THE IMPACT OF FERAL DEER, PIGS AND GOATS IN AUSTRALIA

An inquiry by the
Senate Environment and Communications
References Committee

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About the Invasive Species Council

The Invasive Species Council was formed in 2002 to advocate for stronger laws, policies and programs to keep Australian biodiversity safe from weeds, feral animals, exotic pathogens and other invaders. We are a not-for-profit charitable organisation with over 2000 supporters. Our work is funded entirely by donations from supporters and philanthropic organisations.

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1. Introduction

We welcome this inquiry into feral deer (six species are established in Australia), pigs and goats. These species have many things in common. Apart from all being hard-hoofed mammals invasive in Australia, they are among the leading threats to Australian biodiversity and their impacts are set to worsen as their populations spread and increase. They also present several policy and technical challenges in common:

- Control: The fecundity and mobility of these species make them difficult to control half or more of their populations may need to be killed annually just to prevent population increase. We mostly lack effective affordable (at current levels of investment and focus) large-scale methods for control.
- Knowledge: Our understanding of the impacts of these species is limited.
- Economic: The costs of controlling these species over large areas are high and ongoing.
- Social and political: These species are valuable to certain sectors of society, which often undermines the willingness of governments (as custodians of the environment) to enact effective threat abatement policies and programs and stymies threat abatement on private and public lands.

As with many other nationally significant threats to nature, the threats of feral deer, pigs and goats raise important questions about how the federal government can more effectively work with the states and territories and use its powers and resources to better protect matters of national environmental significance.

We will focus mainly on ToR (f) national threat abatement processes because we believe that is where the Commonwealth should primarily focus its efforts. This should include a strong focus on research [ToR (e)] to investigate the full range of impacts of these invasive species and develop more effective methods of threat abatement.

Recommendations

ToRs (a) and (b): Biodiversity blights and landscape degraders

1. Develop a strong national policy aiming to prevent further spread of feral deer, pigs and goats in Australia and reduce their impacts on biodiversity, land health and agricultural productivity. This policy should be implemented through threat abatement plans in partnership with the states and territories.

ToR (f): Feral deer, pigs and goats as key threatening processes

General recommendations

2. Comprehensively list and prioritise key threatening processes based on expert advice.
3. Develop threat abatement plans for all key threatening processes, with flexible plan requirements depending on the extent to which there are other processes by which their threat is being effectively abated.
4. Develop an intergovernmental agreement that commits the federal, state and territory governments to implement threat abatement plans for key threatening processes and to which the federal government commits a substantial proportion of funding.
5. Provide a base level of funding to implement each threat abatement plan and for high priority abatement projects.

6. Legislate under the EPBC Act to oblige individuals and corporations to avoid actions that are likely to significantly exacerbate key threatening processes.
7. Require monitoring of all key threatening processes and make an annual report to parliament on abatement progress.

Recommendations specific to deer, pigs and goats

8. Prepare a threat abatement plan for feral deer (as well as other high priority invasive species encompassed by the novel biota KTP listing) that prioritises the prevention of further spread of all species of feral deer and the development of effective control methods.
9. Prepare an updated threat abatement plan for feral goats.
10. Establish a taskforce to drive implementation of the threat abatement plans for feral deer, pigs and goats, with the taskforce consisting of government, non-government and scientific representatives (the feral cat taskforce is a good model).
11. As part of the recommended threat abatement plan for feral deer, develop an agreement with state and territory governments to adopt a consistent legislative and policy approach to feral deer that commits to preventing further spread, recognises the limitations of recreational hunting for control and commits to pursuing more effective control methods.

ToR(c): Limitations of current policy and management

12. Commission an independent investigation of perverse incentives that stymie or undermine prevention of biosecurity risks and abatement of invasive species threats as a basis for developing more effective invasive species policies. This includes policies protecting feral deer as 'game' animals and commercialising the harvest of feral goats.
13. As previously recommended (by the 10-year independent review of the EPBC Act), develop a horizon scanning unit within the environment department to investigate emerging and potential environmental threats as a basis for developing preventative policies. Functions should include conducting public inquiries into the likely environmental impacts of proposed new or altered land uses (such as the commercialisation of feral goat harvesting).
14. Commission an investigation of the ecological consequences of the commercial harvest of feral goats, taking into account the seasonally varying influence of commercial incentives and as part of threat abatement planning, develop a national policy for commercial feral goat harvesting that supports and does not undermine threat abatement.

ToRs (d) and (e): Research priorities

15. As part of threat abatement planning, develop a national research plan for each of feral deer, pigs and goats. Likely high priorities include an improved understanding of their impacts and of social and other factors that influence threat abatement as well as more effective control methods.
16. Undertake prioritisation across all key threatening processes to identify the highest priority research needs to guide decision-making for national funding programs.
17. As a high priority, commit national funding to the development of efficient, humane, landscape-scale, cost-efficient methods of control of invasive animals that do not harm non-target species.
18. Require that monitoring is incorporated into control programs funded by the federal government.
19. Commission the Productivity Commission to assess the long-term funding needed to effectively abate major invasive animal threats to the environment, including feral deer, pigs and goats, and to assess the economic benefits of prevention and early action over later management, with feral deer as one case study.

2. ToRs (a) and (b): Biodiversity blights and landscape degraders

Feral deer, goats and pigs between them imperil hundreds of threatened plant and animal species and ecological communities, and cause extensive landscape degradation. Unless containment and control efforts substantially improve, this damage will escalate as populations spread and densities increase.

Below, we provide a very short summary of their current and potential occurrence and their impacts. We refer the committee to the following sources for more detailed information:

- For feral deer impacts: a 2011 nomination by the Invasive Species Council of feral deer as a key threatening process (**Attachment 1**) and a review by Davis et al. (2016).
- For feral pig impacts: the background document to the threat abatement plan (Department of the Environment and Energy, 2017a) and a report by Mitchell (2010) on the impacts of pigs on tropical freshwater ecosystems.
- For feral goat impacts: Burrows (2018) and the background document to the threat abatement plan (Department of the Environment, Water, Heritage and the Arts, 2008a).

We recommend that the committee undertake a field trip to see for themselves examples of damage caused by these species. We are happy to help organise such a trip to inspect damage caused by deer.

2.1 Feral deer

A 2011 nomination by the Invasive Species Council of herbivory and environmental degradation caused by six feral deer species (sambar, rusa, red, chital, fallow and hog deer) as a key threatening process presents evidence of threats to 18 species and ecological communities (most listed as nationally threatened) (Invasive Species Council, 2011) (see Boxes 1 and 2 for examples). However, these are just the tip of the iceberg. Victoria's draft deer management strategy says more than 1000 plant and animal species there are impacted by deer (Victorian Government, 2018). Deer can cause gross habitat change, as shown in a study in Royal National Park (Moriarty, 2004). They can severely damage sensitive habitats such as wetlands, riparian areas and mossbeds.

The potential range of each deer species in Australia is far greater than their present distribution, implying much greater damage in future unless they can be contained and controlled. As shown by maps of current and potential distribution in Davis et al. (2016), all species except rusa could occupy almost the entire continent (where there is water) and they currently occupy less than 5 10% of their potential range (see Figure 1).

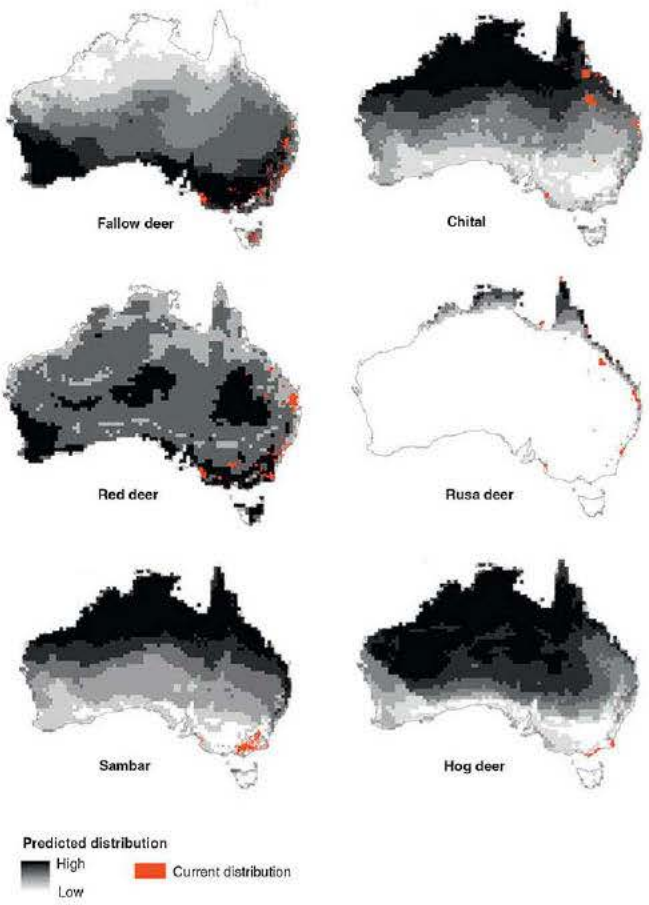

Figure 1. Current and potential distribution of feral deer species in Australia ***(from Davis et al., 2016)***

Box 1 Impacts of feral deer on shiny nematolepis (Nematolepis wilsonii)

Shiny nematolepis is a shrub or small tree in the understorey of cool temperate mixed forest in Victoria (Murphy, White, & Downe, 2006). It is known from just two populations in the Yarra Ranges National Park. When shiny nematolepis was listed as vulnerable under the EPBC Act in 2000 there was no deer damage observed on the one population then known. Sambar numbers then escalated in the Yarra Ranges National Park and within just a few years have rendered the species critically endangered (a Victorian government assessment) despite discovery of a second population, also affected by Sambar. Sambar were recognised as the principal threat to this species in the 2006 recovery plan (Murphy ***et al.***, 2006). Sambar rub their antlers on this species to remove velvet, which can ringbark and kill the plants or damage them, exposing them to wood borers or fungal infections (Bennett & Coulson, 2011). Sambar also thrash saplings while rutting and trample seedlings. Numbers of mature plants crashed from more than 400 in 2005 to 12 just a few years later.

