

THREAT ABATEMENT PLAN

for

Competition and Land Degradation by Feral Goats

Biodiversity Group
Environment Australia
GPO Box 787
CANBERRA ACT 2601

1999

FOREWORD

The Commonwealth *Endangered Species Protection Act 1992* (the Act) seeks to promote the recovery of species and ecological communities that are endangered or vulnerable, and to prevent other species and ecological communities becoming endangered. The key mechanisms prescribed in the Act to achieve these two aims are recovery plans and threat abatement plans.

These mechanisms are designed to complement each other. Recovery plans focus on the actions needed to ensure the continued existence in the wild of listed endangered and vulnerable native species and communities. Threat abatement plans are designed to focus on strategic approaches to reducing to an acceptable level the impacts of processes that threaten the long term survival of native species and ecological communities.

The Act defines threatening processes as those that threaten, or may threaten, the survival, abundance or evolutionary development of a native species or ecological community. Key threatening processes are identified as those which:

*adversely affect two or more listed native species or two or more listed ecological communities; or
could cause native species or ecological communities that are not endangered to become endangered.*

These processes are listed in Schedule 3 of the Act and each requires the preparation and implementation of a nationally coordinated threat abatement plan. The Act prescribes the content of a threat abatement plan and the mechanisms by which such plans are to be prepared, approved and published. Where a threatening process occurs in more than one jurisdiction, the Commonwealth must seek the cooperation of the relevant States and Territories in the joint preparation and implementation of a threat abatement plan.

Competition and land degradation by feral goats is listed as a key threatening process in Schedule 3 of the Act. Recognising that the feral goat is a pest of agriculture as well as a major conservation concern, preparation of this plan has been a cooperative endeavour involving Commonwealth, State and Territory agencies responsible for conservation and for agricultural pest management. While the focus of the plan is clearly on actions required to reduce the threat posed by feral goats to endangered species and ecological communities, its implementation will also help land managers to reduce the impact of feral goats on agricultural landscapes.

Colin Griffiths
Director of National Parks and Wildlife

CONTENTS

FOREWORD	II
EXECUTIVE SUMMARY	V
INTRODUCTION	1
MEASURES TO ADDRESS THE KEY THREATENING PROCESS	4
MUSTERING	4
TRAPPING	5
FENCING	5
SHOOTING	6
JUDAS GOAT	7
FERTILITY CONTROL	7
POISONING	8
BIOLOGICAL CONTROL	8
TAX INCENTIVES	9
FACTORS AFFECTING FERAL GOAT CONTROL	10
COMMERCIAL INTERESTS	10
LEGAL STATUS	12
COST EFFICIENCY	12
ANIMAL WELFARE	13
WATER MANAGEMENT	14
INTERACTION WITH OTHER FERAL HERBIVORES	14
DEVELOPING A NATIONAL APPROACH TO FERAL GOAT MANAGEMENT	16
PLANNING FOR NATIONALLY COORDINATED ACTION	16
STRATEGIES	16
RANKING AREAS FOR PRIORITY ACTION	17
THREAT ABATEMENT OBJECTIVES AND ACTIONS	19
FERAL GOAT MANAGEMENT	20
LOCAL CONTROL PLANS	20
REGIONAL CONTROL PLANS	21
FERAL GOAT FREE AREAS	23
INNOVATIVE AND HUMANE CONTROL METHODS	25
TRAPPING SYSTEMS	25
FENCING	25
FERTILITY CONTROL	26
HUMANE POISONING	26
INFORMATION	27
DOCUMENTING FERAL GOAT IMPACTS	27
UNDERSTANDING INTERACTIONS WITH OTHER FERAL PESTS	28
REFINING PRIORITY SETTING MECHANISMS	28
EDUCATION	29
EDUCATION AND EXTENSION	29
ADMINISTRATION	30
NATIONAL COORDINATION	30

EVALUATION AND REVIEW	32
REFERENCES	33
ACKNOWLEDGMENTS	40
APPENDIX <i>Endangered Species Protection Act 1992</i>	41
TABLES	
Table 1 - Species listed on Schedule 1 of the <i>Endangered Species Protection Act 1992</i> for which feral goats are a known or perceived threat.	2
Table 2 - A summary of initial densities, levels of reduction and costs of various goat control techniques used in a semi-arid environment.	13

EXECUTIVE SUMMARY

The feral goat is a generalist herbivore that can survive in many environments. It is found in all States and Territories except the Northern Territory and also survives on many Australian islands. It is most commonly found in the arid and semi-arid rangelands of New South Wales, Queensland, South Australia and Western Australia. There is evidence indicating that competition and land degradation due to feral goats is threatening some native species and ecological communities and for this reason 'competition and land degradation by feral goats' is listed as a Key Threatening Process under Schedule 3 of the Commonwealth *Endangered Species Protection Act 1992* (the Act). The Act requires the preparation and implementation of a threat abatement plan to nationally coordinate management of the impact of competition and land degradation by feral goats.

Eradication of feral goats on the mainland is not possible but there are effective methods for reducing feral goat numbers and impacts on wildlife in significant areas. This plan aims to reduce feral goat impacts on native wildlife over five years by:

- implementing feral goat control programs in specific areas of high conservation priority;
- encouraging the development and use of innovative and humane control methods for feral goat management;
- educating land managers and relevant organisations to improve their knowledge of feral goat impacts and ensure skilled and effective participation in control activities; and
- collecting and disseminating information to improve our understanding of feral goat ecology in Australia, their impacts and methods to control them.

The strategy advocated in the implementation and further development of this threat abatement plan involves the use of conventional methods to control feral goats in manageable areas critical to threatened species conservation. In implementing these controls close links will be established with species recovery plans, other threat abatement plans and with existing State programs. Animal welfare issues will be specifically addressed during the application of conventional control methods. Measures will also be implemented to ensure that feral goats do not become established in sensitive areas or on important islands that are currently feral goat free.

The five-year life of this plan is seen as consolidating and coordinating the long term process of managing feral goat impacts on native flora and fauna. The main priority during this period is to support on-ground control programs necessary to ensure recovery of endangered species. The management of domestic goats will be dealt with separately through the development of a goat meat industry strategic plan. Such a strategic plan will need to take account of the fact that some domestic goats do have the capacity to become feral.

Feral goat control will have to continue for the foreseeable future and the costs of control can be significant. This plan therefore establishes a framework that will enable the best use of resources. The Commonwealth contribution to implementation of the plan will be delivered primarily through the programs of the Natural Heritage Trust.

INTRODUCTION

The feral goat in Australia has been derived from a variety of domestic goat breeds that were introduced to provide meat, milk and fibre. Feral goats are defined as those animals which have escaped the ownership, management and control of people and are living and reproducing in the wild (Parkes *et al.* 1996). Feral populations were established when domestic herds were deliberately released or animals escaped (McKnight, 1976). These populations survived and proliferated in many environments for reasons such as high levels of fecundity, lack of predators, freedom from disease, high mobility, and diverse diet (Henzell, 1992a). It is important to recognise that the key difference between a feral goat and a domestic goat is that the latter is secured behind a fence while the former is not subject to any form of intensive control nor permanently restrained by any fences.

Feral goats are found in most regions of Australia, with the highest densities seen in the arid and semi-arid pastoral regions of Queensland, New South Wales, South Australia and Western Australia (Parkes *et al.* 1996). Southwell *et al.* (1993) estimated that nearly one million feral goats exist in eastern Australia. This figure is probably an under-estimate since it was based on uncorrected aerial counts. Parkes *et al.* (1996) estimated approximately 2.6 million feral goats in Australia. However, they consider this a conservative figure in view of the number of goats harvested each year.

Feral goat populations are capable of increasing by up to 50 per cent each year under favourable environmental conditions (Mahood, 1985; Maas and Choquenot, 1995; Parkes *et al.* 1996). They are a generalist herbivore (Coblentz, 1977) and can occupy a great variety of habitats. In the arid and semi-arid regions of Australia they tend to be primarily browsers switching to grass and forbs when these are green (Wilson *et al.* 1975; Harrington, 1986). Their feeding habits in more temperate regions tend to be seasonal (O'Brien, 1984). Feral goats need to water every two to three days during summer (Dawson *et al.* 1975), but can otherwise extract most of their water requirements from their food.

The distribution of the feral goat does not totally reflect its generalist dietary habits. Its presence in various environments is thought to be limited by several factors, including the type and nutritional quality of vegetation; the availability of shelter; the need to drink water during dry times; the occurrence of various parasites and diseases possibly resulting in the goat's absence from wetter parts of the country (Harrington, 1982); and predation from dingoes and feral dogs, which is believed to limit their populations in areas where these predators occur (Parkes *et al.* 1996).

The feral goat is a very successful invader of a variety of habitats including the arid and semi-arid rangelands and an assortment of offshore islands (Parkes *et al.* 1996). At least 20 goat-sized herbivores per square kilometre can be supported in rangelands with annual rainfall of 240 millimetres. Estimates of goat densities range from two (average density in all States during the early 1990s) to five (estimate in more preferred habitats) per square kilometre. At these densities feral goats would be contributing from ten per cent to twenty-five per cent of the total sustainable grazing pressure (Parkes *et al.* 1996). Management of feral goats will need to be integrated

with the management of other large herbivores to ensure that the total impact of grazing on the vegetation is maintained within ecologically sustainable limits.

The feral goat is reported as responsible for a variety of impacts on native flora and fauna. These include competing with native fauna for food, water and shelter (Lim *et al*, 1992) and threatening the survival of native flora through their feeding habits (Auld, 1993). Destruction of vegetation is also thought to cause soil erosion (Yocom, 1967). It is for these reasons that it is listed as a Key Threatening Process under Schedule 3 of the Act.

Feral goats have been identified as a confirmed threat or a perceived threat to several endangered and vulnerable species listed under Schedule 1 of the Act (Table 1).

Table 1. Species listed on Schedule 1 of the *Endangered Species Protection Act 1992* for which feral goats are a known or perceived threat.

Known Threat		
Scientific Name	Common Name	Reference
Birds		
<i>Leipoa ocellata</i>	Malleefowl	(Benshemesh, J., 1998)
Plants		
<i>Acacia araneosa</i>		(Davies, R.J-P., 1990)
<i>Acacia barattensis</i>		(Davies, R.J-P., 1995)
<i>Cynanchum elegans</i>		(Matthes, M. & Nash, S., 1993)
<i>Drakonorchis drakeoides</i>		(Holland, E., et al., 1997)
<i>Eriocaulon carsonii</i>		(Pickard, J., 1992)
<i>Grevillea beadleana</i>		(Gross, C.L. & Steed, A., 1997)
<i>Grevillea iaspicula</i>		(Butler, G., et al., 1991)
<i>Westringia crassifolia</i>		(Davies, R. & Riley, M., 1993)
Perceived Threat		
Mammals		
<i>Petrogale lateralis</i>	Black-footed Rock-wallaby	(Hall, G.P. and Kinnear, 1991)
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	(Hill, F.A.R., 1991)
<i>Petrogale xanthopus</i>	Yellow-footed Rock-Wallaby	(Dawson, T.J. and Ellis, B.A., 1979; Sheppard, N. 1990)
<i>Pseudomys fieldi</i>	Djoongari	(Morris, K. , et al., 1997)
Plants		
<i>Brachyscome muelleri</i>		(Jusaitis, M., 1998)

While key threatening processes are listed because of their impacts on listed threatened species, impacts from feral goats are not restricted to these species. Feral goats are also known to be seriously affecting the demographic status of several currently widespread tree species in the rangelands (Henzell *in litt.*). Such species include *Alectryon oleifolius*, various *Santalum* species (including *S. acuminatum* and *S. spicatum*) and *Capparis mitchelli*. While mature specimens of these trees are unlikely to be threatened by mammalian herbivores, grazing is a significant threat to survival and recruitment of juvenile plants. Best practice management of feral goats must involve action to reduce the threat not only to targeted threatened species, but to all potentially vulnerable native species.

