Australian Government

Department of the Environment and Energy

STANDING COMMITTEE ON ENVIRONMENT AND COMMUNICATIONS REFERENCES COMMITTEE

Inquiry into the impact of feral deer, pigs and goats in Australia, and national priorities to prevent the problems worsening for the natural environment, community and farmers.

SUBMISSION

FROM THE

DEPARTMENT OF THE ENVIRONMENT AND ENERGY

October 2018

Contents

Case studies

Tables

EXECUTIVE SUMMARY

The Australian Government Department of the Environment and Energy welcomes the opportunity to provide a submission to the Standing Committee on Environment and Communications References Committee's Inquiry into the impact of feral deer, pigs and goats in Australia, and national priorities to prevent the problems worsening for the natural environment, community and farmers.

Many vertebrate animals introduced to Australia since colonisation have become pests. Pest animals are a significant social, economic, and environmental burden for Australia, negatively impacting on Australia's agriculture, biodiversity, natural and built environment, public health and productivity (Invasive Plants and Animals Committee 2016).

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides for the identification and listing of key threatening processes. The impacts of some feral animals, including feral pigs and feral goats, have been listed as key threatening processes and threat abatement plans have been developed. These are respectively the *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017)* and the *Threat abatement plan for competition and land degradation by unmanaged goats (2008)*. The impacts of six deer species has been recognised under the overarching key threatening process of *Novel biota and their impact on biodiversity*.

The National Landcare Program is a key part of the Australian Government's commitment to natural resource management. Around $1 billion is being invested in the National Landcare Program Phase Two, continuing on from the $1 billion invested from July 2014 to June 2018. Introduced feral animals and weeds are part of work in the program's partnership with state and local governments, industry, communities and individuals.

The Department of the Environment and Energy works closely with other Australian Government departments, particularly the Department of Agriculture and Water Resources on biosecurity activities that include abating the threats posed by feral animals. The Commonwealth also works with state and territory governments to develop strategies, undertake research and fund key management activities.

Introduction

The Australian Government Department of the Environment and Energy recognises the impacts that feral deer, pigs and goats have on the environment, heritage, and cultural values as well as agriculture and community safety.

The State of the Environment 2016 (Cresswell and Murphy 2017) report notes that approximately 80 per cent of threatened species are at potential risk from invasive species impacts. The damage from feral buffalo, camels, cattle, donkeys, goats, horses and pigs is a key pressure on native ecosystems. Introduced herbivores transform ecosystems, thus reducing the resilience of native systems, opening pathways for weed invasion and increasing fire risks.

The environmental impacts from feral deer, pigs and goats include plants being eaten or destroyed, habitat being degraded, the spread of weeds and pathogens, native herbivores being disadvantaged by competition, native animals being eaten by pigs, and native species being exposed to pathogens. Further detail on our understanding of the environmental impacts from these invasive species is provided in this submission.

The submission provides an overview of the breadth of the work of the Department related to feral deer, pigs and goats, and how it links to the responsibilities of the Australian Government.

Environment Protection and Biodiversity Conservation Act

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's primary environmental legislation. The EPBC Act provides a legal framework to identify, protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. These are defined in the EPBC Act as matters of national environmental significance. Additionally, the EPBC Act allows the Commonwealth to regulate actions on Commonwealth land or carried out by a Commonwealth agency.

Key threatening processes under the EPBC Act are defined as processes that threaten or may threaten the survival, abundance or evolutionary development of a native species or ecological community and could cause a native species or ecological community to become eligible for listing as a threatened species (other than conservation dependent) or to become eligible for listing in a higher category of endangerment or adversely affect two or more listed threatened species or ecological communities.

The impacts of feral deer, pigs and goats on threatened species and ecological communities are recognised through their listing under the EPBC Act. Their impact on other matters of national environmental significance in Australia, including Ramsar wetlands, world and national heritage sites and migratory species has also been identified. The recognition is either through a specific key threatening process listing under the Act, as for pigs and goats, or, for the six deer species, under the overarching key threatening process of *Novel biota and their impact on biodiversity*.

National coordination

The Australian Government has international obligations to protect and conserve biodiversity under various conventions and treaties, such as the Convention on Biological Diversity. The Australian

Government provides for the protection of environmental matters related to threatened species, ecological communities and invasive species through the operation of the EPBC Act and also delivers non-statutory measures such as programs that invest in recovery, restoration, monitoring, and science for the protection and conservation of biodiversity.

Within Australia, biodiversity protection and conservation is delivered by the combined efforts of local, state, territory and Commonwealth governments, along with the actions of landholders, communities, traditional owners, the private sector and non-government organisations.

States and territories are responsible for regulating environmental matters in their respective jurisdictions and are the primary regulators for pests and weeds affecting the environment and agriculture. State and territory governments identify problematic pests and weeds with varying levels of requirement for control depending on their level of threat and ability of landholders to undertake effective control measures.