Box 2. Impacts of feral deer on 'littoral rainforest and coastal vine thickets of Eastern Australia' ecological community

This ecological community, listed as critically endangered under the EPBC Act, is a complex of rainforest and coastal vine thickets on the east coast of Australia, typically within 2 km of the coast or adjacent to a large salt water body, such as an estuary. Sambar, rusa and hog deer are a significant threat, with the draft national recovery plan documenting the following impacts (Department of the Environment and Energy, 2017b):

> Grazing and browsing by feral Sambar deer ***(Cervus unicolor),*** hog deer ***(C. porcinus)*** and Rusa deer ***(C. timorensis)*** has been shown to detrimentally impact the ecological community on both a local and landscape level. These activities can result in structural modification, erosion and altered species composition within Littoral Rainforest. Rubbing causes direct physical damage to established trees, while browsing prevents regeneration of Littoral Rainforest canopy and understorey species and creates gaps in the vegetation which allows colonisation by weeds. This has occurred in the area near Genoa River, in Victoria, where the vegetation gaps have been colonised by cape ivy (***Delairea odorata***) and dense thickets of Madeira Winter-cherry ***(Solanum pseudocapsicum***). When infestations are severe these weeds are contributing significantly to the collapse of the existing Littoral Rainforest patches through the smothering of shrubs and young trees (Peel et al., 2005). Severe damage to Littoral Rainforest has also been observed from Twofold Bay in NSW to the Gippsland Lakes in Victoria. Persistent infestations are documented as causing the local loss of rainforest species and whole sections of mature rainforest in Victoria (Peel et al. 2005). The coastal expansion of feral deer has reached at least as far north as Bermagui (Peel 2010). Where the ranges of the deer overlap patches of littoral rainforest (e.g. Marl Island) have been destroyed (Peel 2010). In the Royal National Park in NSW, herbivory by Rusa deer has led to a 54% reduction in understorey plant species richness in sites were deer densities are high (Moriarty, 2009) and caused a 75% reduction in cover of the threatened plant magenta lilly pilly ***(Syzygium paniculatum)*** (Keith & Pellow, 2005). In the East Gibbsland region of Victoria, Samba deer are the most damaging feral species impacting upon Littoral Rainforest (Peel et al., 2005). 'Herbivory and habitat degradation caused by feral deer' is listed as a Key Threatening Process under the NSW ***Threatened Species Conservation Act 1995.*** 'Reduction in biodiversity of native vegetation by ***Cervus unicolor*** (Sambar Deer)' is listed as a Key Threatening Process under the Victorian ***Flora and Fauna Guarantee Act 1988.***

In Royal National Park, where rusa deer are in high densities they substantially reduce diversity in littoral rainforest (Moriarty, 2004). In plots with high deer densities the mean number of plant species was 17 compared to 37 in plots with low densities. Plant diversity was reduced by 54%.

Sambar are causing severe damage to littoral rainforest communities in East Gippsland (Peel, Bilney, & Bilney, 2005). Damage was observed in 74 sites surveyed during 2002-2005 and several species were suffering high rates of morality from sambar browsing. Those species subject to heavy browsing during drought have reduced capacity to recover. Destruction of regeneration refuges is of particular concern as it exposes palatable seedlings to browsing by native and exotic herbivores and undermines species' capacity for regeneration. Wallowing, antler rubbing and rutting behaviours also cause considerable damage. Damage to rainforest can facilitate weed invasion and increase the risk of fire.

2.2 Feral pigs

Feral pigs currently occupy about half the continent and impact more than 150 nationally threatened species and ecological communities (Department of the Environment and Energy, 2017c). This number will undoubtedly grow over the next few years as species not currently listed under the EPBC Act are assessed under the common assessment method now adopted by all jurisdictions. Feral pigs eat threatened plant and animal species, severely degrade wetlands and riparian ecosystems, transform habitats, and spread weeds and pathogens (such as ***Phytophthora cinnamomi***) (Department of the Environment and Energy, 2017a). They cause particular harm in wetlands through rooting, eating plants and preying on freshwater species such as turtles, crayfishes and frogs. Soil disturbance by pigs may have 'hidden' ecological impacts disruption of nutrient and water cycles, altered soil micro-organism and invertebrate populations, altered plant succession and erosion (Mitchell, 2010). Pigs are major predators of marine turtle eggs and hatchlings (see Box 3).

In 1990 feral pigs inhabited an estimated 38% of mainland Australia; in 2008 the estimated area was 45% of the continent (Department of the Environment and Energy, 2017a). Pig populations are expanding due both to natural spread and illegal introductions (Spencer & Hampton, 2005). There is potential for further spread, including to large parts of central and eastern Tasmania, Eyre Peninsula, south-eastern South Australia, and south-western Western Australia, where they are absent or in low numbers (Braysher, 2000). Recently established populations in the Kimberley across 26,000 km^2 could spread by natural means to occupy more than 90,000 km^2 (Cowled ***et al.***, 2009).

Box 3 Impacts of feral pigs on marine and freshwater turtles

The background report to the national threat abatement plan records threats to five marine species and two freshwater turtle species (Department of the Environment and Energy, 2017a).

Loggerhead turtles (endangered), green turtles (vulnerable), flatback turtles (vulnerable), olive ridley turtles (endangered) and hawksbill turtles (vulnerable) are impacted by pigs preying on their eggs and hatchlings. Studies on Pennefather Beach in western Cape York, for example, found overall nest mortality for flatback, olive ridley and hawksbill turtles ranging from 42% to 70%, most of it due to feral pigs. It was mostly due to a small number of feral pigs specialising in turtle nest predation.

Pigs are considered the major threat to Jardine River painted turtles (***Emydura subglobosa***), a species surviving in very small numbers in Cape York Peninsula (but also in Papua New Guinea) and likely to be endangered (Freeman ***et al.***, 2014).

Also in northern Australia, pigs dig up northern longneck turtles (***Chelodina oblonga***) that aestivate in sediments as wetlands dry out after the wet season. A radio tracking study of 38 longneck turtles found that only 10 survived and that pigs were responsible for all but one of the deaths (Fordham ***et al.***, 2006). This level of mortality, which exceeds 40% per lagoon or wetland, cannot be sustained. The researchers predict rapid population decline and 'certain elimination of affected populations within 50 years' (Fordham, Georges, & Brook, 2008). The Kowanyama community (western Cape York Peninsula) reports feral pigs have wiped out freshwater turtles at popular harvesting sites, and Yolngu people (north-east Arnhem Land) and Thamarrur (Wadeye, Northern Territory) rangers report impacts as well (Department of the Environment and Energy, 2017a).

2.3 Feral goats

Feral goat numbers are difficult to estimate because goats are nomadic and occupy terrain difficult to survey, and their numbers fluctuate depending on conditions. The estimated population grew from 1.4 million in 1997 to 4.1 million in 2008 and estimates have ranged up to 6 million (Pople & Froese, 2012; Meat & Livestock Association, 2015). About 70% of the population occurs in New South Wales, where in 2011 there were an estimated 3 million feral goats (Pople & Froese, 2012). The proliferation of artificial water sources (for cattle and sheep) has provided goats with the means to inhabit most of the Australian rangelands (Russell, Letnic, & Fleming, 2011).

Feral goats are known to impact more than 50 nationally threatened species, according to the outdated threat abatement plan, mostly plant species (Department of the Environment, Water, Heritage and the Arts, 2008b). In New South Wales, feral goats pose a threat to at least 94 threatened species, 59 due to goat grazing and browsing alone (Coutts-Smith *et al.*, n.d.). Where they occur in high densities, 'feral goats are the most destructive pest animal in the semi-arid and arid regions' (Burrows, 2018). They are highly efficient herbivores, able to eat almost any vegetation, including foliage, bark, twigs, flowers, fruits, roots, plant litter and seeds on the ground. There are few plants that they don't eat. They can significantly alter the composition of plant communities and, because they can survive on low-nutrient fibrous vegetation and tolerate drought conditions, goats 'can cause irreversible changes to plant communities' (Burrows, 2018). They can stand on their hind legs or partially climb trees to browse, and are able to access difficult habitats such as rugged gorges, breakaways and stony ranges, which often support rare remnant assemblages of plants and animals.

Box 4 Impacts of feral goats on threatened rock wallaby species

The Action Plan for Australian Mammals 2012 records habitat degradation and resource competition by feral goats as a threat for at least six threatened rock wallaby species or subspecies (Woinarski, Burbidge, & Harrison, 2014):

- Black-flanked (***Petrogale lateralis lateralis***), endangered
- Brush-tailed (***P. penicillata***), vulnerable
- Purple-necked (***P. purpureicollis***), near threatened
- Yellow-footed (***P. xanthopus***), near threatened
- Yellow-footed (***P. xanthopus celeris***) (central west Qld), vulnerable
- Yellow-footed (***P. xanthopus xanthopus***) (South Australia, New South Wales), near threatened

For five taxa, the consequence is rated as 'severe' over a 'large' part of their range, and for the other (black-flanked rock wallaby) the consequence is 'unknown'.

All six taxa threatened by goats are also threatened by exotic predators, particularly foxes (with the consequences rated as severe or catastrophic), as are other threatened rock wallabies. This means control of both invasive species is necessary. South Australia's Bounceback program, which controls both foxes and goats, has led to a significant recovery of yellow-footed rock wallabies since the early 1990s. Numbers in Flinders Ranges National Park increased from fewer than 50 in 1993 to more than 1000 in 2009 (Woinarski ***et al.***, 2014).

Although rock wallabies are generally closely associated with rugged rocky areas, this association at least for brush-tailed rock wallabies may be an 'artefact' resulting from range retraction since European colonisation (Woinarski ***et al.***, 2014).