For each process listed in Schedule 3 of the Act, a nationally coordinated threat abatement plan must be prepared and implemented. The Act prescribes the content of a threat abatement plan and the mechanisms by which plans are to be prepared, approved and published. The relevant sections of the Act are reproduced in the Appendix. Where a threatening process occurs in more than one jurisdiction, the Commonwealth must seek the cooperation of the relevant States and Territories in the joint preparation and implementation of a threat abatement plan.

The feral goat has not been eradicated from any extensive mainland environment in Australia, despite decades of control effort. Eradication from island habitats, however, has been successfully achieved in Australia (Daly and Goriup, 1987; Allen and Lee, 1995) and New Zealand (Parkes, 1990), and should be considered an option to protect native species and ecological communities on Australian islands where goats still exist.

The most common management techniques currently used to control feral goats are mustering, trapping and aerial shooting. Mustering and trapping have the advantage of providing the option of humane slaughter or sale of captured animals. Aerial shooting is used in inaccessible terrain. It is advocated as being the most effective technique currently available for such areas and is considered humane when conducted by trained shooters using suitable weapons. Other techniques that are occasionally used or are the subject of research are ground-based shooting; using Judas goats; poisoning; and predation by dingoes. Non-lethal techniques such as fencing and habitat manipulation have also been investigated.

The success of this threat abatement plan will depend on a high level of cooperation between all key stakeholders, including landowners and managers, community groups, local government, State and Territory conservation and pest management agencies, and the Commonwealth Government and its agencies. Success will only be achieved if all participants are prepared to allocate adequate resources to achieving effective on-ground control of feral goats at critical sites and in critical regions, improving the effectiveness of control programs and measuring and assessing outcomes.

This threat abatement plan will need to be complemented by appropriate plans for managing domestic goats. Commercial harvesting of feral goats is acceptable practice providing that is done in accordance with the national code for the destruction, capture, handling and marketing of feral animals. However, there is the danger that some landholders may seek to 'farm' feral goats, thereby maintaining high densities.

By taking a measured, stepwise approach, recognising the realistic limitations and opportunities that exist, and ensuring that field experience and research are applied to further improve feral goat management, the threat abatement plan will ensure a responsible use of public resources and give the best outcome for wildlife.

MEASURES TO ADDRESS THE KEY THREATENING PROCESS

Eradication of feral goats is an attractive prospect because, once achieved, it requires no further commitment of resources. To achieve eradication:

- the mortality rate for feral goats must be greater than the replacement rate at all population densities;
- there must be no immigration;
- sufficient feral goats must be at risk from the control technique so that mortality from all causes results in a negative rate of population increase;
- all feral goats must be detectable even at low densities;
- a discounted benefit-cost analysis must favour eradication over control; and
- there must be a suitable socio-political environment (Bomford and O'Brien, 1995).

Complete removal of feral goats from Australia is well beyond the capacity of available techniques and resources because the species is well established across a vast area. Eradication from an island, or of a localised or newly introduced population, may be feasible provided a sufficiently coordinated, well-funded and persistent campaign can be mounted.

Parkes *et al.* (1996) reviewed current knowledge on techniques for suppressing feral goat populations. The review concluded that the main deficiencies with control programs are associated with decisions on whether to attempt local eradication or strategic management and, if the latter, deciding on the frequency of control activities and the target densities required. In comments on the draft plan, Agriculture Western Australia noted that a lack of resolve on the part of landowners and land managers is the single greatest obstacle to effective management of feral goats.

MUSTERING

Although mustering feral goats for slaughter or live sale is labour-intensive and limited to relatively flat terrain (Harrington, 1982), it is most efficient at high goat densities. The advantage of this technique in the context of harvesting is that the cost of control is either partly or fully offset by the sale of the goats. Two methods are used: aerial mustering, using helicopters or light aircraft to flush animals out of dense vegetation or inaccessible terrain, followed up by a ground team; and ground mustering on motor bikes or horseback usually with the help of dogs (Parkes *et al.* 1996).

The success of mustering in reducing the population can vary greatly from a low of 26 per cent reduction (Brill, pers. comm.) to a high of 80 per cent reduction (Henzell, 1984). In addition to density, effectiveness is also related to the value of a feral goat (Henzell, 1992a) with landholders intensifying efforts when goat prices are high. Parkes *et al.* (1996) described a number of management strategies on pastoral land that involved mustering both alone and in combination with several other techniques. When mustering was combined with other techniques using higher levels of technology, progressively lower goat densities were achieved at an increasing cost.

TRAPPING

Trapping groups of goats around watering points can be an effective and efficient control technique (Harrington, 1982). It involves the construction of goat proof fences around water points with a number of one way entrances or jump down ramps to allow the goats access to the water, but prevent their leaving (Parkes *et al*, 1996). This technique is most effective during dry times when goats are obliged to find water and there is limited access to alternative water sources. Once captured, the goats may be sold to offset the costs of capture or they may be humanely destroyed.

Agriculture Western Australia has designed trap yards to efficiently manage livestock at water points and these are particularly suitable for trapping goats. These trap yards are permanent installations that all animals become accustomed to using and are robust enough to contain goats effectively (Geoff Elliot, pers comm). Western Australia has proposed a general strategy to require the installation of such trap yards throughout the feral goat range in that State to ensure a level of control of both feral and domesticated goats.

Some concerns have been expressed about the use of traps at water points and the potential deleterious impacts on non-target species and animal welfare. Some of these concerns can be addressed by providing larger traps to minimise stress and allow for more effective handling of stock. Non-target species may also be trapped and these animals must be drafted out as quickly as possible to avoid undue stress. Trap yards at natural water holes pose special problems as they may severely restrict access by native species. One option suggested by Agriculture Western Australia, is to temporarily close the water source with a fence and provide an alternative water source in a permanent trap yard nearby. An alternative is to design fences that selectively exclude certain species from water points. Knowledge of other species that may be locally at risk from inappropriately designed traps could be used to identify the most suitable trap design and usage.

FENCES

Fences will not permanently stop the movement of all goats and should, therefore, only be used as a tactical technique in a management program (Parkes, 1990).

Fencing can:

- create short-term manageable units during an eradication campaign (Baker and Reeser, 1972; as cited in Parkes *et al*, 1996);
- limit recolonisation during sustained control (Parkes, 1990);
- exclude goats from water points to encourage them to use other water points where they can be trapped;
- constrain captured animals (Parkes *et al*, 1996);
- create exclosures where vegetation can regenerate and create a seed bank; and
- limit access to areas not infested with goats (Daly and Goriup, 1987).

Fencing can be expensive to establish. Lim *et al*, 1992 quoted a figure of \$1500 per kilometre for upgrading an existing fence and \$3000 per kilometre for construction of a new fence. Agriculture Western Australia have experimented with fence designs to enclose trained goats and these cost \$670 per kilometre for material for a five wire

electric fence plus approximately \$800 per kilometre in construction costs. Six and seven wire fences have also been successfully used and these cost about \$1600 per kilometre. Feral goats have been found to respect electric fences, particularly once they have encountered them. Where total exclusion of goats is required, adequate fences are likely to remain unacceptably expensive.

Points to be considered when deciding on fencing an area include the primary purpose of the fence, the area to be enclosed, cost and the position of watering points. To prevent animal welfare problems arising, due consideration must be given to the impact of goat proof fences on access to water by all animals as well as on the movement of native animals.

SHOOTING

Ground based shooting is not commonly used as a control strategy for feral goats in the pastoral areas of Australia due to its labour intensity and its variable efficiency dependent upon climatic conditions. A shooting operation in South Australia during a dry period yielded 3400 goats (an unknown proportion of the population) in seven days over 1000 kilometre square at a cost of \$3 per goat not including labour (Dodd and Hartwig, 1992). A separate shooting operation conducted following heavy rains yielded only 119 goats in nine days at \$774 per goat including labour (Edwards *et al.* 1994).

Regardless of the inclusion of labour costs in the second operation, the congregation of goats around water holes during the dry period and their dispersal after rain would undoubtedly have influenced the cost efficiencies of the two operations. It could also be argued that if goats are congregating around water points, cost efficiency would be maximised through trapping and sale rather than shooting, provided water points were accessible to heavy vehicles.

Volunteer shooters have been successfully used to conduct ground shooting as part of the control methods within Operation Bounceback 2000. The success with volunteer shooters in this case has been achieved by having well defined objectives and an effective system of coordinating their activities to maximise the level of control achieved.

Aerial shooting has been successfully used to control different pest animal species in Australia, including pigs (Saunders and Bryant, 1988; Hone, 1990), donkeys (Choquenot, 1988), water buffalo (Bayliss and Yeomans, 1989) and goats (Mahood, 1985; Naismith, 1992; Maas and Choquenot, 1995; Pople *et al.* 1996). In pastoral areas this method is mostly used to control inaccessible populations, manage low density populations or remove survivors from other control campaigns (Parkes *et al.* 1996). It may also be the only technique to achieve broad scale reductions when goat prices are low (Clancy and Pople, pers. comm.). It generally involves using helicopters as a shooting platform with light aircraft occasionally acting as 'spotters'. This method is costly, but allows difficult terrain to be covered quickly and gives culling rates far in excess of other control methods (Lim *et al.* 1992). The costs of this technique vary greatly, but tend to rise exponentially with decreasing goat density (Parkes, 1993b; Maas and Choquenot, 1995).

JUDAS GOAT

This technique involves attaching a radio collar to a feral goat and releasing it in the expectation that it will join up with other goats. The goat is then tracked down and the herd which it has joined is killed. Judas goats are generally used where there is a low density population; to locate survivors of other control campaigns (Parkes *et al.* 1996); and to monitor areas thought to be free of goats (Taylor and Katahira, 1988).

The threat abatement plan for feral goats in Tasmania (developed by the Tasmanian Parks and Wildlife Service) advocates this technique since feral goats in Tasmania occur in small isolated groups in difficult terrain (Gaffney and Atkinson, 1995). However, this technique is expensive as it requires costly equipment and skilled staff. It may be warranted only in areas where extremely low goat densities are identified as being necessary to protect conservation values or where eradication of goats is a feasible option.

FERTILITY CONTROL

Fertility control of wild animals is still at an experimental development stage. In practice, fertility control of wild vertebrates has been achieved on only a very limited scale using expensive, labour-intensive methods (Bomford, 1990). It has not been successfully applied to a free-ranging population of wild vertebrates over a large area. Nor has it been attempted as a method of reducing the impacts of land degradation or competition on an endangered or vulnerable species or ecological community.