All responsible landholders, managers and lessees contribute to biodiversity conservation through their management of lands and waters across Australia. This contribution includes the management of feral deer, pigs and goats where they are having an impact. Other groups and sectors that invest considerable time, effort and money to protect biodiversity include Indigenous groups, community groups, environmental non-government organisations, businesses including the agricultural sector and researchers. These groups have considerable Indigenous, ecological, local knowledge, and technical expertise and play a critical role in on-ground implementation and raising community awareness. Most biodiversity conservation successes are the product of effective partnerships between governments and non-government groups.

The Australian Government provides national coordination through overarching strategies and through species specific or site specific plans. These strategies and plans allow state, territory and local government, local groups, non-government organisations and landholders to understand how their contribution fits into a broader picture and to provide best practice guidance on how to undertake appropriate management actions.

Roles of the Department of the Environment and Energy

The Department's Environmental Resources Information Network (ERIN) provides environmental and spatial information products, advice, analysis and tools to strengthen the environmental information evidence-base accessible to the Department and stakeholders. ERIN provides data and information that inform overarching strategies and plans and provide groups managing feral deer, goats and pigs with help for their programs. These data range from maps of occurrence of the pests and matters of national environmental significance through to flora, fauna and photographic databases.

Australian Government funding managed by the Department targets impact minimisation from these species through the National Landcare Program and the National Environmental Science Program. The National Landcare Program is a key part of the Australian Government's commitment to natural resource management. Around $1 billion is being invested in the National Landcare Program Phase Two, continuing on from the $1 billion invested from July 2014 to June 2018. Phase two will include a range of measures to support natural resource management and sustainable agriculture, and to protect Australia's biodiversity. The Government aims to work in partnership with governments, industry, communities and individuals to conserve Australia's water, soil, plants, animals and ecosystems, as well as support the productive and sustainable use of these valuable

resources. Introduced pest animals and weeds are identified as requiring a nationwide effort. Details are provided through the submission and in attached tables about funded projects and research.

The National Environmental Science Program (NESP) is a long term commitment by the Australian Government to applied environment and climate science, supporting world-class collaborative and practical research that informs decision-making and on-ground action. Indigenous research partnerships are a highly valued program activity. The NESP funding of $145 million from 2015 to 2021 supports six themed research hubs along with projects to address emerging environmental research needs. Funding agreements require that all NESP funding is met with equal or greater value cash or in-kind co-contributions. The Threatened Species Recovery and Northern Australia Environmental Resources hubs are delivering projects related to feral deer, pigs and goats.

Parks Australia is responsible for Australia's six Commonwealth co-managed National Parks. Dealing with the impacts of feral animals is part of the on-going management program in these parks. Specifically, Kakadu National Park is impacted by feral pigs (and other herbivores such as buffalo) and deer represent a potential threat to Booderee National Park.

The Australian Government is committed to protecting Australia's biosecurity and the Department works in partnership with the Department of Agriculture and Water Resources and other departments to deliver a strong biosecurity system. The two departments are members of the National Biosecurity Committee established under the Intergovernmental Agreement on Biosecurity in 2012. The National Biosecurity Committee, comprising the Australian, state and territory governments, provides advice on minimising the impact of pests and diseases on Australia's economy, environment, and the community to the Agriculture Senior Officials Committee. The National Biosecurity Committee aims to ensure resources are targeted to manage risk effectively from pre-border to post-border while facilitating trade and the movement of animals, plants, people, and goods to, from and within Australia.

Sub-committees provide policy, technical and scientific advice on matters affecting all pests and disease risks to the terrestrial and aquatic (fresh and marine) animals and plants, and the environment more broadly. The Environment and Invasives Committee is responsible for providing national policy leadership on the identification, prevention and management of invasive plant, vertebrate and invertebrate species that adversely impact the environment, economy and community - including feral deer, pigs and goats.

Invasive species research and development

The Australian Government, through the Department of Agriculture and Water Resources, is a member of the Centre for Invasive Species Solutions, an organisation with partners across government, industry and research sectors to support national collaborative invasive species research and development. The Centre for Invasive Species Solutions is managing projects related to feral deer and pigs. The Department of the Environment and Energy participates in forums hosted by the Centre for Invasive Species Solutions and provides environment-related advice to researchers.

The next part of this submission provides comments directly to each of the terms of reference.

The impact of feral deer, pigs and goats in Australia, and national priorities to prevent the problems worsening for the natural environment, community and farmers, including:

(a) the current and potential occurrence of feral deer, pigs and goats across Australia

Occurrence

National mapping of the occurrence of feral deer, pigs and goats was last conducted in 2011 (West, 2011) and provides an indication of where these species may be present in 2018. This mapping was based on a total of 28 individual datasets from national, state or territory governments and other databases such as FeralScan (see below for more detail on FeralScan), and provides reporting of pest occurrence and pest distribution.