The impacts of feral goats on rock wallabies include changes in vegetation communities. For example, goats were probably responsible for the loss of rock wallabies in Kalbarri National Park (Western Australia) in the 1980s because goat grazing led to domination by spiny, unpalatable species (Pearson, 2012). Competition between rock wallabies and goats for food may be particularly severe in drought years (Short & Milkovits, 1990). For example, the high dietary overlap between yellow-footed rock wallabies in central west Queensland and feral goats is thought to limit wallaby access to wattle shrubs, an important food during dry periods. Competition with goats is likely to force rock wallabies to forage further from their refuge areas, exposing them to greater predation risks. Goats can also aggressively displace rock-wallabies from their refuge areas (Pearson, 2012). Although the causality is not clear, goats are now abundant on all rocky habitat west of the Great Dividing Range in New South Wales and occupy ledges and caves formally inhabited by rock wallabies (Short & Milkovits, 1990).

2.4 Recommendations

1. Develop a strong national policy aiming to prevent further spread of feral deer, pigs and goats in Australia and reduce their impacts on biodiversity, land health and agricultural productivity. This policy should be implemented through threat abatement plans in partnership with the states and territories.

3 ToR (f): Feral deer, pigs and goats as key threatening processes

The impacts of feral deer, pigs and goats affect many matters of national environmental significance listed under the EPBC Act threatened species and ecological communities, word heritage areas and Ramsar wetlands. There are no easy solutions effective control requires large-scale killing and abatement across most of Australia is inadequate. A long-term national research and management focus is needed. For all these reasons we need a national response.

The obvious approach is to identify each of these species as key threatening processes under the EPBC Act and prepare a threat abatement plan that identifies priority actions and drives collaborative abatement efforts.

However, as a recent analysis by the Invasive Species Council shows (**Attachment 2**), these processes are failing the listing of key threatening processes (KTPs) is slow and not comprehensive, many listed threats have no abatement plan (TAP), TAP development is slow, and many TAPs are poorly implemented.

We recommend that the inquiry gives high priority to considering how to improve the KTP and TAP processes for these invasive species as well as other major threats. Following is a brief summary of the inadequacies of these processes specifically for feral deer, pigs and goats and then more generally.

KTP listing: Both feral pigs and feral goats are listed as KTPs and feral deer are mentioned in the novel biota KTP listing. The Invasive Species Council nominated feral deer as a KTP in 2011 (**Attachment 1**) but the nomination was not assessed due to the proposed listing of a novel biota KTP to encompass all invasive species threats (Department of the Environment and Energy, 2013).

TAP development: There is a current TAP for feral pigs (Department of the Environment and Energy, 2017c), but the TAP for feral goats is several years out of date (Department of the Environment, Water, Heritage and the Arts, 2008b) and there is no TAP for feral deer, despite them being recognised as one of the significant threats encompassed by the 'novel biota' KTP.

The processes for developing and revising each of the pig and goat TAPs have been extremely slow, which is typical of TAP processes. For feral pigs it took four years for the development of the first TAP (in 2005) and six years for the development of the second TAP (in 2017) after it was reviewed (in 2011). The feral goat TAP has still not been revised five years after it was reviewed in 2013 and revision was recommended.

TAP implementation, monitoring and reporting: One of the major flaws of the KTP system is the lack of requirement for regular monitoring, evaluation, reporting and improvement. The only indication of progress comes with the required five-yearly reviews. But there is no requirement for these to be independent reviews and they are limited by the data available.

The 2011 review of the 2005 feral pig TAP was done by the-then environment department. It mostly reports on activities for example the development of two new feral pig baits, guidance to land managers, updated mapping, improved monitoring rather than an assessment of progress in protecting biodiversity, including matters of national environmental significance, impacted by pigs. This signifies the lack of meaningful monitoring as acknowledged in the review: 'Broadly, it is difficult to determine how the work that has been done on feral pigs has abated the threat because of inadequate monitoring and the differentiation of the threat from feral pigs with that from other threatening processes'. The review found that feral pig control is patchy; that

effective, wide-scale programs to manage pigs are few; and that there is poor knowledge of the number of feral pigs that need to be controlled to benefit native species in a particular environment.

The 2013 review of the 2008 TAP for feral goats, done by the environment department, was highly critical, concluding that the TAP 'has not achieved the goal of minimising the impacts of feral goats' and that the problem is complex and increasing. There had been no significant development in management techniques, and monitoring techniques to measure impacts on key native species were not well developed.

3.1 The importance of KTPs & TAPs

Following is part of our submission to the current Senate inquiry on Australia's faunal extinction crisis. These points are based on a 2018 discussion paper prepared by the Invasive Species Council, *KTPs & TAPS: Australia's failure to abate threats to biodiversity* (**Attachment 2**).

Australia's national processes to protect and recover threatened species are failing. One major reason for this are deficient processes for mitigating major threats through the listing of key threatening processes (KTPs) and the preparation and implementation of threat abatement plans (TAPs) under the EPBC Act. An effective KTP/TAP system is essential for arresting loss of Australia's biodiversity, and developing solutions for major threats is typically more effective and more cost-effective than a species-by-species approach, and also benefits myriad other, often poorly known, species at risk from KTPs.

Here we very briefly summarise the eight major flaws of the current system and outline five major categories of reforms needed. Later this year, the Invasive Species Council will host a workshop to develop more detailed proposals for reform.

3.2 Summary of KTP & TAP process flaws

1. **Limited coverage of major threats**: There are no KTP listings for inappropriate fire regimes, altered hydrological regimes or grazing; the land clearing KTP has no TAP; and the majority of invasive species threats are encompassed within the 'novel biota' KTP, a moribund listing that lacks a TAP. This means the KTP/TAP system is not applied for most major threats to biodiversity and only partially for invasive species.

2. **Stymied listing of invasive species**: For the past six years at least, there has been a refusal to assess invasive species KTP nominations or list any more invasive KTPs. The main reason given in six cases is that invasive species threats are encompassed within a catch-all 'novel biota' KTP (which has no TAP). In a seventh case, the environment minister refused to list the KTP, contrary to advice by the Threatened Species Scientific Committee.

3. **Slow, tedious and ad hoc KTP listing processes**: The listing of KTPs is mostly ad hoc, relying on public nominations and ministerial prerogative, and the assessment processes are slow and tedious. The three KTP listings of the past decade (excluding the novel biota KTP nominated by the scientific committee) have taken three to four years from nomination to listing. Two rejected nominations took five and seven years to complete, and one nomination still under assessment is more than 10 years old. No KTP nomination since 2011 has even been assessed.

4. **Moribund KTP listings**: Almost a third of listed KTPs have no TAP. This could be acceptable if there were already effective processes for abating those threats. But this is mostly not the case. The threat

level for KTPs without TAPS particularly land clearing, climate change, escaped garden plants, noisy miners and novel biota are all likely to have increased since their listings. There is no requirement to show that alternative abatement processes are effective, to monitor abatement progress, or to initiate action if existing processes prove ineffective.

5. **Limited abatement progress**: Due to a lack of monitoring and reporting, the only feasible way of assessing the effectiveness of most threat abatement efforts is through the five-yearly reviews of TAPs required under the EPBC Act. But only half the KTPs can be assessed in this way: six KTPs lack a TAP and four TAPs have not been reviewed despite being overdue by one to four years for review (or their reviews have not been made publicly available). Eleven TAPs (52%) have been reviewed at least once, although only three by independent reviewers. Those reviews indicate that good progress was achieved for four TAPs, moderate progress for four TAPs and poor progress for three TAPs. Although fewer than half of KTP listings have resulted in moderate to good progress on threat abatement, the examples of good abatement progress demonstrate that major threats to Australian biodiversity are surmountable.

6. **Slow TAP processes**: It has taken an average four years to prepare or revise TAPs for the nine KTPs listed since 2001 that have a TAP. There are no formal instruments to engender interim or urgent actions while TAPs are being developed. Most TAPs are reviewed within five to six years, but then it often takes several years for TAPs to be revised after a review it took eight years to revise the root-rot fungus TAP, and five years after a ministerial decision to revise the fox TAP it has still not been updated. Of 15 existing TAPs, 60% are more than 6 years old and 27% are 10 years old.

7. **Limited obligations and accountability**: Although the Australian Government has international obligations to abate threats to biodiversity, there is no obligation under the EPBC Act to list the major threats or act on them. The environment minister has complete discretion about whether to accept the advice of the Threatened Species Scientific Committee to assess a KTP nomination, list a KTP or prepare a TAP. The minister can also delay decisions for years and starve the assessment processes of funding. This means our national system for recognising and abating threats is highly vulnerable to political interference. Moreover, KTP listings come obligation free. Even if the minister decides that a TAP should be prepared, the EPBC Act obliges the federal government to do little to implement it, apart from in Commonwealth areas. A KTP listing or TAP also does not generate any obligations for other governments, landholders or anyone whose actions may exacerbate the KTP. There are no requirements for the federal government to monitor or report on KTP status.

8. **Limited leadership, commitment and funding**: Although the federal government is limited in the extent to which it can compel other governments or individuals to undertake threat abatement, it can apply considerable pressure through strong leadership, incentives and funding for abatement, and use of its own laws to partially compensate for state or territory failings. These have been largely missing in KTP/TAP processes. Abating KTPs has been a low federal government priority. Leadership has improved to some extent with the appointment of a Threatened Species Commissioner as a champion for threatened species and facilitator of partnerships. This has generated considerable focus on the feral cat KTP (and a modest level of additional funding for abating that threat). There is no information about how much Australia spends on abatement (from government and non-government sources), nor how much is needed to properly implement abatement plans. It is clear from the limited progress that the gap between available and needed funding is considerable.

3.3 Summary of changes needed

1. **Make threat abatement a high national priority**: An essential first step is greater recognition that an effective KTP/TAP system is essential for arresting loss of Australia's biodiversity, and that developing solutions for major threats is typically more effective and more cost-effective than a species-by-species approach, and also benefits myriad other, often poorly known, species at risk from KTPs. To drive reform of the KTP/TAP system, Australia needs an ambitious (but realistic) conservation strategy that specifies long-term goals for threat abatement. That ambition needs to be then reflected in each of the TAPs. Enlisting commitment from state and territory governments is essential. The federal government should pursue an intergovernmental agreement with the states and territories to achieve long-term abatement goals for recovery of threatened species and ecological communities.