Fertility control methods include hormone treatment and the use of abortifacients. The use of contraceptive control through hormone treatment is not considered a viable option for managing feral goat populations as there are no practical methods of ensuring effective treatment of unrestrained animals.

An alternative technique based on developing sterility through an auto-immune response to reproductive proteins or hormones (immunocontraception) has been proposed. This technique has the potential to provide a target specific form of fertility control which can be used on wild populations. Tyndale-Biscoe (1994) argued that if the immunocontraceptive technology can be made to work, it may provide a cheap, easily disseminated method for reducing fertility and populations of some pest species on a continental scale. Some scientists and wildlife managers remain sceptical about the likely success and effectiveness of this approach (Carter, 1995). The obstacles to achieving a workable method are formidable and include:

- difficulty of isolating an infectious virus specific to the species concerned;
- difficulty of developing a contraceptive vaccine;
- difficulty of combining the two into a treatment that causes permanent sterility and no other significant disorders in an infected animal;
- the possibility that in the field, natural selection and elements of the target animal's ecology may overcome or compensate for any attack on the species' reproductive capacity;
- social concerns that the methods may not be controllable once released; and
- the need to be cost-effective relative to other methods.

A major benefit of the development of immunocontraceptive techniques is that they can be made species specific and are humane. Broad scale control of goats using an immunocontraceptive vaccine, if one were developed, would depend on developing a suitable delivery mechanism for the vaccine and obtaining appropriate approvals to release the vaccine into the wild.

In those situations on pastoral properties where feral goats can be effectively trapped and mustered regularly, normal livestock management procedures involving mechanical and surgical sterilisation may be viable options to regulate breeding. Every effort should be taken to convert unmanaged feral herds into managed livestock and to remove animals from refuge areas where they are uncontrollable.

POISONING

The only poison that has been trialed for feral goat control in Australia is 1080 (sodium monofluoroacetate). The main risk with this technique is consumption of baits by non-target species. Eliminating the risk to native species relies on exploiting differences in the behaviour, ecology and tolerance of this poison between goats and other species (Daly and Goriup, 1987).

Three baiting techniques have been reported: pelletised grain bait (Forsyth and Parkes, 1995); foliage baiting (Parkes 1983); and poisoning of a water supply (Norbury, 1993). Pelletised baits are ineffective, due to feral goats' aversion to eating food off the ground (Forsyth and Parkes, 1995). Foliage baiting works well if only preferred food plants which are baited are accessible (Parkes, 1983). However, it is unsuitable in Australian conditions due to the lack of a highly preferred food plant and the high risk to non-target species (Parkes *et al.* 1996). For these reasons it is illegal in all Australian States and Territories. The addition of 1080 to water supplies has been successful in trials conducted in Western Australia. The risk to non-target species was reduced by designing the trough to exclude birds and livestock, and poisoning between 8:00am and 12:00pm to circumvent consumption by macropods (Norbury, 1993). This technique is being used in experimental trials only in Western Australia by certified Agricultural Protection Board Officers under strict regulation.

BIOLOGICAL CONTROL

Control of feral goats using a pathogen may be theoretically possible, but currently none is known to be virulent, humane, specific to goats and not transferable to other species. The potential risks to both the domestic goat industry and other livestock industries from using a pathogen are too high to warrant any research on this approach. Another disadvantage is that animals are likely to develop resistance to the pathogen and such resistance will eventually spread through the species.

Feral goats do not generally occur where there are uncontrolled populations of dingoes (Parkes *et al.* 1996). One feral goat population on an offshore island was successfully controlled by releasing dingoes onto the island (Allen and Lee, 1995). It is unlikely that dingoes would be acceptable as a 'biological control' in pastoral areas where most feral goats occur, as predation by dingoes is not a target specific control measure and other livestock would be at risk.

TAX INCENTIVES

Under the *Income Tax Assessment Act 1997* expenditure on preventing and treating land degradation is eligible for a rebate or a deduction. Subdivision 387-A allows for:

- (1) erecting a fence (including an extension, alteration or addition to a fence) primarily and principally to exclude animals such as feral goats from an area affected by land degradation;
 - to prevent or limit the land degradation extending or becoming worse; and,
 - to help reclaim the area;
- (2) eradicating or exterminating pest animals such as feral goats from the land; and,
- (3) extensions to the activities described above.

FACTORS AFFECTING GOAT CONTROL

COMMERCIAL INTERESTS

Commercial interest in goats is based upon both a domestic goat industry and a wild harvest industry. Given that commercial harvesting of feral goats can reduce density, it is feasible to assume that such a measure has the potential to contribute to conservation objectives (Choquenot *et al*, 1995). While the presence of a commercial option for use of feral goats presents some opportunities for reducing costs of control it also presents a potentially confounding factor to effective control. Similarly the presence of a domestic goat industry also presents a confounding factor to management of feral goat populations by providing a potential source of new populations or reinfestation of controlled areas if the domestic stock are not adequately managed. The risks associated with both of these situations can be estimated and are amenable to management through appropriate actions.

Effective management of domestic goats depends on having adequate fencing and a maintenance regime to ensure that the fences are not breached. Domestic goat facilities near environmentally sensitive areas or areas which could act as refuges for escapees (for example broken ranges which are difficult to access) should be assessed for risk. The level of security required to keep the goats on the property should be determined by the level of risk posed by any potential escape. Currently no State or Territory has provision for such an assessment process.

Commercial use of feral goats can involve using field shot animals to supply a game meat market or live goats for a live export trade or to supply abattoirs producing meat for a chilled or frozen meat market. In addition, the development of a domestic goat industry has been partly supplemented with breeding stock derived from live captured feral animals. For the purposes of this plan the term 'wild harvest' is used to refer to both field shot animals and live captured animals which are immediately shipped off the property. Farmed or domestic animals are identified as being both bred and maintained in an enclosed system. Feral animals that are live captured and held on the property within goat proof yards to adjust to captive conditions, and maintained to match market demand and supply, are identified as ranched animals.

A significant problem with managing feral goats is the ambivalent attitude of many land managers. Feral goats are perceived as both a competitor to other livestock industries and a potential alternative source of income. The nature and significance of feral goat impacts on biological diversity is often unclear. This is particularly so where endangered or vulnerable species identified as being threatened by the presence of goats are not present. Such views must be resolved to enable clear management outcomes to be defined. For example, if feral goats are simply seen as a pest and competitor with other livestock industries, the desired management outcome will be to reduce numbers to the lowest level economically achievable. In contrast, where feral goats are seen as an economic resource, and managed to maximise income from them, the desired management outcome may be to maintain high densities of animals to maintain high offtake rates. In other words, the management outcomes in terms of population densities for these two management aims are diametrically opposed. The presence of feral goats on the conservation estate is generally seen as incompatible

with the management of these areas for conservation of biological diversity and maintenance of normal ecosystem functioning. In these areas the desired management outcome is to reduce feral goat numbers to a level at which they have no significant impacts on these values.

Similar problems have arisen in the management of the commercial species of kangaroos where they are seen both as a pest and as a valuable natural resource. The significant difference with kangaroos is that they are native species for which the primary aim is to ensure their conservation throughout their distributional ranges. Management programs for these species have established two subsidiary aims: to mitigate damage caused by the species, and where appropriate to manage them as a sustainable natural resource. The Commonwealth has promoted a regional approach to kangaroo management. This allows the relative priority given to each of the two secondary aims to be adjusted to regional circumstances and priorities. By establishing the relative regional priorities of damage mitigation and sustainable resource use, the specific management outcomes in terms of population regulation can be specified and appropriate harvest quotas established.

A similar approach to management of feral goats would clarify the management aims for particular regions and enable land managers to coordinate their actions. It would also assist in establishing regional conservation priorities and integrating management of feral goats across all land tenures.

The development of an industry dependent upon a regular supply of feral goats is likely to lead to pressure to maintain densities of goats incompatible with sustainable land management. The Standing Committee on Agriculture and Resource Management at its meeting in October 1994 recognised this problem. It supported the development of industries based on the use of feral animals but agreed that such development should aim to eliminate rather than encourage the propagation of those species in the wild. The move from a wild harvest industry to a domestic goat industry is also more compatible with establishing and maintaining regular markets for goat products. The absence of a nationally agreed management framework for transforming the feral goat industry into a coherent domestic goat industry is a significant impediment to rational management of uncontrolled feral goat populations.

From a national perspective, it may be that commercial harvesting of feral goats is not a sufficient measure to control the population. This could be because of population dynamics and the fact that the industry cannot match market demand due to the variability of quality and supply of animals. Nevertheless, local control may be possible through commercial harvesting where access to markets, and adequate prices, allow reduction of feral goat numbers to very low levels.

To ensure that feral goat control and management integrates conservation and primary production outcomes, both the Australian and New Zealand Environment and Conservation Council and the Agricultural Resource Management Council of Australia and New Zealand should cooperatively develop national guidelines for the wild harvest of feral goats. These guidelines should also provide an agreed national policy framework for transforming the wild harvest industry into a domestic goat industry.

LEGAL STATUS

Comments provided by a number of respondents to the draft threat abatement plan highlighted the problem of defining the transition from feral animal to domestic animal. Across Australia, the legal status of the feral goat varies. Commonwealth legislation identifies feral goats as contributing to a key threatening process but is otherwise silent on their legal status. Queensland, South Australia and Western Australia define feral goats as pests and prescribe actions to manage them. Other States and Territories do not define feral goats as a class and do not prescribe particular action for land managers. This lack of consistency in the legal definition of what constitutes a feral goat, and variation in the requirements imposed on land managers, impede actions to ameliorate their impacts on endangered species. It also impedes development of a national approach to commercial use of feral goats and transformation of a wild harvest industry into a domestic goat industry.

COST EFFICIENCY

The level of control that may be achieved will be determined both by the cost of control and the funds available. Table 2 summarises the available data on the costs of various control techniques.

Management strategies including both helicopter shooting and mustering are thought to achieve the highest population reductions for the minimum net cost (Parkes *et al.* 1996). In general, the cost of helicopter shooting rises exponentially with decreasing animal density (Parkes, 1993b; Maas and Choquenot, 1995). However, it is a very effective technique (as the population reductions indicate) and it can be used in all terrains except those with heavy vegetation. Mustering does not reduce goat populations to the same extent as helicopter shooting. However, this is offset by the lower cost, with cost effectiveness depending on the price of goats at the time.

Trapping, like mustering, may make a profit due to sale of captured animals, but can only be used during dry times in places where access to water can be controlled. The Judas goat technique is expensive and is only appropriate where protection of native species and ecological communities can only be achieved with extremely low goat densities. Ground based shooting is not appropriate as the primary means of control in a pastoral setting, because of high labour costs, but may be a useful supplement if conducted as a commercial wild harvest for game meat or hides. In densely vegetated areas, such as Tasmania's forests, it is the only available technique.

Table 2 A summary of the expenditure for various feral goat control techniques used in a semi-arid environment.

