rangelands are allowed to become severely degraded over broad areas it can be inferred that this will be detrimental to the recovery of identified native species and ecological communities.

The Mutawintji Lands, in which the Mutawintji National Park lies, have the only known population of the yellow-footed rock wallaby or Wankarru (*Petrogale xanthopus*) in New South Wales (NSW National Parks and Wildlife Service, 2010). Feral goats browsing in the rocky areas where wallabies live are a threat to this population through food competition. The park management plan recognises the threat of feral goats, as well as the European red fox, to the yellow-footed rock wallaby (NSW National Parks and Wildlife Service, 2010). The park management plan also recognises the direct threat to soil erosion from trampling by goats that breaks the crust on the soil surface, and the indirect threat from vegetation removal by goats. Other national parks have similar management plans or may be broader in their recognition of feral goats as a threat requiring management.

Mutawintji National Park is also used as an example of where the protection of an area of cultural significance can flow through to the protection of biodiversity (NSW National Parks and Wildlife Service, 2010). Mutawintji National Park is renowned for its Aboriginal art sites. Feral goats are using these caves and rock overhangs, which is causing damage to the artwork and soil erosion. The recognition of this problem has helped with feral goat control in the park. Around the important rock art sites fencing and goat mesh (similar to cattle grids with the spacing unsuitable for a goat's hoof) are used to prevent the goats camping in the cave areas rubbing on the artwork (oils, dirt and possible chemical deterioration of pigments and rock surfaces from the goats' waste). The managers have also identified the park as a site where it is inappropriate to use aerial shooting as a control for feral goats as ricocheting bullets have previously damaged rock art sites. The fouling of culturally significant water holes by goats may also provide impetus for feral goat management in some other national parks.

In Western Australia, the Mt Gibson Sanctuary, owned by the Australian Wildlife Conservancy, identified feral goats as one of the threats to the important flora resources on the property. It is located in a transitional area between the eucalypt and the mulga lands and contains 13 major vegetation associations so is an important biodiversity asset. While the property had only been lightly grazed with sheep, goats were a problem. The feral goat population is restricted to the northern part of the property as the goats are an economic asset to the northern neighbour. The Australian Wildlife Conservancy was able to reduce the population to small numbers simply by turning off bores on which they relied. Since then, the feral goats have been managed through organised culls if mobs are found, or through opportunistic shooting. The Australian Wildlife Conservancy has not been able to attribute any changes in vegetation specifically due to the removal of feral goats because this is only part of the larger management program for the property (pers. com. Fay Lewis, Australian Wildlife Conservancy, 5 December 2012).

The Australian Wildlife Conservancy has an approach at its other properties where feral goats occur (Buckaringa, Scotia, Paruna and Bowra) of continually removing small populations to prevent them becoming a major problem through regular culling or mustering. At both the Paruna and Bowra properties these feral goat culls are only sporadic as goats make incursions to the properties. The Australian Wildlife Conservancy believes one of the most important factors in controlling feral goats is having vigilant, on-ground staff that are experienced and equipped for dealing with the issue in the most appropriate way for the particular circumstances (pers. com. Fay Lewis, Australian Wildlife Conservancy, 5 December 2012).

Bush Heritage Australia has control programs for feral goats on their reserves where goats have been identified as requiring management. At Nardoo Hills in Victoria incidental shooting of feral goats is used and at Boolcoomatta Reserve in South Australia the feral goats are managed in conjunction with the South Australian Department of Environment, Water and Natural Resources and other land holders, as part of the recovery of the yellow-footed rock wallaby. This is an aerial shooting program. Feral goat control on both Nardoo Hills and Boolcoomatta commenced shortly after destocking. Other invasive animals were also controlled at the same time, such as foxes and rabbits. This makes it challenging for Bush Heritage Australia to measure the specific ecological outcomes of feral goat management as it is critical that all these species are co-managed to prevent unintended release of these species from predation pressure or competition. However, Haywood et al (2011) were able to measure a significant reduction in their home range to less than 50% of the estimated area in the early 1980's. The authors hypothesise the removal of sheep and control of the goats has allowed yellow-footed rock-wallabies to forage over smaller areas close to refuges from foxes. This has the double effect of removing competition and predation. More generally, good rainfall at Boolcoomatta Reserve has also compounded the difficulty of measuring the change due to the control of the feral goats. However, Bush Heritage Australia (pers. comm. Jim Radford – email 20 December 12) says the condition of the woodland understory around the wells where feral goats used to congregate has improved markedly.

This objective has identified an action to apply incentives to promote and maintain on-ground control of unmanaged goats on private or leasehold lands within or adjacent to priority sites. As stated, this action is beyond the resources of the majority of land managers of conservation areas (or those wishing to undertake conservation activities as part of natural resource management activities) and many government funding programs do not consider funding long-term ongoing management activities. There is further discussion below about the ways in which some parks and reserves are able to work with adjoining landholders but this tends to be on a cooperative basis rather than through provision of incentives. The case study below is one example from South Australia where incentives have been trialled.

Case study 2: Cross-regional strategy in SA to trial incentives for land managers

The South Australian Arid Lands Natural Resources Management Board developed a cross-regional feral goat management strategy in 2008/09 covering the land areas in the Murray Darling Basin, Northern and Yorke, and Arid Lands (South Australian Arid Lands Natural Resources Management Board, 2009). Under the strategy, the South Australian Arid Lands NRM Board ran a trial to provide incentives to land managers to remove goats to a lower level than the historic norm for their property.

Technical experts and coordinated control were offered where the methods exceeded individual landholders capacity to access, and included aerial shooting, aerial mustering, portable yards, trap yard materials or a combination of techniques as suited the property and landscape. The Board, after an initial period, made it compulsory to have an aerial shoot following aerial mustering to remove remaining goats that would otherwise quickly breed up again.

Landowners were initially reluctant to do this as it removed the goats that they would be able to muster in the near future. This suggests (note: reviewer's comment – not stated by the report) that the incentives paid to landowners may have been viewed as additional income rather than aiming to achieve the natural resource management improvements gained by a longer-term knockdown in feral goat numbers.