2. **Strengthen governance and accountability**: The assessment and listing of KTPs and preparation of TAPs should be free of political influence and not subject to ministerial discretion. We endorse the recommendation by the Places You Love Alliance for an independent National Sustainability Commission to undertake such functions. It is also worth considering co-governance models, such as exemplified by the industry-government partnerships, Animal Health Australia and Plant Health Australia. More meaningful, independent and regular reporting is needed. The five-yearly TAP reviews are important and, for the sake of credibility and rigour, should be done by expert reviewers independent of government. An annual progress report (based on meaningful abatement indicators) should be presented to the federal parliament. This needs to be underpinned by monitoring of threatening processes and the species and ecological communities at risk.

3. **Systematically list KTPs for all matters of national environmental significance**: The KTP list under the EPBC Act should be the authoritative list of major threats to Australian biodiversity. The listing process needs to be more systematic to properly reflect the major threats. A systematic expert process can be supplemented by a public nomination process to fill gaps and keep the KTP list up to date. Australia's KTP list should be scientifically determined. As with similar processes at the state level, the decision to assess and list a KTP should emerge wholly from an independent scientific process.

4. **Strengthen obligations for abatement**: For each KTP, it should be mandatory to prepare a TAP (or equivalent) to specify long-term abatement goals and shorter-term targets, the research and actions needed to achieve them and a monitoring regime. A TAP should serve as a national statement of what is needed to achieve abatement and as the basis for monitoring and reporting on the status of the KTP and abatement progress. A TAP should be required even where abatement can best be achieved through existing processes or relies on processes beyond the control or influence of the federal government. This ensures that the federal government takes responsibility under the EPBC Act for specifying the desired conservation direction and monitoring progress. If state and territory governments fail to participate in implementing TAPs, the federal government should be obliged to consider options for over-riding or compensatory measures, such as using its own laws to limit land clearing or regulate trade in invasive plants. Obligations should extend to individuals and corporations. All Australians are bound by the EPBC Act to avoid having a significant impact on matters of national environmental significance. They should also be bound to avoid actions likely to significantly exacerbate a KTP.

5. **Commit to long-term funding to achieve abatement targets**: A government demonstrates it is serious about mitigating harms when it is prepared to fund the necessary actions. To assess funding needs, each TAP should include an estimate of costs to achieve 10 20-year targets. New funding

sources such as levies and taxes should be considered to provide long-term base funding for implementing TAPs.

3.4 Recommendations

The Invasive Species Council is convening a workshop in late November 2018 on how to improve processes for listing and abating KTPs. We will make more detailed recommendations to the inquiry after that workshop. The following are our interim recommendations.

General recommendations

2. Comprehensively list and prioritise key threatening processes based on expert advice.
3. Develop threat abatement plans for all key threatening processes, with flexible plan requirements depending on the extent to which there are other processes by which their threat is being effectively abated.
4. Develop an intergovernmental agreement that commits the federal, state and territory governments to implement threat abatement plans for key threatening processes and to which the federal government commits a substantial proportion of funding.
5. Provide a base level of funding to implement each threat abatement plan and for high priority abatement projects.
6. Legislate under the EPBC Act to oblige individuals and corporations to avoid actions that are likely to significantly exacerbate key threatening processes.
7. Require monitoring of all key threatening processes and make an annual report to parliament on abatement progress.

Recommendations specific to deer, pigs and goats

8. Prepare a threat abatement plan for feral deer (as well as other high priority invasive species encompassed by the novel biota KTP listing) that prioritises the prevention of further spread of all species of feral deer and the development of effective control methods.
9. Prepare an updated threat abatement plan for feral goats.
10. Establish a taskforce to drive implementation of the threat abatement plans for feral deer, pigs and goats, with the taskforce consisting of government, non-government and scientific representatives (the feral cat taskforce is a good model).

4 ToR(c): Limitations of current policy and management

Protecting the natural environment and agricultural businesses from feral animals such as deer, pigs and goats is difficult and expensive. It has been made even more so by the failure of many state governments to fully apply their laws and implement strategic policies and programs to prevent the spread of these species and optimise their control. This is particularly the case for feral deer, which have been managed in south-eastern Australia primarily for hunters. In this section we consider some of the current limitations to abating the threats of feral deer, pigs and goats, due not only to their biology but also to social and political factors that have stymied the development of effective policies and control methods.

4.1 The stymying of feral deer control

There have been warnings for many years, including from our organisation, that feral deer are a serious emerging conservation and agricultural threat (Low, 1999; Moriarty, 2004; Peel et al., 2005; Invasive Species Council, 2008). This has largely been ignored or denied by state governments for example, Hall and Gill (2005) of the Tasmanian government's Game Management Services Unit claimed it was only 'traditional perceptions' of deer as exotic species that led people 'to believe that deer caused damage to agricultural, forestry, and conservation areas'.

The New South Wales, Victorian and Tasmanian governments, in particular, have protected deer as a hunting resource rather than protect conservation and agricultural assets from damage by deer. This is reflected in the special status accorded to deer in these states different to the status of other harmful invasive species which means that authorisation is required to control deer (with various exceptions). In Victoria deer are classed as 'protected wildlife' under the *Wildlife Act 1975*; in NSW they are classed as 'game' under the *Game and Feral Animal Control Act 2002*; and in Tasmania they are classed as 'partly protected' under the *Nature Conservation Act 2002*. In contrast, Queensland, South Australia, the Northern Territory and Western Australia have all declared deer as pest species. See Davis et al. (2016) for a summary of the legislative status of deer in each state and territory.

The protection of deer for hunters in New South Wales, Victoria and Tasmania has meant the abrogation of deer policy to hunting interests and the squandering of opportunities to prevent deer increase. In 2000 it was estimated there were 200,000 feral deer Australia-wide (Moriarty, 2004). Now, the Victorian government estimates there are at least a million deer in that state alone (Victorian Government, 2018). In New South Wales the distribution of deer increased by about 30% between 2004 and 2009 and by about 60% between 2009 and 2016 (Natural Resources Commission, 2016; NSW Department of Primary Industries, 2016). In Tasmania fallow deer numbers have tripled since the 1970s and the area occupied has increased 5-fold to about 2 million hectares. it has been predicted that under current policy settings fallow deer numbers will increase by 40% over the decade to 2026 and number more than 1 million by mid-century (Lefroy, Johnson, & Bowman, 2016).

The NSW Game Council (abolished in 2013), the Game Management Authority (Victoria) and the Tasmanian Game Council (established in 2018) are bodies that prioritise game hunting objective and hamper science-based pest management policies and actions by government. Since the abolition of the NSW Game Council, the NSW government has been less restricted in its ability to progress effective pest management responses to deer impacts. The influence of the Game Management Authority and the Tasmanian Game Council with the Victorian and Tasmanian government must be diminished if progress on addressing the impacts of feral deer in these states is to be realised.

Although the governments protecting deer are finally acknowledging the damage they cause and relaxing some of the restrictions on deer control, they are still failing to fully prioritise the public interest over the private interests of deer hunters. For example, in 2017 the New South Wales government rejected the recommendations of the Natural Resources Commission to declare deer a pest species and remove their protection as a game animal (Invasive Species Council, 2016; Natural Resources Commission, 2016; Invasive Species Council, 2017). The draft Victorian deer management strategy proposes relaxing the requirement for public land managers to get a permit to control deer and containing deer to their current geographic range (where feasible), but overall it is a weak strategy that mostly maintains the current unacceptable status quo (Victorian Government, 2018).

The Invasive Species Council has heard from many farmers in New South Wales, Victoria and Tasmania incensed and immensely frustrated by the growing deer problems they are facing and the failure of governments to enact deer policies in the public interest.

Although the federal government cannot force state or territory governments to enact more effective policies and programs on feral deer (and other invasive species), it should apply as much pressure and encouragement as it can. Given the highly significant impacts these invasive species have on matters of national environmental significance, the federal government should also consider its own responsibilities and capacity to improve threat abatement. This should include a substantial research effort to develop the tools and community and government capacity necessary for effective abatement.

One promising (although belated) development has been the recent investment in deer research by the Centre for Invasive Species Solutions with $8.7 million direct and in-kind funding from the Australian, New South Wales, Queensland, Victorian and South Australian governments. The four deer research projects include one on cost-effective management of feral deer and another on a deer aggregator that is accessible to feral deer but not to native animals (see https://invasives.com.au/research#pest-animals). These are vitally important projects.

4.2 The challenge of invasive animal control

One of Australia's most difficult environmental and animal welfare challenges is controlling feral deer, pigs and goats as well as other invasive animals that imperil native species and degrade the land. These invasive species are typically highly fecund (capable of producing many offspring) and mobile, able to bounce back quickly when some are killed. Millions of invasive animals are killed each year in Australia, but much of the killing is likely to be futile for reducing conservation and agriculture impacts.

One major reason for the rapid rebound of populations of invasive animals is they typically have a large 'doomed surplus', due to far more individuals being born than can survive on available resources (food, shelter or territories). For example, up to 85% of feral pigs in Kosciuszko National Park die in their first year from starvation, predation or disease (Saunders, 1993). Those killed are likely to have been doomed anyway or be replaced by individuals who wouldn't otherwise have survived or by those moving in from other areas. This can sometimes lead to even higher populations as has occurred with low-level cat culling in Tasmania, probably due to influxes of cats moving in after dominant resident cats were killed (Lazenby, Mooney, & Dickman, 2014).

> *…as a rough guide, control programs probably need to reduce pig populations by at least 70% annually to keep their numbers below pre-control levels.*
>
> McIlroy (1995)

The thresholds for population reduction vary between species, places and seasons, but the estimates in Table 1 provide some idea of how difficult it is to achieve, with removals of half or more a population needed for most species (if conditions are ideal for the species). This means that large numbers of feral animals can be killed for little or no environmental or agricultural benefit.