Technique	Density/km ²	% Reduction	Cost per Goat	Reference
Helicopter Shooting	6.22	45	3.95	Naismith, 1992
	1.19	70	7.16	Parkes <i>et al.</i> 1996
	26.00	85	7.30	Maas and Choquenot, 1995
			13.69	Shepherd, 1996
			12.84	Shepherd, 1996
	6.99	99	15.00	Henzell, 1984
	1.85	13	19.70	Edwards <i>et al.</i> 1994
	14.50	49	2.91	Pople <i>et al.</i> 1996
	5.10	75	4.62	Pople <i>et al.</i> 1996
	4.75	100	19.10	Pople <i>et al.</i> 1996
Mustering	40.00	80		Henzell, 1984
	2.73	32	+1.00	Edwards <i>et al.</i> 1994
	23.00	26	+4.18	Brill, pers. comm
	7.50	26	+3.50	Brill, pers. comm
			+4.00	Parkes <i>et al.</i> 1996
			+1.93	Miller <i>et al.</i> 1998
Trapping			+5.90	Parkes <i>et al.</i> 1996
			+2.08	Miller <i>et al.</i> 1998
Ground shooting			2.94*	Dodd and Hartwig 1992
	5.60	0	774.00	Edwards <i>et al.</i> 1994
			1.07	Frazer, 1992
Judas goat	0.1-2.0	100	70.00	Henzell, 1992b#

(*does not include the cost of labour; # not based on an actual control campaign, but are a theoretical calculation; + income resulting from the sale of the feral goats)

ANIMAL WELFARE

Feral goat control techniques have raised concerns with animal welfare organisations particularly where captured goats are commercially used. The National Consultative Committee on Animal Welfare (NCCAW) considers it essential that animal welfare concerns be given equal weighting with other factors in assessing management options (O'Flynn, 1992). Both NCCAW (O'Flynn, 1992) and the RSPCA (Peters, 1992) opposed the capture and transport of feral goats as then practised because of high mortality rates.

Other techniques that are considered unsuitable on animal welfare grounds are denial of water as a means of killing animals; and trapping without prompt destruction or removal (Peters, 1992).

In 1991 the Standing Committee on Agriculture released a model code of practice entitled *Feral Livestock Animals- Destruction or Capture, Handling and Marketing to*

promote the welfare of feral livestock animals which are captured or destroyed. Adherence to this code of practice is recommended when feral goats are commercially used or destroyed. Further improvements to animal welfare should be based on regular monitoring and assessment of the code's effectiveness.

Helicopter shooting is accepted as the most efficient method for killing feral goats in rough country and NCCAW notes that it can be a humane technique if done by appropriately trained and equipped marksmen (Peters, 1992; O'Flynn, 1992). Many Government agencies now require all personnel shooting feral animals from helicopters to undergo an approved training course.

To ensure the most humane methods are used animal welfare agencies should be consulted and involved in the design of feral goat management plans.

WATER MANAGEMENT

Artificial watering points are so numerous in the arid and semi-arid rangelands of Australia that their spacing is rarely more than 10 kilometres apart (James *et al.* 1997). This water benefits all large herbivores, allowing them to survive in habitats that would not otherwise be suitable (Parkes *et al.* 1996). This has led to a much greater total grazing pressure, which has irrevocably changed the character of the landscape (James *et al.* 1997). Landsberg *et al.* (1997) found that many native species were disadvantaged by providing water and recommended the closure of artificial waters to address this problem. Closing of artificial water points is possible in conservation areas after unwanted herbivores have been removed by humane methods (Parkes *et al.* 1996).

While the permanent closure of artificial water points may be an option on the conservation estate, it is not an option on land being managed for livestock production. In these latter areas the focus will need to be on improved management of water points to minimise waste and more effectively manage livestock and grazing pressure. Current efforts to cap the bores throughout the Great Artesian Basin are likely to contribute in time to more effective management of both domestic livestock and feral goats. In all cases the impact of improved management or closure of water points on non-target species would need to be assessed before taking this action.

INTERACTION WITH OTHER HERBIVORES

The presence of too many herbivores in an area can lead to overgrazing and land degradation. Whereas domestic livestock numbers can be actively controlled by land managers, there are a range of other herbivores, including feral goats and rabbits in particular, that may be significant contributors to total grazing pressure but are not as easy to control. These species are not normally considered in determining total stocking rates on an area but their numbers, combined with domestic livestock numbers, may exceed the safe stocking rates for the land. The impacts of these species will be most pronounced during drought when animals will be competing for declining food and water resources. Goats are known to persist longer than sheep or kangaroos during drought conditions and this is likely to exacerbate their contribution to land degradation.

As goats are generalist herbivores they can affect a wide range of plant species including grasses, forbs, herbs and perennial shrubs and trees. Parkes *et al.* (1996) noted that the contribution of feral goats to total grazing pressure could be assessed by estimating the net annual aboveground productivity of vegetation eaten. Using this method, Parkes *et al.* illustrate that goats at average densities of two per square kilometre consume 0.73 tonnes of dry matter per year, an order of magnitude less than average densities of rabbits (about 300 per square kilometre) that consume 10 tonnes of dry matter per year. Although this comparative figure may suggest that feral goats are only a minor contributor to land degradation, the fact that goats can survive on a wide range of plants means that their impacts may be greater than other herbivores during periods of drought.

Decisions upon the effective allocation of resources to control feral herbivores in an area require a more detailed understanding of the interactions between the individual species.

DEVELOPING A NATIONAL APPROACH TO FERAL GOAT MANAGEMENT

PLANNING FOR NATIONALLY COORDINATED ACTION

It has not been possible to develop a reasonable estimate of current annual expenditure on feral goat control activities in Australia. Undoubtedly, State and Territory agencies make a major investment in feral goat control, but details of the scale of this investment are not available. Commercial harvesters also invest in, and presumably profit from, goat control activities. Landholders and land managers, local government agencies and community groups are also actively involved in feral goat control activities but there is little reliable data on the costs of these efforts.

In recent years, in addition to funding feral goat control programs on its own lands, the Commonwealth has provided funding to State, Territory and national organisations for feral goat control activities. Projects have included:

- strategic planning;
- control of feral goats on islands (Tasmania and Lord Howe Island);
- localised eradication (Peron Peninsula); and
- regional integrated control (Bounceback 2000 in South Australia).

STRATEGIES

Resources will never be sufficient to deal with all feral goat management problems so the threat abatement plan must ensure the strategic allocation of resources to give the best outcome for threatened species conservation.

Localised feral goat control in specific areas of high conservation concern, particularly around populations of threatened species, will be continued as a significant component of this plan. Recovery plans for a number of species identify the feral goat as a perceived threat (Table 1). It is likely that the number of species perceived to be at risk from feral goats will increase as recovery plans are developed for more threatened plants.

Local eradication is an option for areas which meet strict criteria - the chances of reinvasion must be nil or very close to it, all animals must be accessible and at risk during the control operation and animals must be killed at a rate higher than their ability to replace losses through breeding. Maintaining an area free from feral goats requires a sustained control operation to prevent reinvasion from surrounding feral goat infested areas or the use of exclusion fences. As a strategy, local eradication is applicable to small islands, isolated small populations on the mainland or small mainland sites which are surrounded by feral goat exclusion fences.

Where local eradication is not possible, there are two broad strategies which can be used for localised management of feral goats. These are sustained management where control is implemented on a continuing regular basis and intermittent management which seeks to apply control at critical periods of the year when damage is greatest and short term control will reduce impacts to acceptable levels. Intermittent control may be useful as a temporary seasonal measure at sites where competition is a seasonal threat (for example with annual plants) or where the threat is most

pronounced during adverse seasonal conditions such as drought.

To ensure efficient and effective use of resources, an experimental approach will be used to determine the significance of competition and land degradation by feral goats in the decline of endangered and vulnerable species and to identify the level of control necessary for their recovery. By approaching local control this way the true significance of competition and land degradation by feral goats can be determined. If the hypothesis that feral goats are a significant threat is confirmed, this will justify expanding control activities to other sites. Alternatively, if feral goat control is shown to be of little relevance to recovery of the species, efforts can be re-directed to those activities that are effective in promoting its recovery.

Buffer zones may be a necessary component of managing small areas, to reduce the threat from continual reinvasion from surrounding areas replacing feral goats removed during control operations. Development of such lower density buffer zones will require the active participation of surrounding landholders and a clear identification of the benefits to be obtained by all participants.

Regional management focuses on key areas where maximum benefits can be derived from reducing the impacts of feral goats on a range of species. This is a central element of this plan. Regional control programs are designed to provide protection to a number of at-risk species and to provide a substantial expansion of available habitat. Broad scale control of feral goats at this level requires a substantial investment of resources.

Regional management is well suited to an adaptive management approach as it can accommodate different experimental control techniques within a broadly comparable area. Regional management will also provide a means of integrating feral goat control with other biodiversity conservation programs such as Bushcare and other programs funded through the Natural Heritage Trust.

High priority must be given to monitoring the outcomes of feral goat control in terms of conservation benefits derived. Ineffective control may result in high harvest rates but little reduction in competition and land degradation due to feral goats maintaining a sustainably high reproductive rate.

RANKING AREAS FOR PRIORITY ACTION

Identification of those species and regions that will most benefit from coordinated feral goat control activities is clearly important. Recovery plans will identify species that are known or perceived to be threatened by competition and land degradation by feral goats and those areas of habitat critical for the survival of these species. In terms of national action to abate the threat posed by feral goats, implementation of recovery plans for these species must be accorded the highest priority. Local community groups and landowners will be encouraged to become involved in coordinated feral goat control plans for their region.

As recovery plans for more threatened species are finalised and adopted it may be that available resources are not sufficient to fully implement all the feral goat control measures identified as required. Areas will then need to be ranked on a nationally

consistent basis to ensure that decisions about funding for control activities can maximise the conservation benefits to be derived. An agreed national methodology for ranking areas should cover protecting and facilitating the expansion of existing populations of threatened species, and preparing areas for translocation.

A system to weight areas regarding the risk and the possibility of reducing that risk will be developed in order to allocate resources to areas where feral goat management is most needed. Parkes *et al.* (1996) describe a system developed in New Zealand to decide priority areas for investment in feral goat control. This is a complex process that involves scoring native species in an area according to their conservation value and then weighting these scores for the threat posed to the species. Using the New Zealand system as a guide, procedures for prioritising areas for feral goat management in Australia will be refined. Priorities for investment of Commonwealth resources will be selected using the following criteria:

- the degree of threat that feral goats pose to the survival of the endangered or vulnerable species or ecological community;
- the potential that species or ecological community has to recover;
- the number of threatened species likely to benefit from control in that locality; and
- the cost efficiency and likely effectiveness of feral goat control.

THREAT ABATEMENT OBJECTIVES AND ACTIONS

The aims of this plan are to promote the recovery of endangered or vulnerable native species and communities, and to prevent further species and communities becoming endangered by reducing competition and land degradation caused by feral goats to non-threatening levels. These aims will be achieved by implementing currently available feral goat control techniques, providing for improvements to existing control techniques or the development of new techniques, and collecting information to improve understanding of the impacts of feral goats on endangered or vulnerable native species and communities. The key performance indicator will be the degree of security achieved for species or communities that are currently or potentially threatened by competition or land degradation caused by feral goats.