The Australian Government recognises that in parts of rangeland Australia goats that are mustered and may be kept to 'finish off' in holding paddocks may be referred to as unmanaged goats or domesticated feral. However, for simplicity this submission refers to all goats that are not kept in paddocks as feral.

This information, while dated, is useful to understand the minimum range that the species may occupy, noting that their populations fluctuate with prevailing environmental conditions, especially drought. Feral pigs can rapidly build populations in good conditions, with two litters of up to 10 piglets every 12-15 months. Conversely, prolonged drought can see feral pig numbers decline significantly with high piglet mortality and adult mortality of up to 50 per cent of the population. Feral goat populations also fluctuate with environmental conditions and also with exploitation of the goats for sale (e.g. unmanaged goats in the rangelands). In favourable conditions, feral goats have multiple offspring and populations can increase by up to 50 per cent each year. Deer populations may fluctuate more slowly with each doe producing, on average, a fawn every year.

Kakadu National Park estimate current numbers of feral pigs are more than 12,000, predominantly in the floodplain region and areas of the lowland region that are seasonally inundated by water.

State and territory governments, natural resource management areas and other groups monitor and map occurrence of feral deer, pigs and goats on their land. In some jurisdictions regular surveys provide an indication of the changes in distribution of these species over time.

The Atlas of Living Australia (www.ala.org.au) is a collaborative, national project that aggregates biodiversity data from multiple sources and makes it freely available and usable online. The CSIRO hosts the Atlas. The Atlas contains current and historical records of feral deer (9,939 records for fallow deer), pigs (10,675 records) and goats (18,484 records).

Community data is collected through the FeralScan website (www.feralscan.org.au) where feral animal sightings can be recorded. This website is managed by the Centre for Invasive Species Solutions. Pig and goat sightings or damage can be recorded by members of the public and deer sightings may be a future addition. There is also a functionality of the website for closed groups to be formed for landholder groups to plan and coordinate control together. The website contains 6,635 records for feral pigs and 419 records for feral goats.

Potential occurrence

Climate and habitat matching can provide estimates of the potential range for feral deer, pigs and goats.

The six species of deer occupy different habitats across Australia and are currently increasing their ranges.

Feral pigs have occupied extensive areas of Australia but climate matching indicates that there are extensive areas that feral pigs could occupy. These include large parts of central and eastern Tasmania, Eyre Peninsula, the south-east of South Australia, and south-western Western Australia.

Feral Goats have been present in Australia since soon after the arrival of the first fleet in 1788. The presence of watering points for livestock have allowed them to occupy arid and semi-arid rangeland areas as well as higher rainfall areas. Feral goat distribution may change in the future due to the accessibility of water and changes in the distribution or abundance of dingoes and wild dogs that prey on them.

Monitoring to manage feral deer, pigs and goats

Ongoing monitoring of the impacts of feral deer, pigs and goats allows for management activities to be targeted at the right time and place and is more important than knowing the occurrence or absolute abundance of these species. Tools for land managers to monitor the impacts of these species are available on the Pest Smart website (www.pestsmart.org.au) and in particular through the series of “Glovebox guides” published by the Australian Government funded Invasive Animals Cooperative Research Centre.

(b) the likely and potential biosecurity risks and impacts of feral deer, pigs and goats on the environment, agriculture, community safety and other values;

Biosecurity risks

Feral deer, pigs and goats pose potential biosecurity risks to livestock and native species where interactions occur. All three of these species have potential to spread environmental pathogens such as *Phytophthora cinnamomi* — an EPBC Act key threatening process spread by movement of contaminated soil. They also spread weeds through the landscape.

Environmental impacts of deer

Feral deer impacts on the environment include reducing or changing the abundance and diversity of plant species through browsing and grazing; destroying saplings by rubbing against them, trampling or eating; spreading weeds into new areas; competing with native herbivores for feed, water and shelter; contribute to erosion and water quality degradation through trampling, wallowing and faecal contamination; alter soil properties and nutrient cycling; hindering revegetation programs; and carry diseases and pathogens.

The degree of impact of each of these is variable between the six species and the sites where the deer are living. The abundance of deer is increasing across Australia and consequentially the impacts listed above are occurring to a greater number of sites or species, or to a greater degree.

Environmental impacts of pigs

The environmental impacts of feral pigs in Australia include predation of animals, consumption of plants and soil organisms; habitat change and degradation due to destruction of plants, reduced plant regeneration, soil erosion and changes in soil structure, and the spreading of weeds. Feral pigs can act as reservoirs for disease and they are implicated in the spread of plant pathogens. Feral pig impacts are associated with wetlands and riparian ecosystems, which are preferred habitats, leading to impacts on water quality such as water turbidity and dissolved nutrient levels.