Table 1. Estimated proportions (%) of feral deer, pigs and goats that need to be killed annually to achieve population reduction (under ideal circumstances for population growth)

Invasive animal	Maximum population growth	Proportion to remove annually
Hog deer (*Axis porcinus*)	85	52
Ch ta (*Axis axis*)	76	49
Rusa deer (*Cervus timorensis*)	70	46
Fa ow deer (*Dama dama*)	45	34
Sambar (*Cervus unicolor*)	55	40
P g (*Sus scrofa*)	78	55-70
Goat (*Capra hircus*)	53	35

Notes: The maximum annual population growth' is the maximum percentage increase in numbers that occurs when resources are not limiting and there are no predators, parasites or competitors. The maximum annual proportion to remove' is the maximum percentage that needs to be removed (by control, predators or disease) to stop population growth.
Sources: (Caley, 1993; Parkes, Henzell, & Pickles, 1996; Hone, 2002; 2010; Bengsen *et al.*, 2014)

One important issue for the inquiry is how governments can better respond to the social impediments to effective management of feral deer, pigs and goats (and other invasive species) due to certain groups of people placing higher value on them than they do on the native biodiversity and environmental services harmed by those species. In several cases, state governments have prioritised narrow private interests over public interests such as conservation and social safety and amenity and other interests such as agricultural productivity (in the case of feral deer).

The management of feral deer has been greatly impeded by their value for hunters, with the policies of the New South Wales, Victorian and Tasmanian governments focused on protecting them as a hunting resource, which has led to substantial recent population growth and spread and growing damage to biodiversity, agriculture and human amenity. Abating the threat of feral pigs has also been compromised by their value for hunters, which has resulted in them being translocated illegally into new areas (Spencer & Hampton, 2005). Abating the threat of feral goats has been compromised by their commercial value for some graziers (see section 4.5).

4.3 The limitations of recreational hunting for managing invasive animals

One of the impediments to abating the threats of these species has been a major reliance on recreational hunting as a control method, particularly for deer. In NSW, Victoria and Tasmania, deer have been protected for hunters due to the political influence of the recreational hunting lobby.

Hunting organisations have been rebranding recreational hunting as 'conservation hunting' and gaining increasing access to public land, including national parks, on the premise that the environment benefits whenever a feral animal is killed. However, recreational shooting is generally ineffective for controlling feral animals except over a small area because too few are killed to overcome the capacity of their populations to quickly rebound due to immigration, survival of individuals that would normally die due to starvation or disease, and rapid reproduction. Often,

more than half a population has to be killed each year to reduce their density and achieve a conservation benefit.

In the past the typical approach to the control of pigs, goats and deer was simply to encourage the killing of as many animals as possible, including through bounties. But a long history of failures (see Box 5) and improved biological knowledge has led experts to endorse a much more targeted and strategic approach, outlined in government codes of practice and standard operating procedures. These stress the importance of defining objectives in terms of the desired outcomes (such as recovery of a certain threatened species) and careful planning and monitoring to assess whether the objectives are being met. Achieving them may require reducing the density of other invasive species in tandem, prioritising certain areas or certain individual feral animals, and reducing other threats as well. Pest control programs should apply standard operating procedures, using effective and humane methods. Any shooting should be carried out by skilled operators. Effective programs should reduce 'the need to cull large numbers of animals on a regular basis'.

Skilled recreational shooters can and do sometimes contribute to such programs (see Box 6), but most recreational hunting in Australia is ad hoc and does not comply with code of practice requirements. Recreational hunting rules also often ban the use of more effective ground-shooting techniques such as spotlight hunting at night, and do not require hunters to demonstrate a minimum level of shooting competence.

> *Although common, ground shooting of pests often is not an effective technique for most pest animals. It's time-consuming and shooters can cover only a relatively small area.*
>
> Braysher (2017)

One reason for poor outcomes is that ground shooting as a method, particularly by day, is not efficient, except with skilled hunters in small accessible areas with good visibility or when used in conjunction with other methods. The limitations imposed by access were shown in a New Zealand study that found little hunting effect on deer populations more than 1.5 km from a road (Nugent, 1988; Simard *et al.*, 2013). According to model codes of practice, ground shooting is 'not effective' for controlling most invasive animals (eg Sharp & Saunders, 2012a, 2012b, 2012c). Background information for the feral pig threat abatement plan says 'there is no evidence that recreational hunting has a role in controlling feral pig numbers' (Department of the Environment and Energy, 2017a). The Victorian government recently concluded that 'opportunistic ground shooting alone is generally an ineffective means of invasive animal management' (Victorian Government, 2017).

The evidence shows that skilled hunters can contribute to effective feral animal control in the following circumstances:

- when they participate in professional control programs, supplementing other methods of control such as aerial shooting or baiting
- when they exert sustained pressure over small accessible areas, such as may occur on farms.

Governments should primarily use professional pest controllers, with amateur shooters who demonstrate high proficiency deployed under supervision where they can supplement other forms of control. Effective and humane pest control requires a high level of skills. Professional controllers must be proficient in a variety of control methods and can use equipment not available to amateurs (such as semi-automatic rifles). A case study of 58 years of fox control on Phillip Island to protect little penguins demonstrates the benefits of employing professionals to apply the most effective methods compared to reliance on recreational hunters and a bounty system (Kirkwood *et al.*, 2014).

Box 5 The failure of bounties

[R]eviews of bounty schemes around the world indicate that they are an ineffective form of pest animal control … and bounty schemes are ecologically and socially flawed…

Australasian Wildlife Management Society (n.d.) position statement on bounties

Bounty schemes, which are designed to increase recreational hunting effort, almost always fail because hunters cannot achieve the required reduction in feral animal populations. They have typically resulted in the removal of only 2 10% of targeted animals (Hassall and Associates, 1998). Bounties also create incentives for hunters to maintain rather than reduce populations and to concentrate their efforts in areas where the financial return rather than the need for control is greatest (Australian Wildlife Management Society, n.d.).

Traditional bounty payments are unsuitable for the control of animals that are present in large numbers, are widely distributed or have high reproductive rates.

Bureau of Resource Sciences review of bounty schemes (Hassall and Associates, 1998)

We can find no accounts in the scientific or grey literature of successful Australian bounties for an invasive animal. The following are three documented examples of ineffective bounties in Australia.

Foxes, Victoria (Fairbridge & Marks, 2005): A 2002 03 trial bounty on foxes in Victoria resulted in an apparently large tally of 150,000 dead foxes. But a review by government biologists found that this would have reduced fox abundance in less than 4% of the state, that fox numbers would quickly bounce back or climb even higher as a consequence, and that there was a mismatch between hunting effort and where fox control was most needed.

Foxes, Phillip Island, Victoria (Kirkwood *et al.*, 2014): A bounty system was run on Phillip Island (100km^2) for 30 years (1954 1983) to protect ground-nesting seabirds, mainly little penguins and short-tailed shearwaters. On average, 18 sets of fox ears were submitted each year, some of which, it was suspected, did not come from the island. The bounty 'failed to appreciably reduce fox numbers on the island, or their impacts on prey.'

Pigs, sugar cane areas, Queensland (Hassall and Associates, 1998): A pig bounty offered by Queensland Sugar Research Stations (until 1986) resulted in presentations of 175 pigs a year when the bounty was $2 and more than 300 pigs when the bounty was doubled. It was believed that more than half the presentations came from non-bounty areas and that less than 5% of the local pig population was removed. Agricultural damage 'was believed to have increased during the operation of the scheme'.

There are also examples from overseas. For example, a bounty in the United Kingdom in the 1950s for invasive grey squirrels yielded more than a million tails presented for payment, but achieved no population reduction (Sheail, 1999).

Fraud has been synonymous with bounty payments throughout the world.

Bureau of Resource Sciences review of bounties (Hassall and Associates, 1998)

Another problem with bounties is they create an incentive for fraud for example, the presentation of domestic animals or animals killed elsewhere for payment and for counterproductive behaviour such as translocating animals and leaving female animals to sustain income opportunities. In the 2002 03 fox bounty trial in Victoria, fox tails already presented for

the bounty payment were stolen, and there was no way of distinguishing fox tails that were brought from interstate or killed in other ways (Fairbridge & Marks, 2005). For a pig bounty in Georgia, US, hunters obtained pig tails from meat processors and submitted them for payment (Smith, 2018). Other Australian examples of fraud are the use of pound dogs to claim a dingo bounty and the presentation of blackened dried apricots as a substitute for pig snouts (Braysher, 2017).

Box 6 Examples of recreational hunters contributing to feral animal control programs

Bounceback, South Australia (DEWNR, 2012): The Bounceback goat control program, operating since 1992, has been successful in greatly reducing the damage caused by feral goats in the Flinders, Gawler and Olary ranges, through a combination of aerial shooting and mustering and ground shooting, mustering and trapping. Volunteer shooters from the Hunting & Conservation Branch of the Sporting Shooters Association have made a substantial contribution to this program. 'Goat densities have steadily reduced in areas where control has been consistent'. Monitoring has shown good plant recovery in some parts.

National parks and reserves, NSW (Natural Resources Commission, 2017) A three-year trial of 'supplementary pest control' by voluntary shooters in 12 national parks and reserves across almost half a million hectares was completed in 2017. It mainly targeted small feral animal populations such as goats, pigs, foxes and rabbits subsequent to other control programs. All volunteers were required to pass a firearms accuracy test, undergo first aid training, attend briefing days and commit to operations in remote parts of NSW. An evaluation by NSW's Natural Resources Commission found the trial 'demonstrated that volunteer ground shooting can be done safely and humanely when sufficient risk management, supervision and planning are undertaken'. The commission concluded that volunteer shooters had the potential to be effective as part of an integrated pest management program, but conclusions on conservation benefits could not be drawn 'due to the limited scale of the trial and limitations of the ecological monitoring'.