Key objectives for this plan are to:

Objective 1: Promote the recovery of species and ecological communities that are endangered or vulnerable due to competition by feral goats.

Objective 2: Arrest land degradation caused by feral goats and promote recovery of degraded areas to a state which maximises the chances of long term survival of endangered and vulnerable native species and ecological communities affected by such degradation.

Objective 3: Eradicate feral goats from islands or isolated areas where they are a threat to endangered or vulnerable native species or ecological communities.

Objective 4: Prevent feral goats occupying new areas in Australia where they may threaten species or ecological communities with extinction.

Objective 5: Ensure that development of a commercial goat industry does not compromise conservation of native species or ecological communities.

Objective 6: Improve the effectiveness and humaneness of feral goat control methods.

Objective 7: Improve knowledge and understanding of feral goat impacts and interactions with other species.

Objective 8: Improve knowledge and understanding of the role of feral goats as a contributor to land degradation.

Objective 9: Communicate the results of the Threat Abatement Plan actions to management agencies, landholders and the public.

Objective 10: Effectively coordinate feral goat control activities.

Although feral goats are identified under the *Endangered Species Protection Act 1992* as threatening native species and ecological communities, they are also a threat to primary production. Cost effective and efficient control measures will, wherever

possible, be applied through regionally coordinated management partnerships involving landholders, community groups and all levels of government. Management of feral goats will be integrated with other natural resource management activities and, where relevant, with the management of other pest species identified as contributing to key threatening processes. While the focus of this threat abatement plan will be upon controlling the impacts of feral goats on native species and communities, the responsible development and management of the emerging goat industry will also be a major contributor to improved conservation outcomes.

To achieve the aim of threat abatement, the following actions in key areas are prescribed:

- implementing feral goat control programs in specific areas of high conservation priority and maintaining feral goat free areas;
- encouraging the development and use of innovative and humane control methods for feral goat management;
- collecting and disseminating information to improve understanding of the ecology of feral goats in Australia, their impacts and methods to control them; and
- educating land managers and relevant organisations to improve their knowledge of feral goat impacts and ensure skilled and effective participation in control activities.

Specific objectives and actions in each of these areas are detailed below.

FERAL GOAT MANAGEMENT

Objective 1: Promote the recovery of species and ecological communities that are endangered or vulnerable due to competition by feral goats.

Objective 2: Arrest land degradation caused by feral goats and promote recovery of degraded areas to a state which maximises the chances of long term survival of native species and ecological communities affected by such degradation.

Local Control Plans

A number of listed endangered and vulnerable species have been identified as being under significant threat from the impacts of feral goats. Recovery plans for these species identify control of feral goats as a necessary component of the recovery process. Implementation of local control plans in areas identified as critical habitat for these species is a top priority of this threat abatement plan.

In contrast to foxes and feral cats where the threatening process (predation) affects native animals only, goats can adversely affect both animals (through competition for scarce resources such as food or water) and plants (by direct consumption). Direct competition by goats has been identified as a known threat for the mallee fowl only, and a perceived threat for a small number of other listed native animals (Table 1). For those species where competition and land degradation by feral goats have been identified as a perceived threat, there is a need to test whether the perception is valid. Development and implementation of recovery plans for these species should determine the significance of feral goats as a threat to these species and the level of control necessary to secure their recovery. Feral goat control activities promoted

under these recovery plans must be designed to help quantify the significance of the threat posed by feral goats compared to other threats to the species concerned.

Translocation has been an important strategy for expanding existing populations of endangered species. Implementation of local feral goat control plans in areas designated as translocation sites for such species should be a high priority and be consistent with the recovery plans for these species.

Actions

Implement local feral goat control for species where competition by feral goats is a known threat (currently only the mallee fowl).

Implement local feral goat control programs in areas designated as translocation sites for species where competition by feral goats is a known threat.

Implement experimental feral goat control programs, including exclusion fencing for threatened plants, in areas of critical habitat for species perceived to be threatened by competition from feral goats, to determine the significance of the threat and the level of control necessary to secure recovery.

Identify incentives to promote and maintain on-ground feral goat control on private or leasehold lands that contain populations of endangered species or where control is necessary to provide a buffer zone around a population of a listed species.

Implement experimental feral goat control programs in ecological communities perceived to be threatened by land degradation caused by feral goats, to determine the significance of the threat and the level of control necessary to ameliorate the degradation.

The Commonwealth will make funds available, through the Endangered Species Program and other programs of the Natural Heritage Trust, to support projects involving local feral goat control. Commonwealth funding will assist the development of local partnerships, where appropriate, to integrate management of feral goats on both public and private lands. Where local feral goat control confirms that competition or land degradation caused by feral goats is a significant threat to particular endangered or vulnerable native species or ecological communities, this plan will promote the expansion and integration of local site specific control plans into regional control plans, as well as promote direct links with other relevant biodiversity conservation initiatives in the region.

Regional Control Plans

Regional control plans are designed to provide protection to, or to provide a substantial expansion of suitable habitat for, a number of native species threatened by the same process or to address broad scale threats such as land degradation attributable to a particular species. In the case of a species such as the feral goat that impacts on both conservation of biological diversity and on primary production,

regional control plans provide a means of defining agreed outcomes across land tenures and coordinating action to achieve these outcomes. Regional control plans are also valuable in preparing sites for reintroductions of native species to areas within their former range.

Control of feral goats at a regional level requires a substantial investment of resources. Western Australia has been conducting a broad scale feral goat control program since 1991. This program initially sought to eradicate feral goats from the State and to eliminate the wild harvest industry. Lack of resolve by some members of the rural community involved in goat control was identified as a major impediment to effective control and potential eradication. Agriculture Western Australia noted that successful control of the impacts of feral goats on conservation of biological diversity will not occur without a coordinated effort involving both pastoral leaseholds and conservation areas.

South Australia is attempting to control feral goats at a regional level under Bounceback 2000 which is developing an integrated approach to the control of foxes, feral cats, goats and rabbits. This involves national parks, neighbouring landholders and community groups. Implementation of this regional control plan will identify the potential effectiveness of broad-scale control of feral goats using existing technology. It will also substantially enhance the ability of land managers to develop and apply an integrated approach to feral animal control, which must be a priority of this Threat Abatement plan.

Actions

Continue implementation of the broad scale coordinated feral goat control program in Western Australia to promote both conservation and primary production benefits.

Continue implementation of Bounceback 2000 in South Australia to facilitate reintroductions of locally extinct species and to minimise competition with existing remnant populations of threatened species.

Support regional organisations, community groups and government agencies in collaboratively developing and implementing regional feral goat control programs to address problems attributable to competition or land degradation caused by feral goats.

The Commonwealth will make funds available, through the programs of the Natural Heritage Trust, to support the further development of regional feral goat control programs. Where possible, management of feral goats on both public and private lands will be integrated with other regional biodiversity conservation measures through the development of regional partnerships.

Objective 3: Eradicate feral goats from islands or isolated areas where they are a threat to endangered or vulnerable native species.

Objective 4: Prevent feral goats occupying new areas in Australia where they may threaten species or ecological communities with extinction.

Feral Goat Free Areas

Feral goats are known to be present on a number of islands of which Tasmania and Kangaroo Island are the largest (Parkes *et al.* 1996). The threat posed by feral goats to conservation of species on these islands should be reviewed to determine priorities for eradication. There are also a number of isolated populations of goats on mainland Australia where eradication may be a feasible option. Conservation values to be protected in these latter areas should be identified and priorities established for control. Every effort should be taken to contain and eradicate goats from these isolated populations.

Preventing the introduction of feral goats to islands or new mainland sites of high conservation value requires identification of potential routes of invasion, a risk analysis to determine the probability of such an event and procedures to manage and minimise the risk. It is essential that feral goats continue to be excluded from those areas where they do not occur. The risk of goats naturally dispersing to islands is considered very low, as goats are reluctant to swim except under duress. Deliberate introductions to continental islands are now also an unlikely event. Dispersal or introduction of feral goats to new areas of the mainland is, however, a more significant risk that needs to be fully assessed and appropriate management strategies developed to respond to such events. There must also be the ability to detect incursions before populations have a chance to become established. Contingency plans should identify the most appropriate control measures and funding sources to implement the required control.

Actions

Review the species and conservation values at risk from goats on those islands where they occur and identify priorities for eradication.

Identify isolated feral goat populations and determine whether there are any endangered or threatened species present in these areas that would justify eradication of the feral goats.

Develop and implement contingency plans to contain and exterminate any incursion by feral goats into isolated areas with high conservation values.

Environment Australia will provide funds from its operating budget to enable staff to work with relevant State authorities to implement these actions. Identification of islands of high conservation value will be based on existing data. Additional costs of these actions will be determined by the results of the risk analysis.

Objective 5: Ensure that development of a commercial goat industry does not compromise conservation of native species or ecological communities.

The presence of feral goats in Australia is a direct result of human actions in the past, either releasing goats onto islands as potential food for mariners or from domestic animals accidentally or deliberately being released into the wild. The presence of a domestic goat industry presents a continuing risk that further escapes could occur

leading to expansion of the range of feral goats or reinfestation of areas where control may have been effective. The risk that domestic goats could escape, and the potential consequences of such an escape, are amenable to analysis. Based upon the level of risk identified, management measures could be required to minimise the threat of new feral populations being established.

Action

Develop methods for evaluating the risks of establishing feral goat populations through escapees from new and existing goat enterprises.

Identify management options to minimise the threat to the environment and to other primary production activities posed by new and existing domestic goat enterprises.

In addition to the domestic goat industry, there is a wild harvest industry based on either field shot animals or capture of wild animals. The presence of a wild harvest industry based on feral goats presents risks to efforts to manage feral populations. Intermittent and uncoordinated control activities by individual landholders to supply the wild harvest industry will not result in effective management of feral goats nor ameliorate the goats' impacts on endangered or vulnerable native species or ecological communities. The Standing Committee on Agriculture and Resource Management at its meeting in October 1994 supported the commercial use of feral animals with the objective of eliminating them from the wild.

Current State and Territory legislation defines feral goats as either livestock or as pest animals. The consequences for effective management of the differing legal classifications of feral goats should be assessed. Agreement should be sought through the Standing Committee on Agriculture and Resource Management and the Standing Committee on Conservation on a nationally consistent status for all feral goats.

Action

Assess the relative merits of the differing legal status currently ascribed to feral goats and review the implications for management actions.

Review the economics of the wild harvest industry and identify those areas and circumstances under which it would be an economically viable supplement to control options.

Encourage the development and implementation of a national policy on the commercial use of feral goats.

Assessment of the legal status of feral goats is a matter that could be considered by the feral goat threat abatement team proposed to be established as an action relating to objective 10. Development of a national policy on commercial use of feral goats is an activity that should be considered jointly by the Standing Committee on Agriculture and Resource Management and the Standing Committee on Conservation.

INNOVATIVE AND HUMANE CONTROL METHODS

Objective 6: Improve the effectiveness and humaneness of feral goat control methods.