The results from the trial showed that aerial shooting and aerial mustering were most time efficient but that aerial shooting in particular was the most expensive at \$14.30 per goat. Where aerial mustering and culling activities were carried out on properties in combination, the proportion of total goats removed by mustering demonstrated that mustering left behind significant proportions of feral goats at each property (33-65%). With 43% of populations needed to be removed annually to reduce the population size when food is not limiting, (paper quotes Henzell (2007)) these results suggest that mustering alone is unlikely to achieve lasting population reductions.

As with the work on Kangaroo Island with the goat eradication program (see objective one), contacting and gaining support from land holders was a key element. This required direct contact with people and was time consuming to travel to properties in the semi-arid areas of South Australia.

Monitoring and evaluation of the trial lead to some recommendations. It identified a need to include a systematic herbivore – including goat – count in the current aerial and ground kangaroo and rock wallaby surveys. For each herbivore, correction factors for the numbers spotted versus the actual numbers on the ground need to be calculated for different habitat types. Research into the impact of feral goats on natural waterholes, including aquatic and other dependent biota, is needed. Finally, further work on indicators and monitoring programs for specific habitat types and sampling intervals needs to be undertaken to improve impact-based monitoring.

A current example of cooperative feral goat management by a number of landholders is the Cumberland Livestock Health and Pest Authority (LHPA) aerial management program. This is in the Wollondilly, Wingecarribee and Paddys Rivers corridors within the Upper Warragamba Catchment, NSW. The participating landholders are the Cumberland and Tablelands LHPA, Hawkesbury-Nepean Catchment Management Authority (CMA), the Sydney Catchment Authority (SCA), National Parks and Wildlife Service (NPWS), Crown Lands and landholders to ensure all land tenures are covered. The aerial shooting program has been run since 2003. The LHPA has identified that feral goats impact on native vegetation, rock wallaby habitat and potentially reduce water quality through fouling. In 2012, the program received funding of \$50,000 from the Hawkesbury-Nepean CMA through the Australian Government's Caring for our Country program and in-kind contributions from landholders, LHPA, NPWS, SCA and Crown Lands. The aerial control program shot 506 goats in 2012 as well as opportunistic destruction of other feral animals. The program has shot over 3400 goats from the area

over several years and has observed improvements to vegetation, soil and water. See the Cumberland Livestock Health and Pest Authority website (www.lhpa.org.au/news/successful-goat-control-program-reaps-benefits - accessed 28 March 2013) for more information.

At Mutawintji National Park, managers have employed strategies to ensure the mustering of feral goats in the park does not provide an incentive that has perverse conservation outcomes through the ongoing income from goats. Feral goats are mustered within the park and sold to abattoirs. Adjoining landholders do the same and this is a source of income for all the land holders. In many mustering situations, goats under a certain size or age are released to grow more before it is economical to send off to an abattoir. Release of any feral goats is prohibited in the park and the National Park Managers use a strategy of employing three contractors on a monthly rotation to remove the perception of goat farming because contractors will not release any goats for the next contractor. All contractors use dogs on foot and are restricted to services tracks only with their vehicles to minimise vegetation and soil damage from operations. The move from a single contractor to multiple contractors in 2006 had an increase of approximately 470% in annual goat captures initially (Norman, 2008). The management of the feral goats at Mutawintji National Park and Nature Reserve will be ongoing due to recolonization from surrounding areas.

Conclusion

The biggest difficulty faced by managers in protecting flora and fauna from degradation by feral goats is funding the long-term control of feral goats in high priority areas. It is often beyond their resources to provide funding to participate in cooperative regional control programs with neighbours. Where neighbouring properties have aligned interests in feral goats or their management, this may be done in a cooperative manner and may utilise external funding obtained by one party as well as providing in-kind support. However, there is no evidence of incentives being used to promote control programs on private or lease-hold lands adjacent to priority sites. A second difficulty is the high costs of undertaking continuous control programs, especially in areas where immigration levels are high and rapid.

OBJECTIVE THREE – knowledge of goats

Improve knowledge and understanding of unmanaged goat impacts and interactions with other species and other ecological processes.

Performance Indicators

- Reliable monitoring techniques have been developed for unmanaged goats.
- Control of unmanaged goats is better integrated with control of other vertebrate pests.
- The unintended effects of programs to control unmanaged goats are minimised.

Objective three is focused on providing an improved understanding of feral goats and the habitats in which they live so as to better undertake management through targeting control programs. The control programs can be targeted to times or sites, or through joint management programs with other species to reduce the problems from unintended effects, and to improve the restoration of those ecosystems.

The publication *Managing Vertebrate Pests: feral goats* (Parkes, et al., 1996) is still the definitive book on goat management including their biology, measuring abundance and impacts and control techniques.

Methods for monitoring feral goat abundance and impacts were comprehensively outlined by Mitchell and Balogh (2007). However, short of obvious differences (e.g. grazing height on shrubs will be higher for goats than rabbits) there was no simple, cost-effective method for determining impacts of feral goats relative to other sources of impact until 2013. Work on the links between the impacts on specific key species from different densities of feral goats has been started in semi-arid areas by McDonald and Brandle (2009) and Lethbridge et al. (2013).

McDonald and Brandle (2009) evaluated ecological indicators of goat impact in semi-arid rocky ranges in South Australia. They were able to identify a suite of plant indicator species and put these plants into four classes of growth according to the amount that the goats had browsed them. *Uninterrupted* was classed as no or minimal browsing, *arrested* was where the outer new growth had been pruned, *retrogressed* was where the older woody growth had been eaten away as well, and *released* was where browsing had ceased and growth was recommencing. In the short-term (the report was unable to cover any longer term measurements) it was possible to compare the dimensions of the plants in the four classes to measure recovery after goat control. They believe this monitoring method may also be applicable to arid rocky areas.