Habitat degradation is mostly a consequence of their digging up of soils, grasslands and forest litter as they forage or 'root' for subterranean food items such as roots and fungi. Moist soils particularly attract digging activities. Feral pig disturbance can be locally extensive, such as in or around swamps and lagoons, and may be associated with sites modified by people, or close to roads, tracks and watercourses. Foraging can result in obvious large expanses of deeply turned over or rooted soil in highly profitable foraging patches. More commonly, damage is distributed discontinuously throughout a broad area, such that a few sites experience high levels of damage while many sites have little.

The presence of feral pigs often results in increases in weed abundance, although whether this is through passing seeds in faeces, spreading seeds attached to fur, creating localised nutrient enrichment through urine and faeces, or simply by creating ground disturbance in which weeds can take root, is not certain.

Native fauna preyed upon by feral pigs include earthworms, amphipods, centipedes, beetles and other arthropods, crustaceans, snails, frogs, lizards, snakes, the eggs of the freshwater crocodile, freshwater turtles and their eggs, marine turtle eggs and hatchlings, and small ground-nesting birds and their eggs.

The Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) lists eight ecological communities, 63 threatened animals and 85 threatened plants impacted or potentially impacted by feral pigs. This includes six of the 20 threatened birds listed in the Threatened Species Strategy.

Environmental impacts of goats

The characteristics of feral goats that help to explain their invasiveness and impacts are their diet and fecundity. As generalist herbivores, they can colonise a wide range of habitats. Similarly to other grazing animals, feral goats can affect native flora and fauna by browsing and grazing on native vegetation, thereby preventing regeneration; by overgrazing, which causes soil erosion; by competing for food and shelter; by introducing weeds through seeds carried in their dung; and by fouling waterholes.

There are 99 threatened plants and 11 threatened animals impacted by feral goats. This includes the malleefowl, listed in the Threatened Species Strategy.

Impacts on EPBC Act heritage sites

Feral deer, pigs and goats impact on the values of at least 19 listed World Heritage and Australian Heritage sites.

Deer threaten water quality in the Australian Alps National Parks and Reserves and have significant impact on vegetation structure, regeneration of native species and soil stability in other heritage sites. Deer are considered a game animal in Victoria and recreational deer hunting by stalking is permitted seasonally in parts of the Victorian Greater Alpine National Parks. This assists in reducing deer numbers in some areas, but overall the deer population is considered to be increasing in numbers and extent.

Pigs cause local impacts, especially along creek lines and temporary wetlands; cause damage to vegetation; spread weeds; contaminate water; damage fences; predate on small native animals; damage breeding habitats of threatened species; overturn soil for tubers and fungi; spread dieback disease; damage archaeological sites; cause significant damage to wetland areas from fouling and muddying of water; destroy vegetation and destabilise wetland banks.

In Kakadu National Park, feral animals—particularly pigs—frequently take refuge in the shade of ground level shelters and damage rock art by rubbing on rock faces. This has been a significant cause of degradation of some rock art sites.

At the Mount William Stone Hatchet Quarry pigs cause surficial damage to some flaking floors and mining pits.

Goats contribute to the decline in the integrity of native vegetation; contribute additional grazing impacts, especially in riparian areas and adjacent floodplains; trample vegetation and accelerate soil erosion. Selective grazing by goats has substantial impacts on sensitive vegetation including threatening the survival of some sensitive vegetation populations.

In the Greater Blue Mountains Area goats selectively graze on rock shelf vegetation and their hard hooves can cause considerable disturbance to fragile cliff face soils, and they compete for habitat with the threatened brush-tailed rock wallaby.

Table 1 lists which species impacts on each of the heritage listed places.

Table 1: Feral deer, pig and goat impacts on heritage listed places

Heritage listed place	State/territory	Deer	Pigs	Goats
Willandra Lakes Region	NSW		X	X
Warrumbungle National Park	NSW		X	X
Australian Alps National Parks and Reserves	NSW, ACT, Vic.	X	X	X
Royal National Park and Garawarra State Conservation Area	NSW	X	X	
The Greater Blue Mountains Area	NSW	X	X	X
Ediacara Fossil Site	SA			X
Budj Bim National Heritage Landscape - Mt Eccles Lake Condah Area	Vic.	X	X	X
Budj Bim National Heritage Landscape - Tyrendarra Area	Vic.	X	X	X
Grampians National Park (Gariwerd)	Vic.	X		X
Mount William Stone Hatchet Quarry	Vic.		X	
Porongurup National Park	WA		X	
Lesueur National Park	WA		X	X
Shark Bay	WA	X	X	X
The Ningaloo Coast	WA			X

Heritage listed place	State/territory	Deer	Pigs	Goats
Kakadu National Park	NT	X		
Ngarrabullgan	Qld.	X		
Great Artesian Basin Springs: Elizabeth	Qld.		X	X
Glass House Mountains	Qld.		X	
Tasmanian Wilderness	Tas.	X		

Impacts on Ramsar wetlands

Feral animals including pigs, goats and deer constitute a significant threat to Australia's wetlands of international importance (Ramsar wetlands). All of these species can damage wetlands' critical wetland components and processes. Potential damage includes predation of waterbirds by pigs and damage to soil, vegetation and water flows by all three species. Of the three species, pigs are the most commonly reported threat to the ecological character of Ramsar wetlands. Ramsar wetlands where these feral species have been reported to be a threat are listed in Table 2.