Trapping Systems

The majority of feral goats in Australia are within the arid and semi-arid rangelands. Distribution and survival of goats in the rangelands is determined by the availability of either natural or artificial water sources. While goats in temperate or wetter climates may obtain all of their water requirements from their food, goats in the rangelands need to drink during dry times. This reliance on water during dry times is a critical weakness in the resilience of goats to other control measures. Current moves to cap the bores and regulate water supply in large areas of the rangelands provide an opportunity to increase the effectiveness of goat control at water points. Permanent traps may be placed around water sources and left open except for short periods when they are made operational to capture goats.

Actions

Evaluate and disseminate information on the effectiveness of permanent traps placed on water sources as a means of capturing feral goats, and assess the effects of their use on domestic livestock.

Identify the most effective trap designs and determine the relative cost effectiveness of individual trap designs as a means of capturing feral goats and protecting local populations of endangered species.

Investigate feral goat behaviour at traps to determine potential weak points in designs that may compromise their effectiveness.

Investigate goat behaviour at traps on water sources to develop guidelines on their usage that will ensure that animal welfare is not compromised.

Evaluate and disseminate information on management options for humane disposal of feral goats that are trapped.

Fencing

A large range of fence designs has been used to contain domestic goats and several designs for conventional and electric fences have been recommended for normal Australian conditions (Lund and May 1990). However there is little information on the effectiveness of specific designs for use on feral goats and there are no nationally accepted standard designs for particular habitats or terrain. A recent (1994) review of predator proof fence designs highlighted the need for a comprehensive evaluation of the cost-effectiveness of different fence designs, to ensure that future investment in fox resistant fences is directed towards the most effective designs. A similar review is warranted to assess the effectiveness of stock proof fencing for containing domestic goats on farms and excluding feral goats from areas of high conservation value. Exclusion fencing is seen as a particularly useful means of providing interim protection to plants and other species that cannot move. Longer term protection may

involve broad scale reduction in goat numbers to restore normal ecosystem functioning.

Actions

Evaluate existing fence designs for containing domestic goats, and their suitability for excluding feral goats from areas of high conservation value, and disseminate this information to land managers.

Identify the most effective fence designs for particular habitats or topographies and determine the relative cost effectiveness of individual fence designs as a means of enclosing or excluding feral goats and protecting local populations of endangered species.

Investigate the behaviour of both domestic and feral goats at electrified and non-electrified fences to determine potential weak points in fence designs that may compromise their effectiveness.

Fertility Control

Feral goats have a high rate of reproduction, and can breed twice a year under good conditions. The average litter size is 1.59 and litters are produced, on average, 1.57 times a year (Henzell quoted in Parkes *et al.* 1996). In the absence of human control efforts goats have the ability to double their population every 1.6 years (Parkes *et al.* 1996). In these circumstances, control methods that result in only temporary sterility would be unlikely to provide any effective level of population control.

Given the high cost of research on fertility control agents and the existing research on other species, this plan recommends that progress in the development of fertility controls for foxes, rabbits and mice be monitored, but that no additional funds be invested in similar work on feral goats until the benefits of current research have been demonstrated.

Action

Monitor progress with the development of fertility control methods for foxes, rabbits and mice. Should these studies demonstrate the effectiveness of fertility control methods for any of these species, review the potential applicability to feral goat control and identify the research necessary to develop and apply the methodology to feral goats.

Humane Poisoning

The use of 1080 poison on hoofed animals appears to be relatively humane. However, poisons have not been extensively used as a control method for feral goats. Western Australia has experimented with the use of 1080 in water but this method appears to be more suited to higher densities of goats (Norbury 1993). Problems with potential non-target impacts have limited the wide use of 1080 as a control method for feral goats.

The use of poisons is not considered a priority for control of feral goats but there may be a need to examine their potential use in temperate or wet climate areas where feral goats can survive without free water. The identification, testing and registration of

new control substances for use on feral animals is an expensive exercise. Such studies would only be considered if existing control methods proved inadequate to control feral goats in these areas.

Action

Identify existing usage of poisons as a control method for feral goats and evaluate the effectiveness and humaneness of existing poison methods.

Review and evaluate the range of poisons that could be used to control feral goats.

Implementation of these actions may be supported with funding made available through the National Feral Animal Control Program of the Natural Heritage Trust.

INFORMATION

Objective 7: Improve knowledge and understanding of feral goat impacts and interactions with other species.

Objective 8: Improve knowledge and understanding of the role of feral goats as a contributor to land degradation.

Documenting Feral Goat Impacts

Ensuring that field experience and research are applied to improve feral goat control programs is an important element of this plan. Despite the fact that feral goats have been in Australia since the last century, knowledge of their interactions with other species, ecology and behaviour is still inadequate. There is a recognised need to improve understanding of the impact of feral goats on a range of native species, especially those native plants currently listed as endangered or vulnerable, and to determine whether this is compatible with the long term conservation of these species. In addition, the relative contribution to land degradation that is directly attributable to feral goats has not been determined.

Adaptive management approaches that experimentally test different control techniques will be encouraged. By measuring the effectiveness of different control strategies in achieving recovery of threatened species, the ability to effectively abate the threat posed by feral goats will be improved.

Actions

Develop simple and cost effective methods of monitoring the impacts of feral goats on threatened species as a means of evaluating control activities.

Develop improved methods for estimating feral goat numbers to assist in determining broad scale control priorities and assist in strategic planning.

Investigate interactions between feral goats and other herbivores to identify the relative contribution of feral goats to total competition and

land degradation, particularly in rangeland areas.

Implementation of these actions may be supported with funding made available through the National Feral Animal Control Program of the Natural Heritage Trust.

Understanding Interactions with Other Feral Pests

Rabbits have also been identified as contributing to competition and land degradation which is threatening native species and ecological communities. In areas where goats and rabbits are present control activities should be planned to identify the relative contribution of each species to the threatening process. Where resources for control activities are limited, such information will be important in determining the most effective strategy to be employed.

Dingoes and feral dogs have been identified as the main predators of feral goats, although foxes, feral pigs and wedge-tailed eagles are also known to prey upon them. Feral goats are rarely present unless dingoes or feral dogs are absent or controlled to low densities (Parkes *et al.* 1996).

Actions

Identify the relative contributions of feral goats and rabbits to land degradation affecting endangered and vulnerable native species and ecological communities so that control of both species can be integrated to maximise recovery of native species.

Determine the level of competition between feral goats and rabbits for plant material to integrate feral goat control activities with rabbit control activities more effectively.

Determine the significance of predation by dingoes as a control of feral goat populations and assess the relative costs and benefits of controlling either one species alone or both species together.

Funding support may be made available through the National Feral Animal Control Program of the Natural Heritage Trust. Implementation of these actions will be integrated with any similar actions prescribed in the threat abatement plan for the rabbit.

Refining Priority Setting Mechanisms

Identification of species and regions that will benefit most from coordinated feral goat control activities is vital. Recovery plans identify those species at risk and areas of habitat critical for their survival. Implementation of these plans must be accorded the highest priority in national action to abate the threat posed by feral goats. Available resources will seldom, if ever, be sufficient to fully implement all the control measures recommended in recovery plans. Increasingly, areas will need to be ranked on a nationally consistent basis to ensure that decisions about funding for control activities result in maximum conservation benefits. An agreed national methodology for ranking areas should be developed to cover protecting existing populations of endangered species, facilitating their expansion, and preparing areas for translocation.

Actions

Prioritise areas for investment in feral goat control to take account more effectively of the degree of threat that feral goats pose to the survival of an endangered or vulnerable species or ecological community; the potential that species or ecological community has to recover; and the cost efficiency and likely effectiveness of feral goat control.

Develop decision support systems to assist land managers to identify locally appropriate control method(s) and the circumstances and times to apply them in controlling feral goats.

Map the distribution of susceptible species, high risk habitats and feral goats to produce a national overview of priority regions.

The feral goat threat abatement team, specified in the actions relating to Objective 10, will take responsibility for implementation of these actions. Environment Australia will provide funds from its operating budget to enable staff to work with relevant State authorities to ensure the available data are collated and analysed.

EDUCATION

Objective 9: Communicate the results of the Threat Abatement Plan actions to management agencies, landholders and the public.

Education and Extension

The success of this threat abatement plan will be dependent upon a high level of cooperation between all key stakeholders. These include landholders, community groups, feral goat harvesters, local government, State and Territory conservation and pest management agencies and the Commonwealth Government and its agencies. While the focus of this threat abatement plan is upon minimising the impacts of feral goats on endangered and vulnerable species and communities, it must take account of the fact that feral goat populations were founded by domestic goats which escaped. It is important that development of the domestic goat industry occurs in an ecologically sustainable manner and that adequate provisions exist to minimise the risk of future escapes, especially in environmentally sensitive areas. Educating land managers and community organisations to ensure their skilled and effective participation in feral goat control activities, and to improve their knowledge of the impacts that feral goats have upon native species and communities, is an essential component of the plan. Landowners involved in development of the domestic goat industry should be aware of the threats posed by uncontrolled feral goat populations and the necessary management actions to minimise the risk of domestic livestock escaping.

The plan is also intended to assist in documenting significant advances in knowledge, techniques and practice for abating the threat to endangered and vulnerable species and ecological communities posed by feral goats. A number of actions identified require an extension/education effort to ensure effective implementation.

Actions

Prepare and distribute extension material to promote understanding of the actions to be undertaken under this plan, the use of humane and cost effective feral goat control methods, a wider knowledge of species recovery plans and the importance of competition and land degradation caused by feral goats as a key threatening process.

The feral goat threat abatement team, specified in the actions relating to Objective 10, will guide the development and implementation of an education, extension and information transfer program. Environment Australia will provide funds from its operating budget for the initial development of a communications strategy. This strategy will include detailed budgets for future years of the five year life of this plan.

ADMINISTRATION

Objective 10: Effectively coordinate feral goat control activities.

National coordination

The presence of both a domestic livestock industry based on goats and the wild harvest of feral goat populations highlights the importance of national coordination in managing the impacts of goats on endangered and vulnerable species and communities. Inadequate management and containment of domestic goats could compromise any benefits that may be gained by improved control of feral goats. Similarly, actions to control feral goats will need to take account of potential implications for managed domestic goats. The activities and priorities under this plan will need to ensure that field experience and research are applied to further improve management of feral goats. Success will only be achieved if all key stakeholders are involved in its further development and cooperate in its implementation. The threat abatement plan Advisory Group was of considerable assistance in the development of this plan and a similar body will be needed to direct its implementation.

Implementation of this plan will require:

- establishing national priorities for local control plans based on individual species recovery plans;
- evaluating the evidence that land degradation caused by feral goats constitutes a significant threat for species where this has not previously been established;
- identifying opportunities for integrating individual local control plans to enhance efficiency of control; and
- recommending regional priorities for funding.

As identified above, the development of material to assist in extension and information transfer would be assisted by input from an advisory group comprising persons with relevant technical and practical experience in feral goat control and/or management of domestic goats. This group, with both technical and practical experience to draw upon, could assess the potential broader application of control methods or approaches developed through local control plans.

Actions

A Feral Goat Threat Abatement team composed of people with relevant technical and practical experience, and convened by Environment

Australia, will be established to advise the Minister on implementation of the plan.