Lethbridge et al. (Lethbridge, 2013) have developed a framework to link activity measures to the density and impact of pest herbivores. This included feral goats in semi-arid sites. For feral goats the growth form of McDonald and Brandle (2009) is important and Lethbridge et al. (2013) also found that the thickness of the tip of growing parts was a key indicator of the age of the wood that has been exposed by browsing (i.e. thicker is older and hence more heavily browsed). To link this to activity and density, goat dung accumulation was correlated to aerial survey data in high and low density areas. Lethbridge et al. (2013) have translated these indicators into a Resilience Failure Indicator containing five risk levels. A zero risk level being low goat activity and no vegetation arrested, two being all the high palatability species arrested or retrogressed, and five being all species retrogressed. [note: *report not yet released by CfoC – information from a talk by Lethbridge 7 May 2013*].

It has been established for some time that other livestock species, rabbits, macropods, foxes and wild dogs/dingos will effect the impact that goats have through competition or predation. McMurtrie et al. (2010) compared the results of groundcover in a grazing regime where some areas had feral goat harvesting and other areas were fenced with total grazing pressure control fencing to completely remove feral goats and other grazing species. Managed goats were selectively allowed to graze these paddocks on a rotational system. The results showed that perennial groundcover recovered to a much higher degree in the total grazing pressure paddocks. The other areas, even though goats are controlled with about 50% removal, are never completely spelled from grazing. Further work in this area is required to also determine the impacts from other grazing animals – sheep, rabbits and macropods.

One study has been undertaken to investigate the recovery of vegetation following water point closure. Fensham and Fairfax (2008) identified water remoteness thresholds for various grazing animals and Russell et al. (2010) manipulated access to water and found an immediate (12 month) improvement in leaf litter cover and presumed this is likely to have a response in both browse regrowth and ground vegetation. Westbrooke et al. (2010) considered the biodiversity effects of closing ground tanks in the rangelands and found close to the water-points higher mammal activity, a greater species richness of birds very close with a predominance of honeyeaters and parrots, greater ant diversity but fewer ground nesting birds, reptiles and small mammals immediately adjacent (these mammals were more abundant out to 500 m). This study did not specifically consider feral goats but will help inform land managers about the potential impacts on other native species when closing water points for feral goat control.

It is known that rock wallabies are impacted by feral goats through competition for both food and shelter sites (e.g. Mutawintji National Park Plan of Management, Cumberland Livestock Health and Pest Authority – examples given above). However, no specific work has been found that has considered the potential unintended effects of feral goat control on rock wallabies, such as moving predation pressure by wild dogs/dingos from feral goats onto rock wallabies.

Conclusion

The reasons for this objective are well understood. Reliable monitoring tools were available at the time of the writing of the 2008 threat abatement plan but being able to distinguish between the impacts from feral goats and some of the other herbivore species is not so clear cut and there have been few additional resources published since 2008. The work by McDonald and Brandle (2009) and Lethbridge et al. (2013) have developed tools for semi-arid areas and it would be useful to have this quantified for other habitats.

Little information has been produced in the last five years about the interactions between the impacts of feral goats and other species other than a consideration of total grazing pressure for primary production stocking rates. The total grazing pressure for primary production and the potential impacts on the rangeland vegetation have been identified by the NSW Western Catchment Management Authority (e.g. Kimball and Chuk (2011) and Ferguson (2012) – see objective two).

Therefore it is concluded that there has been little work published on the objective but recent work on impact indicators suggests there are now some good tools for improved design of programs for feral goat management.

OBJECTIVE FOUR – control options

Improve the effectiveness, target specificity, integration and humaneness of control options for unmanaged goats.

Performance indicators

- Increased proportion of goat control programs use ‘best-practice’ techniques.
- Increased use of exclusion fencing in situations where it is considered to be more cost-effective than ongoing control of unmanaged goats and to protect critically endangered species.
- Increased adoption and adaptation of the model codes of practice and standard operating procedures for humane management of unmanaged goats, including their recognition as a reference under the National Competency Standards for Vertebrate Pest Management.

Objective four is focused on providing land managers with better tools to undertake control programs for feral goats. This objective has seven actions to look at self-mustering trap systems, water-point closures, toxins, and exclusion fence designs for the control of feral goats. It also considers how to best help land managers including training programs, model codes of practice and standard operating procedures, and commercial use approaches.

Effectiveness

There are two main control techniques used for feral goats - mustering or shooting.

Mustering may be done with self-mustering systems usually related to water points with one-way gates or jump down traps. These are only useful when there are relatively few water points and the goats are water stressed such as during summer in the rangelands. Otherwise, mustering is done using more conventional techniques but, likewise, is more effective when the goats are water stressed as they do not range as far and tend to mob. Access to some areas (such as the rangelands in Western Australia (Forsyth, et al., 2009)) is also severely restricted during or up to a month or so after significant rain. Some improvements to the basic self-mustering systems have been explored but there have not been any great improvements such as the use of new technologies (the 2008 threat abatement plan suggests research into using ‘machine vision’ species recognition).

The objective also includes the action of looking at technologies related to water point management such as bore capping. Technologies for doing this have progressed, driven from broader water management needs, rather than for the management of feral goats.

Target specificity

Exclusion fence designs are the same as for boundary fence designs for goats on farms (also known as total grazing pressure fences). There are special requirements for goats as they will challenge any fence and are adept at getting under and over fences. There are a number of different sources of this information and it is readily available, including cost estimates for different sites (e.g. Western Australian Department of Agriculture and Food (Undated), NSW Department of Primary Industries (2003)). One of the challenges of using exclusion fences in conservation work is that they prevent movement of native species as well as invasive species such as feral goats. The Australian Wildlife

Conservancy property at Buckaringa in South Australia has identified goats and foxes as the main threats to the yellow-footed rock-wallabies but installing goat-proof fencing on the boundary is challenging due to the topography and the need to maintain free movement for the yellow-footed rock-wallabies to and from neighbouring properties (Australian Wildlife Conservancy, no date).

Rob Hunt, NSW National Parks and Wildlife Service, is developing a new baiting technique for feral goats utilising a toxic version of a salt block (Hunt, et al., 2012). This has a mesh plate that feral goats step through to access the block. Kangaroos, that are also attracted to the salt, are forced to step onto the mesh plate due to their foot shape. Stepping on the mesh plate drops a cover over the salt block preventing consumption by and poisoning of the kangaroo. Figure 2 shows the feed structure.