Table 2: Feral deer, pig and goat impacts on Ramsar sites

Wetland	State/territory	Deer	Pigs	Goats
Currawinya Lakes	Qld.		X	X
Hattah-Kulkyne Lakes	Vic.		X	X
Lake Pinaroo	NSW		X	X
The Coorong and Lakes Alexandra and Albert Wetland	SA	X		X
Muir-Byenup System	WA	X	X	
Paroo River Wetlands	NSW	X	X	X
Shoalwater and Corio Bays Area	Qld.		X	X
Riverland	SA		X	
Coongie Lakes	SA		X	
Ginini Flats Wetland Complex	ACT		X	
Gwydir Wetlands	NSW		X	
Logan Lagoon	Tas.		X	
Myall Lakes	NSW		X	
Narran Lakes	NSW		X	
Macquarie Marshes	NSW		X	
Lake Toolibin	WA		X	
Cobourg Peninsula	NT		X	
Lavinia	Tas.	X		

Impacts on the Murray-Darling Basin

Feral deer, pigs and goats impact on wetland areas within the Murray-Darling Basin. Monitoring of vegetation in the Barmah and Millewa forests has shown feral pigs 'ploughing' the wetland floor as floodwater recedes and directly damaging the vegetation.

Impacts on Kakadu National Park

The Kakadu National Park management plan 2016-2016 and Kakadu National Park Threatened Species Strategy 2014 – 2024 recognises the threats to the park's values from hard-hoofed feral herbivores. There is localised impact from buffalo and pigs on some spring areas in the upland areas of the park and extensive impacts in floodplain areas. Pigs prey on several wetland dependent species including frogs and turtles. Pigs target *Eleocharis* bulbs which are a major food source for the culturally important magpie geese. The spread of weeds such as mimosa and *olive hymenachne* by pigs and buffalo through foraging activities is of major concern. Buffalo and pigs also affect recruitment of rainforest species, particularly those associated with springs. The decline in yams in the park is likely to due to pig activity. In addition, pigs and buffalo can damage cultural heritage sites.

(c) the effectiveness of current state and national laws, policies and practices in limiting spread and mitigating impacts of feral deer, pigs and goats

Australian Pest Animal Strategy

The Australian Pest Animal Strategy (2017-2027) is a strategy of the intergovernmental Environment and Invasives Committee. The strategy provides national guidance on best practice vertebrate pest animal management. It re-affirms agreed national pest animal management principles, and sets national goals and priorities that will help improve Australia's overall ability to prevent and respond to new pest animal incursions and manage the negative impacts of established pest animals. This provides the policy foundation to guide and inform the actions of stakeholders, including landholders, industry, communities and government, rather than prescribing detailed on-ground actions and activities.

Threat abatement plans

Under the EPBC Act, pigs and goats are explicitly listed as the key threatening processes of *Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs* in 2001 and *Competition and land degradation by unmanaged goats* in 2000, while deer are captured by the overarching listing *Novel biota and their impact on biodiversity* in 2013. Listing a key threatening process under the EPBC Act provides official recognition that a process is a key threat to biodiversity at the national level, raises awareness of how that threat is operating across Australia and assists with understanding and prioritising management of the threat. Threat abatement plans may also be developed. These establish a framework to guide and coordinate Australia's response to the impact of a key threatening process. All threat abatement plans include the listed threatened species and ecological communities affected by the key threatening process. A threat abatement plan identifies the research, management and other actions necessary to reduce the key threatening processes to an acceptable level in order to maximise the chances of the long-term survival of native species and ecological communities affected. There are threat abatement plans for predation, habitat degradation, competition and disease transmission by feral pigs (2017) and competition and land degradation by unmanaged goats (2008).

The Commonwealth must implement a threat abatement plan to the extent to which it applies in Commonwealth areas and the Department seeks the cooperation of affected states and territories with a view to implementing the plan jointly to the extent to which the plan applies.

While there are species specific actions identified for these three species, common threads of research and management requirements relate to understanding the relationships between the impacts and density/distribution of the pest animal in order to understand when and how much control is required; a better understanding of the interactions between these pest animals and other animals in the landscape (feral, native and livestock); further development of alternative control methods and building public awareness of the impacts of feral deer, pigs and goats. The research requirements are expanded on in section (e).

Recovery plans and conservation advices

When a native species is listed as threatened under the EPBC Act, a Conservation Advice must be developed to assist its recovery. A Conservation Advice provides guidance on immediate recovery and threat abatement activities that can be undertaken to ensure the conservation of a newly listed species.