Warby Range, Victoria, feral goat eradication (Department of Environment, Land, Water and Planning, Department of Economic Development, Jobs, Transport and Resources, & Parks Victoria, 2016): Goats were recently eradicated from conservation reserves in the Warby Range through ground and aerial shooting. Initial ground shooting by professional and accredited volunteer shooters reduced goat numbers but could not achieve eradication due to the increasing effort per kill needed as goat numbers decreased. Parks Victoria engaged NSW National Parks and Wildlife Service to conduct aerial shooting and two years of monitoring showed that local eradication was achieved.

Nature refuges, Queensland (Sporting Shooters Association, nd): The Conservation and Wildlife Management Qld branch of the Sporting Shooters Association provides pest management services to several nature refuges and state reserves, based on pest management plans. Participants must undertake training and pass a shooting test. One focus is control of foxes and cats at Taunton National Park and Avocet Nature Refuge to protect endangered bridled nailtail wallabies. There is, however, no publicly available information on program outcomes.

4.4 When hunting undermines conservation

Some hunters have exacerbated feral animal problems by spreading feral animals into new areas and advocating against effective control. The Invasive Species Council has been particularly concerned by the influence of the hunting lobby over feral animal policy.

> *[T]he ultimate objective - the deer established in its rightful place as the game animal of Australia, accepted and managed as such at government level, thus ensuring its place among Australia's wildlife.*
>
> Australian Deer Association (n.d.)

Deer are probably Australia's worst emerging feral animal threat (Invasive Species Council, 2011), set to rival 'feral pigs and feral goats in distribution, abundance and impacts in the near future' (Moriarty, 2009). Yet deer have been largely protected for hunters in NSW, Victoria and Tasmania, with restrictions undermining the ability of landholders to control them (Invasive Species Council, 2011; Bilney, 2013). The Australian Deer Association has lobbied against any declaration of deer as pest species and took the Victorian government to court to try to stop the declaration of sambar as a threatening process (Australian Deer Association, 2008).

Much of the deer problem Australia faces is due to hunters shifting them into new areas. A survey in 2000 found that 58% of populations had probably established due to illegal translocation (Moriarty, 2004). Feral deer were observed in 30 new locations in NSW between 2002 and 2004 (West & Saunders, 2007).

> *…continued release of feral pigs for hunting, either in new areas or in areas that they do not currently occupy is a major threat to effective management of feral pigs and their damage.*
>
> Department of the Environment and Heritage (2005)

A rapid increase in pig distribution from the 1970s in NSW and Queensland was attributed to 'deliberate release of piglets and juveniles by unscrupulous hunters' (Pavlov, 1995) and a genetics study in southwestern Australia found intermixing of pigs from different areas, implying they were being 'deliberately and illegally translocated to supplement recreational hunting stocks' (Spencer & Hampton, 2005). The Western Australian Department of Parks and Wildlife warned in 2014 that expanding options for recreational hunting on public lands will provide incentives for more illegal translocations of pest animals (Western Australian Department of Parks and Wildlife, 2014).

> *Recreational hunting can disturb the pests and severely disrupt well-planned pest programs.*
>
> Braysher (2017)

Recreational hunting can make professional control more difficult and expensive by altering the behaviour of targeted animals. Animals subject to shooting disturbance are likely to become more wary pigs and some deer species, for example, forage more at night than during the day and may inhabit more secure areas within their range or move elsewhere (Jayakody *et al.*, n.d.; Graves, 1984; Kilgo, Labisky, & Fritzen, 1998; Stankowich, 2008). The Western Australian Department of Parks and Wildlife (2014) reported several ways in which recreational shooters have undermined pest control programs there, including Illegal pig hunters who reduced the effectiveness of departmental baiting operations by causing changes in pig behaviour and hunters who shot 'judas' goats used by the department.

4.5 Commercial harvest as an impediment to abating the threat of feral goats

Some graziers are harvesting feral goats for profit rather than controlling them as a pest. The 2013 review of the threat abatement plan for feral goats raised concerns about this expanding industry, which generates 'a tension between the resource utilisation of feral goats by farmers and the need for an abatement of the threat to biodiversity from feral goats' (Department of the Environment, 2013). It creates a perverse incentive for keeping goats in the landscape (particularly when sale prices are not high or goats are underweight), and feral goat numbers have risen as the rate of harvesting has increased. It generates problems for land managers seeking to control feral goats such as national park managers and conflict with those who 'see the goats as an asset waiting to be harvested' (Department of the Environment, 2013). A control program at Currawinya National Park in 2008, which cost $350,000 to remove 9000 goats, was characterised as 'money down the drain' due to goats reinvading from neighbouring properties, where they were regarded as a resource (Roberts, 2008).

In Western Australia, the status of goats was changed in 2002 from prohibited to authorised stock (in certain circumstances), allowing graziers to exploit them as stock rather than requiring goats to be controlled. This change has in some places 'reversed the motivation' to control goats (Pearson, 2012). The Western Australian environment department found it difficult to engage pastoralists near parks in effective feral goat control, particularly when the commercial market declined, and warned that goat control will be variable 'while commercialisation is a primary tool for control' (Department of Parks and Wildlife, 2013). Feral goats will 'continue to move from pastoral to DPaW-managed lands in the absence of goat-proof fencing, especially when better grazing exists on DPaW-managed lands and there is sufficient water available' (Department of Parks and Wildlife, 2013).

A goat livestock strategy developed by Meat & Livestock Australia (MLA) acknowledges there is insufficient knowledge of rangeland goat ecology and sustainable population numbers, but there have been no industry or government efforts to address these weaknesses (Meat & Livestock Association, 2015). Instead, MLA advocates an expanded industry: 'In order to continue to grow and stabilise the supply base, increased numbers of producers choosing to build in goats as an enterprise within their business, rather than as a pest or an opportunistic harvesting option, are needed.'

This issue highlights the problems arising from new industries that are developed and promoted in a policy vacuum and lack of assessment and consideration of their environmental impacts. Continuing to permit and promote this industry is likely to compound the threat of feral goats.

We support the position of the Australian Wildlife Management Society (n.d.) that where landholders consider feral goats to be a resource, they should be managed as livestock and 'landowners must take responsibility for their management and its consequences'. Maximum stocking rates should apply, and 'adverse effects on neighbours [and the natural environment] should be eliminated'.

4.6 Recommendations

11. As part of the recommended threat abatement plan for feral deer, develop an agreement with state and territory governments to adopt a consistent legislative and policy approach to feral deer that commits to preventing further spread, recognises the limitations of recreational hunting for control and commits to pursuing more effective control methods.
12. Commission an independent investigation of perverse incentives that stymie or undermine prevention of biosecurity risks and abatement of invasive species threats as a basis for

developing more effective invasive species policies. This includes policies protecting feral deer as 'game' animals and commercialising the harvest of feral goats.

13. As previously recommended (by the 10-year independent review of the EPBC Act), develop a horizon scanning unit within the environment department to investigate emerging and potential environmental threats as a basis for developing preventative policies. Functions should include conducting public inquiries into the likely environmental impacts of proposed new or altered land uses (such as the commercialisation of feral goat harvesting).
14. Commission an investigation of the ecological consequences of the commercial harvest of feral goats, taking into account the seasonally and yearly varying influence of commercial incentives. As part of threat abatement planning, develop a national policy for commercial feral goat harvesting that supports and does not undermine threat abatement. Where landholders use feral goats as a resource, they should be managed responsibly and sustainably as livestock.

5 ToRs (d) and (e): Research priorities

5.1 Understanding population dynamics and environmental impacts

For each of these invasive species, particularly deer, there is still a limited understanding of their environmental impacts.

For feral deer, Davis et al. (2016) nominate the following research priorities:

- long-term changes in plant communities caused by deer
- interactions of deer with other fauna
- impacts on water quality
- economic impacts on agriculture (including as disease vectors)
- changes in distribution and abundance

For feral pigs, Mitchell (2010) nominates the following priorities focused on northern Australia:

- the ecological impacts of pigs in a landscape framework
- a model of their population dynamics and ecology in northern Australia, based on an understanding of the environmental factors driving their population dynamics and movement
- impacts on rare and threatened species, particularly in the Wet Tropics World Heritage Area and wetland ecosystems.

The threat abatement plan for feral pigs (Department of the Environment and Energy, 2017c) nominates the following as research priorities:

- the relationship between the number of pigs and the level of impact within specific areas and ecosystems
- the impacts of feral pigs in environments where they are abundant, including temperate inland river/wetland complexes
- the landscape factors, and interactions between these landscape factors, that drive feral pigs' ecology and their interactions/impacts with the environment

There does not appear to be any recent list of research priorities for feral goats. Parkes et al. (1996) identified a need for research into the impacts of goats at different densities, in wet and dry years, and among the range of co-occurring herbivores. Little is known of impacts on particular plant and animal species. The information in the 2008 threat abatement plan on feral goat impacts is far from comprehensive (Department of the Environment, Water, Heritage and the Arts, 2008b). Other research needs are more accurate population models and better knowledge of the distribution and density of feral goat populations on regional and local scales and changes in response to goat control activities (Parkes *et al.*, 1996). Identifying research priorities for feral goats should be a priority in the development of a revised threat abatement plan.

5.2 Effective and humane methods of control

Due to a lack of research, Australia currently lacks highly effective, low-cost methods of controlling many feral animal species across large areas. This is particularly so for feral deer. We believe the highest priority research focus for all these species should be the development of effective, landscape-scale, cost-efficient and humane methods of control that do not harm non-target species. Often, the most feasible way to achieve this is through the development of species-specific baits and

bait delivery techniques. Humaneness is important for the welfare of the animals being targeted and also for public acceptance of control.