Figure 2. Feral goat feed structure being trialled to exploit the differences in foot size and structure between macropods and ungulates. This trial was non-toxic. (Hunt, et al., 2012)

Integration

There had been an EPBC Act nomination for the key threatening process of “Biodiversity decline and habitat degradation in the Australian rangelands due to the proliferation, placement and management of artificial watering points” (nominated in 2009) and this identifies the issue of regular spaced artificial watering points allowing the spread of domestic and feral livestock, as well as native species, into areas that previously would have been populated only by species able to get their water requirements from food or other specialised techniques rather than surface water. The decision on whether to list this nomination is not due until September 2014.

Figure 1 illustrates the placement of artificial watering points in far western New South Wales. There is very little country that is further than 4-5 km from water making the landscape permanently accessible to feral goats, livestock and kangaroos. This illustrates the challenge faced in rangeland situations of using water point closure to manage feral goat populations.

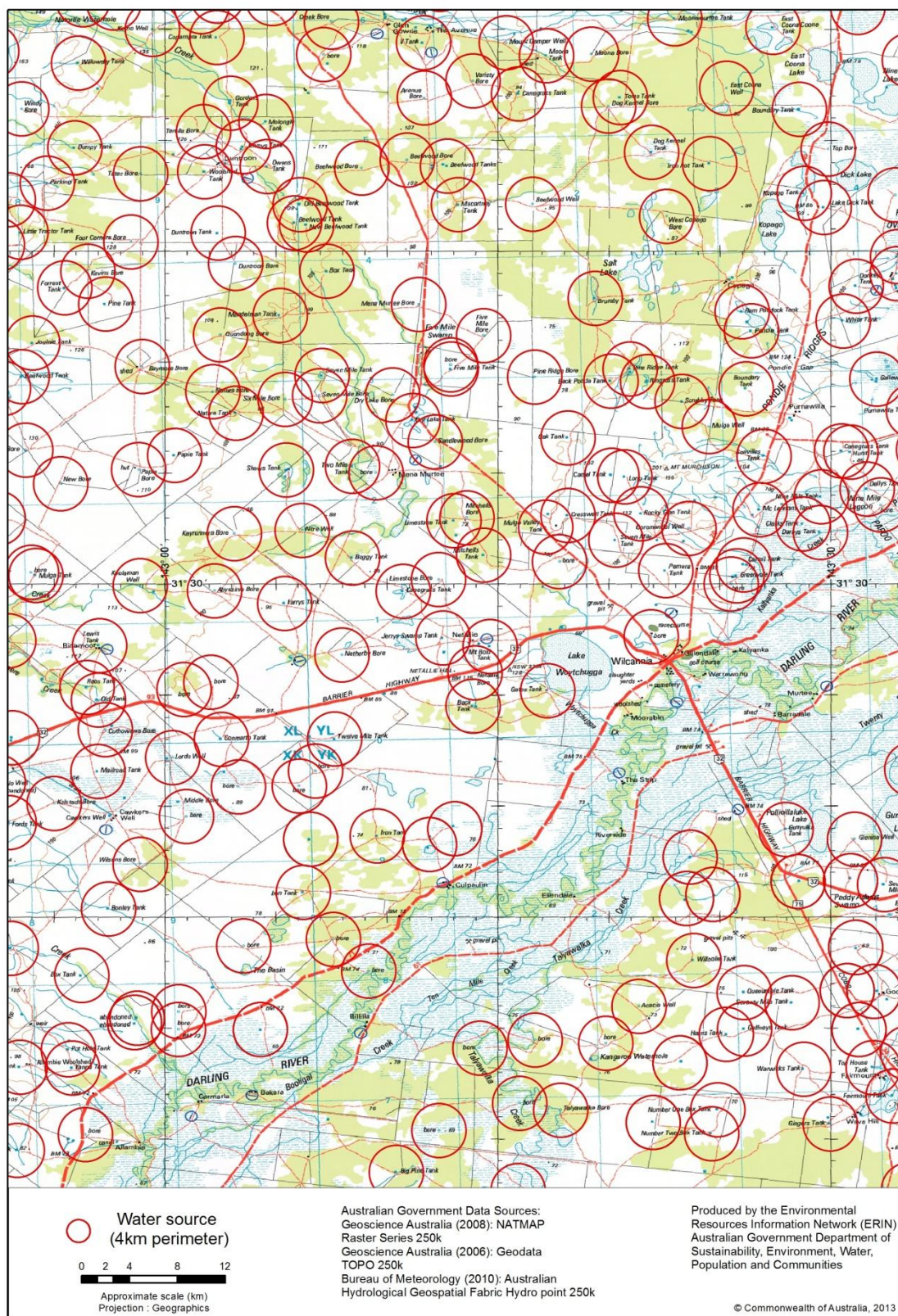


Figure 1. Distribution of water tanks and bores around Wilcannia. The red circles represent a radii of 4 km from earth tanks and bores and wells, the approximate distance that a goat can range from a source of water. Prior to the establishment of the pastoral industry there would have been very few water points available in this area.

Finally, there is an action on integration of conventional techniques for eradication of isolated populations or on islands. When planning an eradication attempt, project managers should consider all options and the case study from Kangaroo Island in South Australia (see case study 1 under objective one) demonstrates the utilisation of different techniques to complement the program and achieve eradication.

Humaneness

In rangeland areas where water is restricted the closure of artificial water points is an attractive option for feral goat management but needs to be undertaken in a way that also considers the humaneness for all animals in the area. Before full closure can be undertaken, trapping or mustering of the feral goats is necessary so that there are no animals left without water. Other livestock or animals that also may be affected should be factored into the program.

The code of practice for the humane management of feral goats has been well publicised by governments, the Invasive Animals Cooperative Research Centre and also through the livestock industry. Training programs for feral animal control, more broadly than feral goats, have been developed through the Invasive Animals Cooperative Research Centre (Invasive Animals Cooperative Research Centre, 2010). These include a Vocational Education and Training diploma in conservation and land management (specialising in pest management) that is nationally approved under the Australian Qualifications Framework. The aim of the course is to increase the capacity of those involved in planning and implementing strategic and cooperative invasive animal management. It is taught through the University of Canberra as a combination of online and residential elements.