Where needed, the Minister may prepare a more comprehensive Recovery Plan to guide recovery of the species. Recovery plans are generally prepared where the listed species has complex management needs due to its ecology, the nature of threats affecting it, or the number of stakeholders affected by or involved in implementing the necessary recovery actions. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or ecological communities.

Conservation Advices and Recovery Plans list feral deer, pigs and goats where they are known to pose a threat to the native species. The advice or plan may provide specific advice where the threat abatement action is specific to that species or provide more general advice where the Threat Abatement Plan provides the appropriate guidance.

Targeted funding

Feral deer, pigs and goats are a target of Australian Government funding to support on-ground action through the Natural Heritage Trust, Murray-Darling Basin Environmental Water Knowledge and Research Project, and Australian Government Reef programs. Most recently, investments under the Natural Heritage Trust have been delivered through major programs including the National Landcare Program, 20 Million Trees, Threatened Species Recovery Fund and Indigenous Protected Areas. The National Environmental Science Program funds applied environmental science that relates to these invasive species.

National Landcare Program

From 2014 to 2018, the Australian Government invested $1 billion through the National Landcare Program to help support local environmental and sustainable agriculture projects. Last year the Australian Government announced funding of more than $1 billion over six years to continue the National Landcare Program to ensure it remains a key part of the Australian Government's commitment to protect and conserve Australia's water, soil, plants, animals and ecosystems, as well as support the productive and sustainable use of these valuable resources.

With the Government's investment in the next phase of the National Landcare Program, the Department aims to work in partnership with states and territories, industry, communities and individuals to protect and conserve Australia's water, soil, plants, animals and ecosystems, as well as support the productive and sustainable use of these valuable resources.

A major component of the National Landcare Program Phase 2 is the Regional Land Partnerships program. Regional Land Partnerships investment under the second phase of the Program commenced from July 2018, providing $450 million over five years Australia-wide to deliver national priorities at a regional and local level. Shifting to a procurement investment model secures ongoing capability to deliver projects on key priorities for the life of the program. It also enables more funding to flow directly to on-ground activities.

The program is delivering against six outcomes, five of which are relevant to abating the threat from feral deer, pigs and goats.

- Outcome 1: The ecological character of Ramsar sites (internationally recognised wetlands) is maintained or improved.
- Outcome 2: The trajectory of species targeted under the Threatened Species Strategy, and other EPBC Act priority species, is improved.
- Outcome 3: The natural heritage Outstanding Universal Value of World Heritage properties is maintained or improved.
- Outcome 4: The condition of EPBC Act listed Threatened Ecological Communities is improved.
- Outcome 5: The conditions of soil, biodiversity and vegetation are improved.
- Outcome 6: Agriculture systems have adapted to significant changes in climate and market demands.

A mapping tool included links to relevant recovery plans, threat abatement plans and conservation advices to help tenderers develop their project designs and proposals.

Other components of the National Landcare Program Phase 2 are:

- Indigenous Protected Areas - The Government is providing $15 million for Indigenous Protected Areas, in addition to an investment of $93 million for the ongoing support of existing Indigenous Protected Areas.
- Environment Small Grants - The Government is providing $5 million in small grants to community, landcare, environment and other natural resource management groups to deliver natural resource management activities that improve the quality of the local environment. The small grants will be allocated through a one-off grant round in the 2018- 19 financial year.

The National Landcare Program provided funding to projects specifically mitigating the impacts of one or more of deer, pigs or goats. The three case studies below provide examples of projects.

Case Study – feral deer: Protecting and connecting EPBC species in the Yarra Ranges

This project was undertaken in the Yarra Ranges of Victoria and is a partnership between the Australian Government, Parks Victoria, local land managers, and Landcare and community groups. The project has provided improved habitat for the endangered helmeted honeyeater and Leadbeaters Possum. The second phase of the project received $768,800 from the National Landcare Program between 2015 and 2018.

The project included deer monitoring and control within the Yellingbo Nature Conservation Reserve and on adjoining private land, where there are sambar and fallow deer. Ten landholders were engaged in the project and a total of 50 volunteers participated in monitoring or control work. Deer were monitored by pellet counts and controlled through shooting. A deer exclusion fence was also set up around the perimeter of one 3.4 hectare site, linking to an existing deer proof fence, to protect new plantings.

Deer control at Yellingbo Nature Conservation Reserve and adjoining properties will prevent severe browsing and rubbing of plants, trees being ripped out and trampling of the ground at revegetation sites that are currently inhibiting the revegetation efforts.

Case Study – feral pigs: Nest to Ocean Turtle Protection Program

www.npsr.qld.gov.au/managing/pest-plants-animals/nest-ocean-turtle-protection-program.html

The threat of predation on marine turtle nests and hatchlings is a key concern for the sustainability of turtle populations in coastal Queensland. Two studies conducted on western Cape York showed feral pigs were responsible for the loss of up to 70 per cent of clutches of eggs on many beaches. The threat from feral pigs on turtle eggs and hatchlings is identified in Recovery plan for marine turtles in Australia and the Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs.