The current options for feral deer control are primarily aerial shooting (effective only in open areas) and ground shooting (generally ineffective except over small areas). There are no deer baits approved for use in Australia. In our view, the primary research need is a humane bait with a species-specific delivery method. A feral deer workshop in 2016 identified an improved 'understanding of lures and options for baiting deer' as one research priority (Forsyth *et al.*, 2017). The Centre for Invasive Species Solutions has recently started work on refining a feed structure developed by the NSW Office of Environment and Heritage that is intended to aggregate feral goats and deer to improve the efficiency of control programs (see https://invasives.com.au/research/feral-deer-aggregator/).

Current control options for pigs are primarily aerial and ground shooting, baiting and trapping. The threat abatement plan for feral pigs identified the need for further research into the effectiveness of control methods and the development of indicators for how and when to undertake control in a particular region or ecosystem (Department of the Environment and Energy, 2017c). A new bait for pigs known as Hog-Gone that uses sodium nitrite as the toxin achieved promising results in field trials and is considered more humane than other options, causing '20 30 minutes of mild symptoms' before death (Lapidge et al., 2012). One research focus should be the effectiveness of dingoes for pig control. There are conflicting opinions on this, but the background document to the threat abatement plan notes that some Indigenous land managers have found a correlation between higher dingo numbers and fewer feral pigs (Department of the Environment and Energy, 2017a). Letnic et al. (2012) note that the distributions of pigs and goats in arid areas show little overlap with that of dingoes except where dingoes are scarce.

Current options for control of feral deer are primarily aerial and ground shooting and trapping around waterpoints. The 2008 threat abatement plan identified the need for 'research into the potential of bore capping and new technologies, such as "machine vision" species recognition, to improve the effectiveness of waterpoint trapping' (Department of the Environment, Water, Heritage and the Arts, 2008b). One high priority should be research on the role of dingoes in abating the threat of feral goats. There are several documented examples of dingoes restricting the distribution of feral goats or goats spreading when dingoes have been controlled (Kimball & Chuk, 2011). For example, the substantial reduction of goats in the Kimberley is thought to have been due in part to the reduction of dingo control following removal of sheep in the 1970s. Another research priority noted in the threat abatement plan is the potential drawbacks of toxins used to poison goats; for example, their potential to affect non-target species (Department of the Environment, Water, Heritage and the Arts, 2008b). As noted above for deer, the Centre for Invasive Species Solutions is working on a feeding structure that is intended to enable goat-specific poisoning. As also noted, a high priority is to develop a humane poison that will not impact non-target species.

5.3 Monitoring the effectiveness of threat abatement

Invasive species control efforts often fail to assess outcomes, particularly for the assets being protected. As stipulated in standard operating procedures, monitoring should be an essential part of control programs. This is vital to determine whether the intended outcomes are being achieved and whether resources are being well spent.) One assessment of 1915 'pest control events' in Australia found that very little is known about the effectiveness of control programs (Reddiex & Forsyth, 2006). Two-thirds of the control events were not monitored (for impacts on either the species targeted or the asset being protected) and consisted of just one treatment area (with no non-

treatment areas to act as a control), and 20% included monitoring of the targeted species only. More than 72% did not monitor the effects on the asset being protected. This means that 'nearly all mammalian pest control activities in Australia with the objective of protecting biodiversity have a design that can yield only the weakest inferences about the effects of that pest control'. Particularly where the effectiveness of control is uncertain, monitoring should be built into control programs.

5.4 Socio-economic issues

As exemplified in this submission, social and economic issues are often a major impediment to effective feral animal control. Research is needed on the social factors that stymie and motivate threat abatement action. We also need more information on the long-term funding needed to properly abate these threats, including to develop more effective control methods. The failure of some state governments to take action to prevent feral deer populations establishing and spreading has resulted in far greater costs to the community and farmers to protect assets. This should be used as a case study to emphasise the adage in invasive species management that early preventative action is far more cost-effective than management once a species has spread.

5.5 Recommendations

15. As part of threat abatement planning, develop a national research plan for each of feral deer, pigs and goats. Likely high priorities include an improved understanding of their impacts and of social and other factors that influence threat abatement as well as more effective control methods.
16. Undertake prioritisation across all key threatening processes to identify the highest priority research needs to guide decision-making for national funding programs.
17. As a high priority, commit national funding to the development of efficient, humane, landscape-scale, cost-efficient methods of control of invasive animals that do not harm non-target species.
18. Require that monitoring is incorporated into control programs funded by the federal government.
19. Commission the Productivity Commission to assess the long-term funding needed to effectively abate major invasive animal threats to the environment, including feral deer, pigs and goats, and to assess the economic benefits of prevention and early action over later management, with feral deer as one case study.

6 References

AUSTRALIAN DEER ASSOCIATION (2008) Deer hunters take the State Government to the Supreme Court over the flora and fauna listing of sambar deer. Media release.

AUSTRALIAN DEER ASSOCIATION (undated) Former ADA website (www.austdeer.com.au), accessed January 2009.

AUSTRALIAN WILDLIFE MANAGEMENT SOCIETY (undated) AWMS position statement: bounties.

AUSTRALIAN WILDLIFE MANAGEMENT SOCIETY (undated) Management of feral goats. AWMS position statement. Https://www.awms.org.au/management-of-feral-goats.

BENGSEN, A.J., GENTLE, M.N., MITCHELL, J.L., PEARSON, H.E. & SAUNDERS, G.R. (2014) Impacts and management of wild pigs Sus scrofa in Australia. *Mammal Review* **44**, 135 147.

BENNETT, A. & COULSON, G. (2011) The impacts of sambar (Cervus unicolor) on the threatened shiny nematolepis (Nematolepis wilsonii). *Pacific Conservation Biology* **16**, 251 260.

BILNEY, R. (2013) The protected pest: deer in Australia. *The Conversation*.

BRAYSHER, M. (2000) Development of an alert list for alien mammals and reptiles. Final project report for Environment Australia. Australian Government, Canberra.

BRAYSHER, M. (2017) *Managing Australia's Pest Animals: A Guide to Strategic Planning and Effective Management*. CSIRO Publishing, Victoria, AUSTRALIA.

BURROWS, N. (2018) Feral animals in the semi-arid and arid regions of Australia: origins, impacts and control. In *On the Ecology of Australia's Arid Zone* pp. 331 374. Springer.

CALEY, P. (1993) Population Dynamics of Feral Pigs (Sus Scrofa) in a Tropical Riverine Habitat Complex. *Wildlife Research* **20**, 625.

COUTTS-SMITH, A., MAHON, P., LETNIC, M. & DOWNEY, P. (2007) The threat posed by pest animals to biodiversity in New South Wales. Invasive Animals Cooperative Research Centre, Canberra.

COWLED, B.D., GIANNINI, F., BECKETT, S.D., WOOLNOUGH, A., BARRY, S., RANDALL, L. & GARNER, G. (2009) Feral pigs: predicting future distributions. *Wildlife Research* **36**, 242 251.

DAVIS, N.E., BENNETT, A., FORSYTH, D.M., BOWMAN, D.M.J.S., LEFROY, E.C., WOOD, S.W., WOOLNOUGH, A.P., WEST, P., HAMPTON, J.O. & JOHNSON, C.N. (2016) A systematic review of the impacts and management of introduced deer (family Cervidae) in Australia. *Wildlife Research* **43**, 515 532.

DEPARTMENT OF ENVIRONMENT, LAND, WATER AND PLANNING, DEPARTMENT OF ECONOMIC DEVELOPMENT, JOBS, TRANSPORT AND RESOURCES & PARKS VICTORIA (2016) Joint Submission to the Parliamentary Inquiry into the Control of Invasive Animals on Crown Land. Victorian Government.

DEPARTMENT OF PARKS AND WILDLIFE (2013) Submission to the Standing Committee on Public Administration. Inquiry into pastoral leases in Western Australia. By State Heritage Office, Office of the Environmental Protection Authority, Conservation Commission of Western

Australia, Department of Environment Regulation, and the Department of Parks and Wildlife. Western Australian Government.

DEPARTMENT OF THE ENVIRONMENT (2013) Five yearly review. Threat abatement plan for competition and land degradation by unmanaged goats (2008). Australian Government, Canberra.

DEPARTMENT OF THE ENVIRONMENT AND ENERGY (2013) Novel biota and their impact on biodiversity. Http://www.environment.gov.au/biodiversity/threatened/key-threatening-processes/novel-biota-impact-on-biodiversity.

DEPARTMENT OF THE ENVIRONMENT AND ENERGY (2017a) Background document threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa). Australian Government.

DEPARTMENT OF THE ENVIRONMENT AND ENERGY (2017b) Littoral rainforest and coastal vine thickets of Eastern Australia ecological community: draft national recovery plan. Australian Government.

DEPARTMENT OF THE ENVIRONMENT AND ENERGY (2017c) Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa). Australian Government, Canberra.

DEPARTMENT OF THE ENVIRONMENT AND HERITAGE (2005) Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs. Australian Government, Canberra.

DEPARTMENT OF THE ENVIRONMENT, WATER, HERITAGE AND THE ARTS (2008a) Background document for the threat abatement plan for competition and land degradation by unmanaged goats. Australian Government, Canberra.

DEPARTMENT OF THE ENVIRONMENT, WATER, HERITAGE AND THE ARTS (2008b) Threat abatement plan for competition and land degradation by unmanaged goats. Australian Government, Canberra.

DEWNR (2012) Bounceback: celebrating 20 years. South Australian Department of Environment, Water and Natural Resources.

FAIRBRIDGE, D. & MARKS, C. (2005) Evaluation of the 2002-03 Victorian fox bounty trial. Vertebrate Pest Research Unit, Victorian Government Department of Primary Industries.

FORDHAM, D., GEORGES, A., COREY, B. & BROOK, B.W. (2006) Feral pig predation threatens the indigenous harvest and local persistence of snake-necked turtles in northern Australia. *Biological Conservation* **133**, 379 388.

FORDHAM, D.A., GEORGES, A. & BROOK, B.W. (2008) Indigenous harvest, exotic pig predation and local persistence of a long-lived vertebrate: managing a tropical freshwater turtle for sustainability and conservation. *Journal of Applied Ecology* **45**, 52 62.