Conclusion

There are good management options for the control of feral goats when used strategically and in an integrated manner. It is more difficult in areas of the country where goats have ready access to water all year or able to obtain it from the vegetation as the animals will be more dispersed in the landscape and be difficult to trap. Tools such as codes of practice, standard operating procedures, information on animal welfare considerations and fencing products are all readily available. The Invasive Animals Cooperative Research Centre has developed training courses for land managers dealing with feral animal problems.

It has not been possible to measure the performance indicators related to the increased use of best-practice techniques and adoption of the code of practice, but the increased availability of information and training is likely to have helped.

Improvements in the next five years should focus on tools for where feral goats have free water access and how strategic fencing and the like can be utilised at a landscape level to remove pressure from high priority sites. The work on a toxin system that excludes non-target native species is promising.

OBJECTIVE FIVE – stakeholder awareness

Increase awareness of all stakeholders of the objectives and actions of the TAP, and of the need to control unmanaged goats.

Performance indicators

- Widespread use of current ‘best practice’ techniques in control of unmanaged goats.
- Greater awareness in the rural community about issues surrounding unmanaged goats.
- Increased awareness of the TAP actions and objectives.

This objective is focused on ensuring feral goats are managed in the best possible way through making sure there is an awareness of the problem and of the tools available.

The problem of feral goats, especially in the rangeland areas of Australia, has received greater public attention through the media as feral goat numbers have risen. The visual impact of goats in national parks and on roadsides in western NSW has gained the attention of the general public to the problem. For example, Australian Broadcasting Corporation (ABC News) (2012).

The Invasive Animals Cooperative Research Centre has achieved a great deal over the last five years in both raising awareness of pest animals generally and in providing education materials for land managers. Feral goats have not been one of the Cooperative Research Centre’s points of focus for research but extension material for invasive animals includes goats. The resources available are on the website www.feral.org.au. As mentioned above, in objective four, training materials have also been developed for land managers who have pest management responsibilities. The Invasive Animals Cooperative Research Centre has also developed materials for primary and secondary schools students linked to the national curriculum.

Feralscan (www.feralscan.org.au) is a community mapping project to identify hotspots where people have identified feral animals as a problem. The feral goat map (accessed 17 April 2013) has 113 locations to date and the map shows goats in similar areas to the aerial surveys but is predominantly concentrated on areas where people live. This will prove to be a valuable resource over time if the community continues to populate the database with data.

The greatest challenge in stakeholder education is in finding the balance between ensuring conservation areas are protected from damage by goats while ensuring that primary producers have a source of rangeland goats (those that are not under active management and fenced in) to supplement their incomes.

This is recognised, not only by national parks and other reserves, but also by government agriculture departments. An example is the Best Management Practice Guidelines for the grazing of goats in the pastoral areas of Western Australia (Western Australian Department of Agriculture and Food, Undated), which identifies most fragile/threatened landscapes and key biodiversity areas where continuous grazing by goats may result in long-term impacts on the more sensitive vegetation and soil and landscape stability. The document also adds that the introduction of goats to areas known to be free of goats should not be considered. The NSW Western Catchment Management Authority also recognises the importance of maintenance of vegetation and ground cover for erosion control and the health of the land through appropriate total grazing pressure management practices.

NSW National Parks and Wildlife Service Far West Region Pest Management Strategy 2008-2011 (2008) provides a number of pest management principles that adopt an integrated approach and, where relevant, a collaborative and across tenure approach.

Objective five also has an action to compare the economic costs and environmental benefits of control activities. There were no studies found that directly costed the environmental benefit of feral goat control. However, Khairo and Hacker (2011) undertook an economic analysis of the profitability for landholders to undertake feral goat control within the western NSW rangelands. This study concluded that opportunistic harvesting, especially when it is combined with some time in a goat paddock to maximise the value adding (allow the goats to gain weight) was the best economic scenario. In all scenarios goat price drove the harvesting rather than goat population densities. They also found that there was no stable incentive to reduce feral goat numbers. They stated that "...since (probably) achievable improvements in carrying capacity can result in favourable returns from total grazing pressure fencing, any attempt to improve natural resource outcomes by public investment may be best directed at encouraging improved grazing management (e.g. through incentives for groundcover) rather than infrastructure for feral goat harvest which is already profitable for landholders." Khairo and Hacker (2011) touch on the management challenge with growing out feral goats in total grazing pressure paddocks of ensuring the groundcover (including grasses, forbes and shrubs) is not completely removed by the grazing and browsing goats, leading to broader environmental problems including soil erosion and revegetation difficulties.

Case Study 3: Economic analysis in NSW (New South Wales Western Catchment Management Authority)

NSW has undertaken an economic analysis of feral goat control within the western NSW rangelands (Khairo & Hacker, 2011). This concluded that opportunistic harvesting of feral goats is profitable and this profitability could be increased by then putting the goats into a goat paddock for a short period to maximise their condition or size. It is not profitable to invest in boundary fencing or goat fencing unless there are additional improvements in the stock carrying capacity – the farmers are better off just harvesting the feral goats. The report also noted that a cessation of feral goat harvesting due to a drop-off in prices would impact on livestock enterprises as well as natural resource condition. They conclude:

"Feral goats represent a conundrum for natural resource management since there are strong economic incentives to retain rather than remove them and there is no stable incentive to reduce their numbers in the interest of either economic returns or resource condition. However, since (probably) achievable improvements in carrying capacity can result in favourable returns from TGP [goat proof] fencing, any attempt to improve natural resource outcomes by public investment may be best directed at encouraging improved grazing management (e.g. through incentives for groundcover) rather than infrastructure for feral goat harvest which is already profitable for landholders".