The Nest to Ocean Turtle Protection Program is an example of how an effective system of identification of an issue at a national level can provide coordinated support to deliver outcomes on the ground – or beach in this instance. The Australian and Queensland governments committed matching funds of $4,875,000 million since 2014 to help reduce the threat of predation on marine turtle nests. The projects were delivered by on-ground groups including Indigenous organisations and natural resource management organisations.

Marine turtle rookeries along the coast have been identified under the Nest to Ocean Turtle Protection Program for active nest protection and predator control efforts to reduce the threat posed by feral pigs and other predator species.

Predator control activities for feral pigs, dogs and goannas along the Western Cape York has delivered impressive results with a very high proportion of nests producing hatchlings across almost all locations. Large numbers of pigs have been removed through aerial culls across the West Cape York; and nest protection activities have increased through intensified monitoring efforts and the placement of aluminium nest protection cages. On the east coast, in 2017, the program is delivered successful hatchings with 83% of nests have not been predated.

Case Study – feral goats and pigs: On-ground action for maintaining ecosystem services in the SA Arid Lands

This project focused on implementing on-ground action to maintain and improve habitat for threatened species in the Gawler Ranges and Kingoonya districts, and Coongie Lakes Ramsar Wetland in South Australia. Coordinated threat abatement focuses on reducing fox predation and competition from feral goats and rabbits. The project involved a partnership between the Australian Government, South Australian Government, six natural resource management groups, Indigenous co-management boards and advisory committees, volunteer groups, progress associations, land managers and mining organisations.

The coordinated feral animal control program involved aerial shooting feral goats across 75,000 hectares with annual follow-ups and aerial shooting of feral pigs across 52,000-80,000 hectares.

Monitoring of pig impacts in the Coongie Lakes Ramsar Wetland showed a significant reduction in pig activity between 2013 and 2018, with a decline in areas where damage was observed from 1% of surveyed areas in 2013, to < 0.01% of surveyed areas in 2018. Pig impact in the form of soil and vegetation disturbance has been kept low and has reduced through an ongoing annual aerial cull.

This project resulted in a direct reduction in threats to biodiversity values in the SA Arid Lands, including known threats to the Yellow-footed Rock Wallaby and species of national significance, as well as threats to Coongie Ramsar values.

Assessments of the impacts of browsing indicated that goat control activities in the Gawler Ranges have suppressed goats to an adequate degree to allow long-lived palatable species to persist

Herbivore impacts were assessed on woody and long lived perennial plants growing at 24 sites. The key finding was that targeted regular culling enabled the more palatable woody plant species to maintain their reproductive capacity and allow for regular recruitment. Some species were still being impacted at vulnerable stages of their life cycle so further measures that reduce total grazing pressure should be investigated. Within the areas where goats are managed using mustering, the results were more variable with the greatest impacts on the most species being adjacent to extensive less accessible hill groups such as Tandaie Rockholes.

Table 3 provides examples of projects funded through the various programs under the Natural Heritage Trust targeting feral deer, pigs and goats.

Table 3: Funding under NHT Programs targeting feral deer, pigs and goats.

State	Funding Program	Organisation	Project title	Project description*	Project duration	Funding (ex GST)
Multi-species						
SA	National Landcare Program	South East Natural Resources	On the brink: Recovery of threatened habitats and	Enhance the recovery of iconic EPBC listed threatened species and ecological communities	2015-2017	$2,016,503

State	Funding Program	Organisation	Project title	Project description*	Project duration	Funding (ex GST)
	Regional Funding	Management Board	species in the SE NRM Region	through pest weed and feral animal control (deer, goats, pigs and rabbits), fencing and revegetation activities.		
SA	National Landcare Program Regional Funding	Kangaroo Island Natural Resources Management Board	Protecting KI from Invasive Species	Continue to manage high risk pest animals by eradicating feral deer, managing the biosecurity risk of domestic deer herds, implementing management of feral pigs across land tenures, trialling new feral cat devices and assessing the need and feasibility of feral peacock eradication. Continue to manage weeds of national significance.	2015-2017	$784,000
Pigs						
NSW	National Landcare Program 25th Anniversary Landcare Grants	GLENRAC Incorporated (sponsored Coldwood Pastoral Pty Ltd)	Wellington Vale Northern NSW - Erosion Control in Beardy River Headwaters	Conduct pest animal control focussing on feral pigs and rabbits, and weed control.	2015-2016	$18,500
NSW	National Landcare Program 25th Anniversary Landcare Grants	Gwydir Valley Irrigators Association Incorporated	Gwydir Valley - Invasive Pest Animal Management Program	Through integrated feral pig management in the region, reduce breeding potential by an estimated 15,000 pigs, thereby reducing damage caused to crops and environmentally significant flora, fauna and Gwydir Valley natural resources of soil and water.	2015-2016	$20,000
NSW	National Landcare Program 25th Anniversary Landcare Grants	Gwymac Incorporated (sponsored South West Inverell Landcare Group)	South West Inverell, NSW - Improving Water Quality and Protecting Myall Creek	Install fencing along a headwater tributary of Myall Creek to exclude stock and control of pest animals such as feral pigs.	2015-2016	$19,850