FORSYTH, D., POPLE, T., PAGE, B., MORIARTY, A., RAMSEY, D., PARKES, J., WIEBKIN, A. & LANE, C. (2017) 2016 National Wild Deer Management Workshop Proceedings, Adelaide, 17-18 November 2016. In p. 65. Invasive Animals Cooperative Research Centre.

FREEMAN, A., BENHAM, B., SEBASIO, D., CANN, J. & STREVENS, W. (2014) Summary of the rediscovery of the Jardine River turtle in Australia: management implications and recommendations. Queensland Government Department of Environment and Heritage Protection, Brisbane.

GRAVES, H. (1984) Behaviour and ecology of wild and feral swine (Sus scrofa). *Journal of Animal Science* **58**, 482 492.

HALL, G.P. & GILL, K.P. (2005) Management of Wild Deer in Australia. *The Journal of Wildlife Management* **69**, 837 844.

HASSALL AND ASSOCIATES (1998) Economic evaluation of the role of bounties in vertebrate pest management. Report to the Bureau of Resource Sciences, Canberra, Australia.

HONE, J. (2002) Feral pigs in Namadgi National Park, Australia: dynamics, impacts and management. *Biological Conservation* **105**, 231 242.

HONE, J., DUNCAN, R.P. & FORSYTH, D.M. (2010) Estimates of maximum annual population growth rates (rm) of mammals and their application in wildlife management. *Journal of Applied Ecology* **47**, 507 514.

INVASIVE SPECIES COUNCIL (2008) A deer mistake.

INVASIVE SPECIES COUNCIL (2011) Herbivory and environmental degradation caused by feral deer. Key Threatening Process Nomination. Department of the Environment, Australian Government.

INVASIVE SPECIES COUNCIL (2016) Report: Overhaul of NSW feral animal control needed. Https://invasives.org.au/media-releases/report-overhaul-of-nsw-feral-animal-control-needed/.

INVASIVE SPECIES COUNCIL (2017) NSW squibs on pest reform and protects deer for hunters. *Feral Herald*. Https://invasives.org.au/media-releases/nsw-squibs-pest-reform-protects-deer-hunters/.

JAYAKODY, S., SIBBALD, A., GORDON, I. & LAMBIN, X. (undated) Red deer Cervus elaphus vigilance behaviour differs with habitat and type of human disturbance. *Wildlife Biology* **14**, 81 91.

KILGO, J., LABISKY, R. & FRITZEN, D. (1998) Influences of hunting on the behavior of white-tailed deer: implications for conservation of the Florida panther. *Conservation Biology* **12**, 1359 1364.

KIMBALL, N. & CHUK, M. (2011) Feral Goat Ecology and Management in the Western NSW Rangelands: a review. Western Catchment Management Authority.

KIRKWOOD, R., SUTHERLAND, D.R., MURPHY, S. & DANN, P. (2014) Lessons from long-term predator control: a case study with the red fox. *Wildlife Research* **41**, 222.

LAPIDGE, S., WISHART, J., STAPLES, L., FAGERSTONE, K., CAMPBELL, T. & EISEMANN, J. (2012) Development of a Feral Swine Toxic Bait (Hog-Gone®) and Bait Hopper (Hog-Hopper™) in Australia and the USA. In *Proceedings of the 14th WDM Conference (2012)* p. 6.

LAZENBY, B.T., MOONEY, N.J. & DICKMAN, C.R. (2014) Effects of low-level culling of feral cats in open populations: a case study from the forests of southern Tasmania. *Wildlife Research* **41**, 407.

LEFROY, T., JOHNSON, C. & BOWMAN, D.M.J.S. (2016) Oh deer: a tricky conservation problem for Tasmania. *The Conversation*.

LETNIC, M., RITCHIE, E.G. & DICKMAN, C.R. (2012) Top predators as biodiversity regulators: the dingo Canis lupus dingo as a case study. *Biological Reviews* **87**, 390 413.

LOW, T. (1999) *Feral Future: The Untold Story of Australia's Exotic Invaders*. Penguin.

MCILROY, J. (1995) New techniques for an old problem recent advances in feral pig control in Australia. *IBEX Journal of Mountain Ecology* **3**, 241 244.

MEAT & LIVESTOCK ASSOCIATION (2015) Goatmeat and Livestock Industry Strategic Plan 2015-2020. Meat & Livestock Australia.

MITCHELL, J. (2010) Experimental research to quantify the environmental impact of feral pigs within tropical freshwater ecosystems. Final report to the Department of the Environment, Water, Heritage and the Arts. Australian Government, Canberra.

MORIARTY, A. (2004) The liberation, distribution, abundance and management of wild deer in Australia. *Wildlife Research* **31**, 291 299.

MORIARTY, A. (2009) Science based management of wild deer in Australia: A case study - rusa deer in the Royal National Park. In *Proceedings of the national feral deer management workshop, Canberra, November 2005* p. Invasive Animals Cooperative Research Centre, Canberra.

MURPHY, A., WHITE, M. & DOWNE, J. (2006) National recovery plan for the shiny nematolepis Nematolepis wilsonii. Department of Sustainability and Environment, Melbourne.

NATURAL RESOURCES COMMISSION (2016) Shared problems, shared solutions. State-wide review of pest animal management. NSW Government.

NATURAL RESOURCES COMMISSION (2017) Supplementary pest control trial. Final evaluation report. NSW Government.

NSW DEPARTMENT OF PRIMARY INDUSTRIES (2016) Distribution maps for vertebrate pests. New South Wales Government. Https://www.dpi.nsw.gov.au/biosecurity/vertebrate-pests/publications/distribution-maps-for-vertebrate-pests.

NUGENT, G. (1988) Successful control of fallow deer by recreational hunters in the Blue Mountains, Otago. *New Zealand Journal of Forestry Science* **18**, 239 252.

PARKES, J., HENZELL, R. & PICKLES, G. (1996) Managing vertebrate pests: feral goats. Bureau of Resource Sciences, Canberra.

PAVLOV, M. (1995) Family Suidae. Pig. In *The Mammals of Australia* pp. 715 717. Reed Books, Chatswood, NSW.

PEARSON, D. (2012) Recovery plan for five species of rock wallabies: blackfooted rock wallaby (Petrogale lateralis), Rothschild rock wallaby (Petrogale rothschildi), short-eared rock wallaby (Petrogale brachyotis), monjon (Petrogale burbidgei) and nabarlek (Petrogale concinna) 2012-2022. Western Australian Government Department of Environment and Conservation, Perth.

PEEL, B., BILNEY, R. & BILNEY, R. (2005) Observations of the ecological impacts of sambar Cervus unicolor in East Gippsland, Victoria, with reference to destruction of rainforest communities. *Victorian Naturalist* **122**, 189 200.

POPLE, T. & FROESE, J. (2012) Distribution, abundance and harvesting of feral goats in the Australian rangelands 1984-2011. Final report to the ACRIS Management Committee. Queensland Government Department of Employment, Economic Development & Innovation.

REDDIEX, B. & FORSYTH, D. (2006) Control of pest mammals for biodiversity protection in Australia. II. Reliability of knowledge. *Wildlife Research* **33**, 711 717.

ROBERTS, G. (2008) Feral farmers get on authorities' goat. *The Australian*, 9.

RUSSELL, B.G., LETNIC, M. & FLEMING, P.J.S. (2011) Managing feral goat impacts by manipulating their access to water in the rangelands. *The Rangeland Journal* **33**, 143 152.

SAUNDERS, G. (1993) The demography of feral pigs (Sus scrofa) in Kosciusko National Park, New South Wales. *Wildlife Research* **20**, 559 569.

SHARP, T. & SAUNDERS, G. (2012a) Model code of practice for the humane control of foxes. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

SHARP, T. & SAUNDERS, G. (2012b) Model code of practice for the humane control of feral pigs. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

SHARP, T. & SAUNDERS, G. (2012c) Model code of practice for the humane control of feral goats. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

SHEAIL, J. (1999) The grey squirrel (Sciurus carolinensis) a UK historical perspective on a vertebrate pest species. *Journal of Environmental Management* **55**, 145 156.

SHORT, J. & MILKOVITS, G. (1990) Distribution and status of the brush-tailed rock-wallaby in South-Eastern Australia. *Wildlife Research* **17**, 169.

SIMARD, M.A., DUSSAULT, C., HUOT, J. & CÔTÉ, S.D. (2013) Is hunting an effective tool to control overabundant deer? A test using an experimental approach. *The Journal of Wildlife Management* **77**, 254 269.

SMITH, A.L. (2018) Investigating Effectiveness of Wild Pig Policy and Legislation in the U.S. M.S., Mississippi State University, United States -- Mississippi.

SPENCER, P. & HAMPTON, J. (2005) Illegal translocation and genetic structure of feral pigs in Western Australia. *Journal of Wildlife Management* **69**, 377 384.

SPORTING SHOOTERS ASSOCIATION (nd) Conservation and Wildlife Management Qld. Http://cwm.ssaaqld.org.au/2013/index.php/projects.

STANKOWICH, T. (2008) Ungulate flight responses to human disturbance: a review and meta-analysis. *Biological Conservation* **141**, 2159 2173.

VICTORIAN GOVERNMENT (2017) Government Response to the Environment, Natural Resources and Regional Development Committee Inquiry into the Control of Invasive Animals on Crown Land.

VICTORIAN GOVERNMENT (2018) Draft deer management strategy for public consultation.

WEST, P. & SAUNDERS, G. (2007) Pest Animal Survey: A review of the distribution, impacts and control of invasive animals throughout NSW and the ACT. NSW Department of Primary Industries.

WESTERN AUSTRALIAN DEPARTMENT OF PARKS AND WILDLIFE (2014) Submission to the Legislative Council Standing Committee on Public Administration inquiry into the potential environmental contribution of recreational hunting systems. Western Australian Government.

WOINARSKI, J.C., BURBIDGE, A.A. & HARRISON, P.L. (2014) *The Action Plan for Australian Mammals 2012*. CSIRO Publishing, Collingwood, VIC.