The eradication of feral goats from Kangaroo Island is a good example of how to ensure that all stakeholders understand the problem and the proposed control/eradication program. Several key lessons were learnt from this program (pers. comm. Pip Masters, Kangaroo Island NRM Board, 2012):

1. Community relations were a key focus of the program, rather than a tack-on to the eradication component. It takes time to build the support and trust of the community, especially if you are new to an area. The length of time this takes cannot be underestimated. For some islands this can be a major challenge as 'new' people may include those who have lived on the island for a number of years. The program found that the best method for getting people on side was face-to-face discussions. For the Kangaroo Island program, this included people who liked goats.
2. Employing local people who already have the trust of the community to undertake the shooting/trapping is really important (providing the trust in these people is justified). Some landholders will not allow people onto their property to shoot unless they personally know the people.
3. Being strategic and thinking about the potential arguments that the program may encounter is important. This may alter the way that the program is undertaken. On Kangaroo Island the program managers decided to eradicate within the National Park first to combat the argument that the landholders won't do anything until the parks have. The landholders who were less supportive of the program were left until last so that there was a good demonstration of the program successfully underway.
4. Kangaroo Island also developed a risk management assessment for the goat farms to allow goat owners to assess whether their fencing and other security measures are sufficient to prevent escape of domestic stock.

Conclusion

Since 2008, there has been some excellent educational material developed and, in selected areas, there is an increase in awareness of the problem of feral goats. However, there has been little work done to put into economic terms the environmental costs and benefits of feral goats and their management. In rangeland systems there has been very little change in the control of feral goats as a result of awareness raising of the environmental impacts. This will be in part due to the profits that rangeland producers can obtain from the harvest of feral goats. Therefore it is concluded that this objective still requires further work.

Australian Government funded projects

Biodiversity Fund

The Biodiversity Fund, under the Clean Energy Futures, has funded five projects in 2012-13 totalling \$5,179,500 (GST exclusive) that relate to feral goats and understanding their impacts on biodiversity (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012). This includes projects to close water points; modify grazing management to restrict feral goat movement and achieve management strategies that improve the rangeland ecosystem while also improving the total grazing pressure. The outcomes of these projects and their associated reports will be available in late 2013.

1. Caring for country and culture: Rockhole rehabilitation & feral goat control

A project by the South Australian Native Title Services Ltd. This project will implement the on-ground management recommendations of five rock-hole sites, previously determined by Department for Water ecologists in partnership with traditional owners. Included is the removal of sediment and fouled water from the rock-holes to restore their natural water harvesting capacity and function as the single natural surface water resource in an area of extreme aridity; the control of weed species such as Horehound and Wards Weed; the collection of native seed for propagation at the Gawler Ranges National Park nursery; and a partnership with the pastoral lessee to address the impacts of feral goat populations by trapping and assembling permanent yards for mustering operations. The Biodiversity Fund has provided \$481,000 for this project.

2. Protecting and buffering a keystone area for semi-arid rangelands conservation

A project by the Department for Environment and Natural Resources, South Australia. This project will increase the integrity of a connected landscape of national conservation significance, namely one of the largest blocks of continuous mallee vegetation in eastern Australia, the 900,00 hectare Riverland Biosphere Reserve. In response to favourable climatic conditions, an accelerated program of goat and rabbit control will reduce the spread of these invasive species by: removing access to water; targeting localised populations in new habitats; and expanding control to rangeland properties to increase the buffer of land managed for invasive species. Reduced grazing pressure both within and surrounding conservation areas will improve vegetation regeneration and land condition, with long-term potential for carbon sequestration. The Biodiversity Fund has provided \$505,800 for this project.

3. Restore habitat, reduce exotic species impact, maintain carbon store

A project by the University of Ballarat. The Scotia mallee of western NSW has high conservation value due to extensive areas of old growth mallee and significant rare plant communities. The contiguous properties: Nanya (University of Ballarat), Scotia (Australian Wildlife Conservancy) and Tarawi Nature Reserve (National Parks and Wildlife Service, NSW), covering 130,000 ha conserve significant fauna including three EPBC listed species, three plant communities and eight mammals, birds and reptiles listed under the NSW *Threatened Species Conservation Act 1995*. Nanya is calculated to store about 2,075,752 tonnes CO₂. The project will undertake vegetation restoration and protection measures including predator control, reduction of grazing pressure through rabbit and feral goat control, and water point closure. Through analysis of records for EPBC and state listed species, the project will prepare fauna, fire, vegetation and endangered fauna management plans. The Biodiversity Fund has provided \$353,400 for this project.

4. Restoring and reconnecting Australia's threatened woodlands in mallee rangelands

A project by Parks Victoria. Despite their high environmental values, Victoria's Mallee parks and surrounding properties share a history of degradation from clearing, overgrazing and pest introductions. Park Management currently stalls further degradation, but with additional effort it is possible to reverse the decline and achieve large-scale, high carbon content revegetation in this

nationally significant region. Mallee rangelands also have great potential to contribute to connectivity and to enhance biodiversity. Through private and public partnerships the project will re-establish broad-acre biodiverse vegetation via planting and restoration, and protect this investment and associated high value (e.g. Ramsar) sites from the impacts of rabbits, goats and other grazing pests. The Biodiversity Fund has provided \$3,004,000 for this project.

5. Landscape scale management of feral goats to improve ecosystem resilience

A project by the Western Catchment Management Authority, NSW. This project will demonstrate strategic new approaches to improving the resilience of semiarid rangeland ecosystems to climate change. These landscapes have high native vegetation connectivity in terms of structure but their condition is highly impacted by unmanaged feral goats. The presence of these highly mobile herbivores compromises the capacity of land managers to manage total grazing pressure (TGP), biodiversity and soil carbon. TGP is the primary NRM issue across Australia's southern rangelands. The project will establish multi-property goat management zones within which feral goat movement will be strictly controlled, enabling land managers to implement effective grazing management strategies. The Biodiversity Fund has provided \$835,300 for this project. The total grazing pressure project has made a call for farms wanting to put in total grazing pressure (TGP) fencing. They intend to work co-operatively with neighbours to place a buffer around the Riverland Biosphere Reserve and provide infrastructure for mustering of feral goats.

Caring for our Country

The Caring for our Country program has funded four projects in 2008-09 and 2009-10 with feral goat components, totalling \$443,800 (GST exclusive) (excluding the Kangaroo Island project) (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012). Below are summaries of the projects.