An independent expert will be commissioned before the end of the five year life of the plan to conduct a comprehensive review of the progress made in its implementation.

Environment Australia will provide funds from its operating budget to enable staff to convene the threat abatement team and provide it with secretariat support. Costs of a comprehensive review of progress with implementation of this plan will be met from the National Feral Animal Control Program of the Natural Heritage Trust.

EVALUATION AND REVIEW

Section 34 (2) of the Act requires that a threat abatement plan identify organisations or persons who will be involved in evaluating the performance of the plan. Section 43 (2) requires that plans must be reviewed at intervals of no more than five years. These statutory requirements for assessment and review are intended to ensure that each threat abatement plan is an evolving document, able to build upon achievements and to be modified in the light of new knowledge or resources.

As specified in the actions relating to Objective 10, a Feral Goat Threat Abatement Team, similar in structure to the Threat Abatement Plan Advisory Group which assisted in the development of this plan, will be established to monitor the implementation of the plan. The team will include representatives from State/Territory conservation agencies, non-government conservation organisations, pest management experts and industry interests. Environment Australia will provide a convenor and act as the secretariat for the team. The team will monitor achievement of the performance criteria and milestones set out in the plan and provide regular annual reports on progress.

The Act provides for a review of the threat abatement plan at any time at the discretion of the Director of National Parks and Wildlife. Environment Australia will advise the Director to request a revision of the plan if evidence is found that a feral goat control technique recommended in this plan results in adverse impacts on a native species such that the species is becoming endangered.

Before the end of the five year life of the plan an independent expert will be commissioned to examine the plan and the supporting technical documents, and the success or otherwise of management actions undertaken. Recommendations from the review will then be used to prepare another threat abatement plan for the next five year phase.

REFERENCES

- Agricultural Protection Board (1993) Trial use of 1080 to control feral goats in Western Australia. pp10 Report and recommendations of the Environmental Protection Authority. *Bulletin No. 719 Agricultural Protection Board of Western Australia*.
- Alexander, P. (1995) *Integrated pest animal control to promote recovery of the yellow-footed rock-wallaby in South Australia: Stage 2*. Report to the Department of Environment and Natural Resources, South Australia.
- Allen, L.R. and Lee J.M. (1995) *The management of feral goat impact on Townsend Island*. Progress report to the Department of Defence, Queensland Department of Lands.
- Biodiversity Group, Environment Australia (1996) *Draft threat abatement plan for predation by the European red fox*. Invasive Species Program, Australian Nature Conservation Agency, Canberra.
- Auld, T.D. (1993) The impact of grazing on regeneration of the shrub *Acacia carnei* in arid Australia. *Biol. Conserv.* 65:165-76
- Bayliss, P. and Yeomans K. (1989) Distribution and abundance of feral livestock in the 'Top End' of the Northern Territory (1985-86), and their relation to population control. *Aust. Wildl. Res.* 16:651-76.
- Benshemesh J. (1993) *Recovery plan research phase for the Malleefowl* (*Leipoa ocellata*). Unpublished report to the Australian National Parks and Wildlife Service, Canberra.
- Benshemesh, J. (1998) *National Recovery Plan for Malleefowl*. Threatened Species Network South Australia.
- Bomford, M. and O'Brien P. (1992) Feral goat control or eradication? Assessment criteria for decision making. pp 57-64 in D. Freudenberger (ed), *Proceedings of the National Workshop on Feral Goat Management*. Bureau of Resource Sciences, Canberra.
- Braysher, M. (1993) *Managing Vertebrate Pests: Principles and Strategies*. Bureau of Resource Sciences. Australian Government Publishing Service. Canberra.
- Briggs, J.D. and Leigh J.H. (1988) Rare or Threatened Australian Plants. *Australian National Parks and Wildlife Service Special Publication No. 14, Canberra*.
- Bullock, D and North S. (1985) Round Island in 1985. *Oryx* 18: 36-41
- Butler, G., Richardson, M. and Ganter, W. (1991) *Recovery Plan for Grevillea iaspicula McGillivray* (Wee Jasper Grevillea). Australian National Botanic Gardens

Brill, T (Pers. Comm.) NSW Agriculture

Carter, D.B. (ed). (1995) *Outfoxing foxes for nature conservation: preparing a national threat abatement plan*. Australian Nature Conservation Agency, Canberra.

Caughley, G. (1976) Wildlife management and the dynamics of ungulate populations. pp 183-246 in T.H. Coaker (ed) '*Applied Biology. Volume 1.*', Academic Press, London.

Caughley, G. (1989) Plant-Herbivore Interactions. In The Future of New Zealand's Wild Animals. A.E. Newton (ed) *New Zealand Deer Stalkers Association*. pp 51-52.

Caughley, G. (1994) Directions in conservation biology. *J. An. Ecolo.* 63:215-244

Caughley, G. and Sinclair A.R.E. (1994) *Wildlife Ecology and Management*. Blackwell, Boston. pp 334

Choquenot, D. (1988) *Feral donkeys in northern Australia: population dynamics and cost of control*. Unpublished Master of Applied Science, Canberra College of Advanced Education, Canberra, Australia, pp113.

Coblentz, B.E. (1977) Some range relationships of feral goats on Santa Catalina Island, California. *J. Rang. Manage.* 30(6): 415-9.

Coblentz, B.E. (1978) The effect of feral goats (*Capra hircus*) on island ecosystems. *Biol. Conserv.* 13:279-86

Daly, K. and Goriup P. (1987) Eradication of feral goats from small islands. Report to International Council for Bird Preservation, Cambridge. *Study Report No. 17*.

Davies, R.J.P. (1995) *Threatened Plant Species Management in National Parks and Wildlife Act Reserves in South Australia*. Botanic Gardens Of Adelaide, South Australia, 184 pp.

Dawson, T.J., Denny, M.J.S., Russell E.M. and Ellis B. (1975) Water use and diet preferences of free ranging kangaroos, sheep and feral goats in the Australian arid zone during summer. *J. Zool.* 177:1-23

Dawson, T.J., and Ellis B. (1979) Comparison of the diets of yellow-footed rock-wallabies and sympatric herbivores in western New South Wales. *Aust. Wildl. Res.* 6: 245-54.

Dickman, C.R. (1996) *Overview of the impacts of feral cats on Australian native fauna*. A report to the Australian Nature Conservation Agency, Canberra.

Dodd, G.J. and Hartwig, G.B. (1992) Goat eradication by hunting, an experience worth reporting. pp37-39 in L.W. Best (ed), *Feral Goat Seminar Proceedings*. Department of Environment and Planning, Adelaide.

Edwards, G.P., Clancy, T.F., Lee J. and McDonnell J. (1994) *Feral animal control in*

the rangelands. Final report to The Australia Nature Conservation Agency, Canberra. pp20.

Forsyth, D.M. and Parkes J.P. (1995) Suitability of aerially sown artificial baits as a technique for poisoning feral goats. *N.Z. J. Ecol.* 19:73-76.

Frazer, T. (1992) Feral goat control, Danggali Conservation Park. pp34-36 in L.W. Best (ed), *Feral Goat Seminar Proceedings*. Department of Environment and Planning, Adelaide.

Gaffney, R.F and Atkinson, G.C. (1995) *Feral Goat Threat Abatement Plan for Tasmania: Management Phase*. Parks and Wildlife Service, Department of Environment and Land Management, Tasmania.

Garnett, S. (1992) Threatened and Extinct Birds of Australia. *Royal Australian Ornithologists Union and Australian National Parks and Wildlife Service. Report No. 82*.

Gross, C.L. and Steed, A. (1997) *Recovery Plan for Grevillea beadleana*. NSW National Parks & Wildlife Service

Hall, G.P. and Kinnear (1991) *Recovery Plan for the Black-Flanked Rock-Wallaby, Petrogale lateralis lateralis* (Gould) Department of Conservation and Land Management for Threatened Species and Communities Section, Biodiversity Group, Environment Australia, Canberra.

Hamann, O. (1975) Vegetational changes in the Galapagos Islands during the period 1966-1973. *Biol. Cons.* 7:37-59

Hamann, O. (1984) Changes and threats to the vegetation. in R Perry (ed) Galapagos. *Key Environment Series*, Pergamon Press.

Harrington, G.N. (1982) The feral goat. pp3-73 in: P.J. Holst, Goats for Meat and Fibre in Australia. *Standing Committee on Agriculture Technical Report Series No. 11*, CSIRO, Canberra.

Harrington, G.N. (1986) Herbivore diet in a semi-arid *Eucalyptus populnea* woodland. 2. Feral goats. *Aust. J. Exp. Agric.* 26: 423-9.

Henzell, R.P. (1984) Methods of controlling feral goats. Department of Agriculture South Australia. *Fact Sheet No. 20/84*.

Henzell, R. (1992a) *The ecology of feral goats*. pp 13-20 in D. Freudenberger (ed), Proceedings of the National Workshop on Feral Goat Management. Bureau of Resource Sciences, Canberra.

Henzell, R.P. (1992b) Summary of goat biology and environmental impacts - implications for eradication. in L.W. Best (ed), *Feral Goat Seminar Proceedings*. Department of Environment and Planning, Adelaide.

- Hill, F.A.R. (1991) *A Research Recovery Plan for the Brush-tailed Rock-wallaby *Petrogale penicillata penicillata* (Gray 1825), in south-eastern Australia*. Department of Conservation and Environment, Victoria for Threatened Species and Communities Section, Biodiversity Group, Environment Australia, Canberra.
- Holland, E., Kershaw, K. and Brown, A. (1997) *Hinged Dragon Orchid* (*Drakonorchis drakeoides*), *Interim Recovery Plan*. Department of Conservation & Land Management, WA
- Hone, J. (1990) Predator-prey theory and feral pig control, with emphasis on evaluation of shooting from a helicopter. *Aust. Wildl. Res.* 17:123-30
- Howell, R. and Atkinson, G.C. (1994) *Survey and control of feral goats, *Capra hircus*, in Australia*. Parks and Wildlife Service, Department of Environment and Land Management, Tasmania.
- Lim, T.L. (1987) *The ecology and management of the rare yellow-footed Rock-wallaby *Petrogale xanthopus* Gray 1854 (Macropodidae)*. PhD thesis. Centre for Environmental and Urban Studies, Macquarie University, Sydney.
- James, C., Landsberg, J. and Morton, S.. (1997) Provision of watering points in Australian rangelands: a literature review of effects on biota. in Landsberg, J., James, C. Morton, S., Hobbs, T.J., Stol, J., Drew, A. and Tongway, H.. (1997) *The effects of Artificial sources of water on rangeland biodiversity*. A report to the Department of Environment, Sport and Territories, Canberra.
- Landsberg, J., James, C. Morton, S., Hobbs, T.J., Stol, J., Drew, A. and Tongway, H.. (1997) *The effects of Artificial sources of water on rangeland biodiversity*. A report to the Department of Environment, Sport and Territories, Canberra.
- Landsberg, J., Stol, J. and Müller, W. (1994) Telling the sheep from the goats. *Rangel. J.* 16:122-34
- Lim, L., Mahood I. and Siepen G. (1980) Yellow-footed Rock Wallaby, *Petrogale xanthopus*. in C. Haigh (ed) *Endangered Animals of New South Wales*. pp27-32. NSW National Parks & Wildlife Service, Sydney.
- Lim, L., Sheppard, N., Smith, P. and Smith J. (1992) The biology and management of the yellow-footed rock-wallabies, *Petrogale xanthopus*, in New South Wales. *New South Wales National Parks and Wildlife Service Species Management Report 10*. Sydney.
- Lobert, B. (1988) *The brush-tailed rock-wallaby (*Petrogale penicillata*) in the Grampians National Park and the Black Range, Victoria*. Part 1 - Survey. A report to the National Parks and Wildlife Division, Department of Conservation, Forests and Lands, Victoria. Technical Report Series No. 64.
- Maas, S. (1995) *Interaction between feral goats and their food supply*. Paper given at the Annual Australasian Wildlife Management Society Conference, December 1995, Christchurch, N.Z.