1. Improving Natural Resource Management Outcomes in the Rangelands by Strategically Removing Feral Goats

The project was undertaken by the South Australian Arid Lands Natural Resources Management Board. This project aimed to improve natural resource condition including biodiversity, aquatic habitat and sustainable pastoralism. It did this by reducing the significant current and potential threat feral goats present to high conservation value natural ecosystems and sustainable land use in the rangelands of South Australia. The project received \$353,182 from Caring for our Country. There is more detail on the outcomes of this project in case study 2.

2. The Middleback Alliance - a Regional Conservation Initiative (South Australia)

The project was undertaken by Ecological Horizons Pty Ltd. The project improved the habitat for threatened species and reduced the impact of threatening species such as feral goats and foxes consequently addressing several priorities outlined in the Secret Rocks Management Plan. The project received \$81,618 from Caring for our Country.

3. Census and control of pest animals for the protection of Brush-tailed Rock-wallabies

The project was undertaken by the New South Wales Southern Rivers Friends of The Brush-Tailed Rock-Wallaby Incorporated. The project had a questionnaire on the presence, abundance, and frequency of a number of key feral animal species observed on private properties mailed out to local landholders in the vicinity of brush-tailed rock-wallaby colonies in the Kangaroo Valley, Illaroo and Bugong areas. Pest species of particular interest were foxes, wild dogs, goats and deer. The results showed that 23 % of survey respondents had seen feral goats on or near their properties but only 13 % indicated they believed the feral goats to be a pest. The respondent in the Upper Kangaroo River thought that goat numbers were rising despite regular shooting. Remote cameras were loaned out to

three interested landholders to assist them with pest animal identification. Following the identification of pest species' locations a contract trapper/shooter was employed to control the threatening pest species on private properties in the vicinity of local Brush-tailed rock wallaby colonies. The project received \$9,000 from Caring for our Country.

4. Kangaroo Island goat eradication

See the case study under objective one for details on this project.

Three projects are current in the 2012-13 financial year, totalling \$324,458; and the project summaries are listed below (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2012).

1. Threat abatement for nationally threatened Middleback mallee species (OC13-00339)

The project is being undertaken by Ecological Horizons Pty Ltd. Feral foxes, cats and goats present a serious threat to nationally threatened malleefowl, Sandhill Dunnart, Chalky Wattle and Yellow Swainsona Pea; in the Middleback Alliance region of Eyre Peninsula, South Australia. Building from a successful Caring for our Country project where vertebrate pests were controlled with tangible results, this project will refine optimal techniques for controlling pests over 500,000 ha of private, public and Natural Reserve System land. Radiotracked Judas goats will be used to improve efficacy of goat control and participation by neighbouring land owners. Automated poisoning devices, targeted trapping, hunting and baiting will be used to control foxes and cats. Results will be assessed by response of both pests and threatened species and volunteer participation. Caring for our Country has provided \$78,000 for this project.

2. Co-ordinated goat control to protect biodiversity in the Billiatt WPA complex (OC13-00434)

This project is being undertaken by the South Australian Murray-Darling Basin Natural Resources Management Board. This project will reduce grazing pressure inflicted by unmanaged goats in the Billiatt Wilderness Protection Area and surrounding district by partnering and coordinating with local land managers, the Browns Well Landcare Group and volunteers in directing and participating in an integrated control program. This control will promote regeneration and recovery of vegetation, such as that relied upon by the nationally vulnerable species the malleefowl as a source of protection and food. Caring for our Country has provided \$76,958 for this project.

3. Fauna reconstruction of Dirk Hartog Island - Shark Bay World Heritage (OC13-00355)

This project is being undertaken by the Department of Environment and Conservation, Western Australia. Dirk Hartog Island in the Shark Bay World Heritage area is WA's largest island. Established as a national park in 2009 it provides the opportunity to largely restore the island's natural environment and reconstruct its native mammal fauna. The island formerly supported at least 13 species of mammals, of which only three still persist following introduction of feral cats, mice and goats and over 100 years of pastoral use. It is proposed that, following the successful eradication of sheep, goats and feral cats, ten species of native mammals will be reintroduced to the island. Continued ground and aerial shooting programs, the use of 'Judas' goats and other innovative techniques will be required to eliminate the sheep and goats. Caring for our Country has provided \$269,500 for this project.

Looking forward

This review has concluded that the key threatening process of competition and land degradation by unmanaged goats has not been abated and that the goal and objectives of the threat abatement plan have not been met. There is a requirement for the Minister to “decide to have a threat abatement plan for the process if he or she believes that having and implementing a threat abatement plan is a feasible, effective and efficient way to abate the process” (EPBC Act Section 270(a)(2)). This decision must be taken every five years. In providing advice to the Minister regarding this decision there appear to be two options for the current threat abatement plan:

1. Retain the threat abatement plan as it stands for a further five years. The current threat abatement plan has objectives that are still valid. Some of the actions under the objectives have been either completed or, as further knowledge has been gained, are no longer as relevant to threat abatement. But in general the threat abatement plan could still guide future management of feral goats for conservation.
2. Revise the threat abatement plan. This would allow the threat abatement plan actions and objectives to be focused on threat abatement issues and priorities for conservation areas, for example rocky semi-arid areas being managed for the recovery of rock wallabies. The threat abatement plan could also provide a greater acknowledgement and assistance with the complex issue of the utilisation of feral or unmanaged goats for financial gain by some land managers (such as rangeland stations). The current threat abatement plan touches on these issues so a revision of the threat abatement plan would need to determine if further benefit could be gained for all land managers with an amended approach.

The second approach of revising the plan provides opportunities to put a different emphasis on the way to undertake threat abatement for feral goats. However, a revision of the plan has potential to be a lengthy process due to statutory requirements and negotiation of the complexities around feral, unmanaged and managed goats.

There are other options to consider for addressing the key threatening process beyond a threat abatement plan. These are explored below.