Maas, S. and Choquenot D. (1995) *Feral goats in outcrop areas of the semi-arid rangelands: aerial survey techniques and the cost of helicopter shooting*. Final report to The Wildlife and Exotic Diseases Preparedness Program, Bureau of Resource Sciences, Canberra.

Mahood, I.T. (1985) *Some aspects of ecology and the control of feral goats (Capra hircus L) in western New South Wales*. Unpublished M.Sc. Thesis, Macquarie University, Sydney.

Matthes, M. & Nash, S. (1993) *Cynanchum elegans: Conservation Research Statement and Species Recovery Plan*. NSW National Parks and Wildlife Service

McKnight, T.L. (1976) *Friendly Vermin: A Survey of Feral Livestock in Australia*. University of California Press, Berkeley.

Miller, E., Riethmuller, J., Kelly, D. and Boyd-Lay, S. (1998) *Economics of feral goat control in south-west Queensland*. Proceedings of the 11th Australian Vertebrate Pest Conference, Bunbury.

Morris, K.D. (1989) *Feral animal control on Western Australian islands*. In, Burbidge, A. Australian and New Zealand islands: nature conservation and management. Department of Conservation and Land Management, Perth.

Morris, K., Speldewinde, P. and Orell, P. (1997) *Djoongari (Shark Bay Mouse) Recovery Plan*. Western Australian Wildlife Research Centre, Department of Conservation and Land Management for Threatened Species and Communities Section, Biodiversity Group, Environment Australia, Canberra.

Morton S.R., Stafford Smith, D.M., Friedel, M.H., Griffin, G.F. and Pickup, G. (1995) The stewardship of arid Australia: Ecology and landscape management. *J. Environ. Manage.* 43:195-217

Naismith, T. (1992) *Feral goat control in national parks in the Flinders and Gammon Ranges*. in: Best L.W. (ed) *Feral Goat Seminar: Proceedings*: pp32-33. Department of Environment and Planning, Adelaide.

New Zealand Department of Conservation (1994) *National Possum Control Plan 1993-2002* Department of Conservation, Wellington.

New Zealand Department of Conservation (1995) *National Feral Goat Control Plan 1994-2003* Department of Conservation, Wellington.

Norbury, G. (1993) The use of 1080 to control feral goats in Western Australia. Appendix 3 in The proposed use of 1080 to control feral goats in Western Australia. *Public Environmental Review EPA Assessment No. 752*. Agricultural Protection Board of Western Australia.

O'Brien, P.H. (1984) Feral goat home range: Influence of social class and environmental factors. *App. Anim. Behav. Sci.* 12: 373-85.

O'Flynn, M. (1992) Animal welfare considerations. pp 40-57 in D. Freudenberger (ed), *Proceedings of the National Workshop on Feral Goat Management*. Bureau of Resource Sciences, Canberra.

Parkes, J.P. (1983) Control of feral goats by poisoning with compound 1080 on natural vegetation baits and by shooting. *N.Z. J. For. Sci.* 13:266-74

Parkes, J.P. (1990) Feral goat control in New Zealand *Biol. Conserv.* 54:335-48

Parkes, J.P. (1993a) Feral goats: designing solutions for a designer pest. *N.Z. J. Ecol.* 17:71-83

Parkes, J.P. (1993b) The ecological dynamics of pest-resource-people systems. *N.Z. J. Zool.* 20:223-230.

Parkes, J., Henzell R. and Pickles G. (1996) *Managing Vertebrate Pests: Feral Goats*. Australian Government Publishing Service, Canberra.

Parkes, J.P. and Nugent G. (1995) Integrating control of mammalian pests to protect conservation values in New Zealand. *Landcare Research Contract Report LC 9495/104*

Peters, M. (1992) Animal welfare considerations and goat control in L.W. Best (ed), *Feral Goat Seminar Proceedings*. Department of Environment and Planning, Adelaide.

Pickard, J. (1976) The effect of feral goats (*Capra hircus* L.) on the vegetation of Lord Howe Island. *Aust. J. Ecol.* 1:103-14

Pickard, J. (1982) Catastrophic disturbance and vegetation on Little Slope, Lord Howe Island. *Aust. J. Ecol.* 7:161-70

Pickard, J. (1992) *Conservation Research Statement Eriocaulon carsonii*. Macquarie University, NSW

Pople, A.R., Clancy, T.F. and Thompson, J.A. (1996) *Control and Monitoring of Feral Goats in Central-Western Queensland*. A report to the Australian Nature Conservation Agency, Canberra. Pp45

Priddel, D. (1989) Conservation of rare fauna: the Regent Parrot and the Malleefowl. in J.C. Noble and R.A. Bradstock (eds) *Mediterranean Landscapes in Australia: Mallee Ecosystems and their Management*. CSIRO Melbourne pp243-49

Riethmuller, J., Boyd-Law, S., Miller, E. and Thompson, J. (1996) *Feral Goat Management in South-west Queensland*. A report to the Bureau of Resource Sciences, Canberra. Pp 7.

Rose, B. (1995) *Land management issues: Attitudes and perceptions amongst Aboriginal people of central Australia*. A report to the Central Land Council, Alice

Springs.

Saunders, G. and Bryant, H. (1988) The evaluation of a feral pig eradication program during a simulated exotic disease outbreak. *Aust. Wildl. Res.* 15:73-81.

Shepherd, R. (1996) *Eradication of feral goats, Peron Peninsula, Western Australia*. Progress report to Australian Nature Conservation Agency, FPP Project No. 48.

Short, J. and Milkovits G. (1990) Distribution and status of the brush-tailed rock-wallaby in south-eastern Australia. *Aust. Wildl. Res.* 17:169-79

Southwell, C. (1996) Bias in aerial survey of feral goats in the rangelands of Western Australia. *Rangel. J.* 18:99-103

Southwell, C., Weaver, K., Sheppard, N. and Morris, P. (1993) Distribution and relative abundance of feral goats in the rangelands of eastern Australia. *Aust. Rangel. J.* 15:334-8

Squires, V.R. (1982) Dietary overlap between sheep, cattle and goats when grazing in common. *J. Rang. Manage.* 35(1):116-9

Taylor, D. and Katahira L. (1988) Radio telemetry as an aid in eradicating remnant feral goats. *Wildl. Soc. Bull.* 16:297-299.

Toseland, B. (1992) Goats are a resource- an industry perspective. p 28-37 in D. Freudenberger (ed), *Proceedings of the National Workshop on Feral Goat Management*. Bureau of Resource Sciences, Canberra.

Tyndale-Biscoe, C.H. (1994) Virus-vectored immunocontraception of feral mammals. In: M.P. Bradley (ed), *Immunological control of fertility: from gametes to gonads. Reproduction Fertility and Development* 6, 281-287.

Walters, C.J. and Holling, C.S. (1990) Large scale management experiments and learning by doing. *Ecol.* 71:2060-2068.

Williams, M.L. and Henzell R.P. (1992) Operation Pewsey Vale: an exercise in controlling an exotic disease in feral goats. *Department of Agriculture South Australia Technical Paper No. 30*.

Wilson, A.D., Leigh, L.H., Hindley N.L. and Mulham, W.E. (1975) Comparison of the diets of goats and sheep on a *Casuarina cristata* - *Heterodendrum oleifolium* woodland community in western New South Wales. *Aust. J. Exp. Agric. Anim. Husb.* 15:45-53.

Yocom, C.F. (1967) Ecology of feral goats in Haleakala National Park, Maui, Hawaii. *Am. Mid. Nat.* 77:418-51

ACKNOWLEDGMENTS

Environment Australia would like to acknowledge the significant contribution made to the preparation of this document by a number of individuals. Ms Sylvana Maas was the author of the original draft of this document. Development of that draft was based upon substantial input from the Feral Goat Treat Abatement Plan Advisory Group. This groups consisted of representatives from Commonwealth, State and Territory agencies, namely: Dr David Freudenberger (CSIRO Division of Wildlife and Ecology), Mr Trevor Naismith (Natural Resources Group, SA), Dr Tim Clancy (Queensland Department of Environment), Mr Graham Wilson (NSW National Parks and Wildlife Service), Mr Steven Smith (Department of Environment and Land Management, TAS), Mr Roger Armstrong (Department of Conservation and Land Management, WA) and Mr Peter Sandell (Department of Natural Resources and Environment, VIC). Thanks must also go to Dr Robert Henzell who commented on various drafts of this document.

This final plan has been substantially amended based upon the comments provided in response to the public exposure of the draft plan. Additional contributions and further development of the plan has been provided by Ms Alana Johnstone, Dr David Kay, Dr Gerry Maynes, Mr Bruce McLaren, Mr Robert Moore, Mr Peter Schaafler and Mr Richard Sharp of the Biodiversity Group, Environment Australia, which will also be responsible for its implementation.

APPENDIX *Endangered Species Protection Act 1992, Sections 33–34*

The following extracts from the Act highlight the main requirements.

Threat abatement plans

33.(1) The Commonwealth must prepare and implement a threat abatement plan for each key threatening process that occurs in Commonwealth areas.

(2) If the key threatening process also occurs outside Commonwealth areas, the Commonwealth must seek the co-operation of the States in which the threatening process occurs outside Commonwealth areas with a view to the joint preparation and implementation of a threat abatement plan for the threatening process throughout Commonwealth areas and those States.

Content of threat abatement plans

34.(1) The threat abatement plan must provide for the research and management actions necessary to reduce the key threatening process to an acceptable level in order to maximise the chances of the long term survival in nature of native species and ecological communities affected by the process.

(2) In particular, the threat abatement plan must:

- (a)** state an objective to be achieved; and
- (b)** state criteria against which achievement of the objective is to be measured; and
- (c)** specify the actions needed to satisfy the criteria; and
- (d)** state the estimated duration and cost of the threat abatement process; and
- (e)** identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan; and
- (f)** specify any major non-target ecological matters that will be affected by the plan's implementation.

(3) In preparing a threat abatement plan, regard must be had to:

- (a)** the objects of the Act; and
- (b)** the most efficient and effective use of the resources that are allocated for conservation of species and ecological communities; and

consistent with the principles of ecologically sustainable development, minimising any significant adverse social and economic impacts.