A threat abatement advice could also be developed for feral goats. The concept of a threat abatement advice is similar to conservation advice for EPBC Act listed threatened species in that it can provide guidance on actions and research required to be undertaken to abate the threatening process. A threat abatement advice is different from a threat abatement plan in that, currently, it is a non-statutory document that is simpler to amend as new information becomes available. It tends to be more concise than a threat abatement plan.

The Standing Council on Primary Industries is currently developing a policy approach to listing established weeds and pests of national significance. This will include species that are of environmental concern and feral goats may be identified within the lists. However, the follow through work subsequent to listing of species, such as the development of national action plans, is likely to take some time. It is suggested this process should be explored in addition to the threat abatement plan so that regardless of the outcome of the Standing Council on Primary Industries deliberations coordination and guidance is available to land managers for conservation management of feral goats in the next few years.

There are also provisions under the EPBC Act to make a TAP jointly with a state or territory. This provision (Section 270B(3) *The Minister may make a written threat abatement plan for the purposes of reducing the effect of the process, jointly with the States and self-governing Territories in which the process occurs or with agencies of those States and Territories*) has not been used to date because individual states and territories have plans at a state scale that are meeting their requirements.

Threat abatement may also be driven for specific sites or species through recovery plans. 146 listed threatened species specifically identify goat grazing, trampling, competition and/or habitat degradation as a threat. There are recovery plans for 56 of the 146 species. It should be noted that recovery plans will promote the control of feral goats to achieve an outcome (less grazing etc) for the threatened species. However, they will not drive the necessary additional threat abatement measures such as the development or improvement of control methods.

In the future, there may be an option to develop regional environmental management plans that incorporate threat abatement planning and recovery planning in the same document. This is drawing further on the concept of regional recovery plans (e.g. the Regional Recovery Plan for threatened species and ecological communities of Adelaide and the Mt Lofty Ranges, South Australia (Wilson & Bignall, 2009). Regional recovery plans are attempting to increase the integration of regional scale threat abatement activities for improved threatened species and ecological community recovery. The management actions have not been devised for individual threatened species but across species, and management actions have been derived from species-based analyses relating to the different elements of recovery planning. Where feral goats are identified as a particular threat to species in an area it may be appropriate to develop specific management actions in response. A regional plan may also be a good vehicle to integrate management planning for a number of threats (e.g. rabbit, fox and goat control).

Another regional planning tool that may be utilised to a greater degree than at present is where there are threatened assets (sites or species) within a natural resource management area. Planning for feral goat control to protect the identified assets while also accommodating primary industry harvesting needs could be included in the natural resource management plan for the area.

It is well known that undertaking control for a single pest animal may lead to unintended consequences. For example, the control of feral goats may provide additional feed for rabbits or switch the predation of young goats by foxes onto native species. Therefore, an option for threat abatement may be to develop a threat abatement plan that covers multiple species that are key threatening processes. Currently the only example of multi-key-threatening-process threat abatement plans is the threat abatement plan to reduce the impacts of tramp ants on biodiversity in Australia and its territories where six key invasive ant species are the focus of the plan. Broad discussion and consultation would be required to determine which invasive vertebrates may be best – if any – to incorporate into a single threat abatement plan.

An implementation team may be established for the threat abatement plan or for another form of management plan. The implementation team, with the Australian Government providing co-ordination, could be a forum for exchange of information, ideas and research. It may be able to co-ordinate funding requests for the highest priority sites for feral goat control. An advantage in an implementation team is in the collective knowledge which helps ensure that feral goat control is being undertaken in the most effective manner possible for threat abatement. However, there are also risks with establishing an implementation team in that there could be an expectation of directly linked

funding or that the team would undertake on-ground action. Directly linked funding is not currently an option for the Australian Government and, while the potential members of an implementation team are likely to include key on-ground managers it would still be expected that on-ground control of feral goats would be undertaken by the relevant manager with their own resources.

At this point in time, these ideas are put forward.

Appendix A

High priority sites from “Prioritisation of High Conservation Status Mainland Islands” by Ecological (2009).

- Armidale Plateau, NSW
- Barrington Tops National Park, NSW
- Beards River Hills, NSW
- Binghi Plateau, NSW – Torrington State Conservation Area POM details management measures including radio tracking feral goats and horses in the area to provide data to monitor population levels of two threatened plants.
- Bowral, NSW – Forests NSW specifically contribute to control programs for goats.
- Deep Water Downs, NSW
- Glen Innes-Guyra Basalts, NSW
- Greater Blue Mountains Area, NSW – goats mentioned in POMs.
- Jervis Bay, NSW
- Lithgow, NSW
- Mann River, NSW – goats monitored
- Nandewar, Northern Complex, NSW – Gibraltar POM mentions goats.
- Nightcap, NSW
- Severn River Volcanics, NSW
- Sydney, NSW
- Tenterfield Plateau, NSW – Mgmt action to protect *Pimelea venosa* from goats.
- Tingha Plateau, NSW
- Canberra, ACT/NSW
- Central Murray, NSW/VIC
- Stanthorpe Plateau NSW and QLD
- Bouldercombe, QLD – Capricorn Pest Management Group maps and monitors pest infestations to determine high priority areas.
- Bowling Green Bay, QLD
- Eastern Darling Downs, QLD
- Fitzroy River Mouth, QLD
- Morton Basin, QLD
- Toowoomba, QLD
- Upper Fitzroy River, QLD
- Upstart Bay, QLD
- Wet Tropics of Queensland, QLD
- Melbourne, VIC
- Port Phillip Bay, VIC
- Western District Lakes, VIC
- Shark Bay, WA
- The Coorong, SA

High priority offshore islands with goats from the report “Prioritisation of high conservation status offshore islands” by Ecosure (2009)

- Dirk Hartog Island, WA
- French Island, Vic.
- Inglis Island and the English Company Island Group, NT – on Truant Island
- Kangaroo Island, SA
- Long Island, QLD
- Moreton Island, QLD

- Nooramunga Islands, Vic. – on Sunday Island
- Sir Edward Pelew Group, NT – on West Island and Vanderlin Island
- Prince of Wales/Muralug Island, Torres Strait, QLD
- Swan Island, Tas.

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