State	Funding Program	Organisation	Project title	Project description*	Project duration	Funding (ex GST)
NSW Qld.	National Landcare Program 25th Anniversary Landcare Grants	Granite Borders Landcare Committee Incorporated (sponsored Tenterfield Wild Dog Control Group)	NSW/QLD – Strategic, Co-ordinated, Cross-Border Pest Animal Control Management	Conduct strategic co-ordinated pest animal control on a landscape scale (across NSW and QLD borders) targeting wild dogs, feral pigs and foxes.	2015-2016	$20,000
Qld.	Nest to Ocean Turtle Protection Program Equally co-funded by QLD and Australian Governments	11 organisations: Queensland Parks and Wildlife Service Northern; Balkanu; Cape York NRM; Carpentaria LCAC; Queensland Parks and Wildlife Service Sunshine / Fraser; Hinchinbrook Community; Gunggandji PBC; Kowanyama ASC; Kalan Aboriginal Corp; Aak Puul Ngantam; Torres Strait Regional Authority	Nest to Ocean Turtle Protection Program	Thirteen projects targeting feral pigs in Queensland and Torres Strait related to the protection of marine turtles.	2014-current	$3,975,363
Qld.	Biodiversity Fund	Balkanu Cape York Development Corporation Pty Ltd	Improving biodiversity outcomes & carbon reduction through feral pig abatement	Support indigenous landholders conducting feral pig abatement activities to significantly enhance, expand and demonstrate improved biodiversity outcomes from pig abatement activities.	2011-2017	$2,800,000
Qld.	Biodiversity Fund	Aak Puul Ngantam Ltd	Enhancing Management of Wik and Kugu Country Biodiversity	Maintain the region's significant biodiversity and address increasing concerns including the impacts of pigs, wild fire and weed infestations.	2011-2017	$3,594,000

State	Funding Program	Organisation	Project title	Project description*	Project duration	Funding (ex GST)
Qld.	National Landcare Program 25th Anniversary Landcare Grants	Cape York Landcare Inc.	Holroyd Plain Pest Management Program	Reduce the environmental impacts of feral animals including pigs and horses over a large area of the Holroyd Plain High Value Aquatic Ecosystem in central Cape York through aerial and on-ground methods.	2015-2016	$19,950
Qld.	National Landcare Program Regional Funding	Desert Channels Queensland Incorporated	Channel Country Feral Pig Control, Monitoring and Community Empowerment	Continue to manage feral pigs within the Channel Country, building on previous control and monitoring programs, complementing work to reduce feral pig numbers downstream into Ramsar-listed wetlands and developing a community feral pig plan to support ongoing control.	2014-2018	$719,178
Qld.	National Landcare Program 25th Anniversary Landcare Grants	Inglewood and Texas Landcare Association Inc	Inglewood Texas Community Advancing Feral Pig Control with Technology	Coordinate a feral pig control program across the Inglewood/Texas district and remove 2,200 pigs from the landscape through trapping, baiting and shooting.	2015-2016	$20,000
Qld.	National Landcare Program 25th Anniversary Landcare Grants	South West NRM Ltd	Caring for Currawinya - Pest and Weeds Mitigation	Control feral animals (pigs, foxes, wild dogs and cats) and weeds, undertake revegetation activities and hold workshops to inform the community of feral animal control and erosion mitigation practices.	2015-2016	$10,000
Qld.	National Landcare Program 25th Anniversary Landcare Grants	South West NRM Ltd	Rehabilitation of Peter's Creek Floodplain	Control feral animals (pigs, foxes, wild dogs and cats) and weeds, undertake revegetation activities and hold workshops to inform the community of feral animal control and	2015-2016	$19,440

State	Funding Program	Organisation	Project title	Project description*	Project duration	Funding (ex GST)
				erosion mitigation practices.		
Qld.	Green Army	Gidarjil Development Corporation Limited	Gladstone Region Coastal Restoration Initiative	The project will monitor and measurably improve the aquatic ecosystems to protect and improve areas of specific marine and terrestrial ecosystems, such as: reducing the impact of vegetation degradation by feral pigs on Curtis Island.	2015-2016	$176,733 (approx.)
Qld.	Green Army	Girringun Aboriginal Corporation	Feral Pig Eradication and Control - Hinchinbrook Island (Phase 1 & 2)	The project will undertake an integrated approach towards feral pig eradication across the project location through collaborative trapping, targeted baiting and removal of feral pigs at selected priority habitation sites, based on existing knowledge of seasonal feral pig movements on Hinchinbrook Island National Park.	2017-2018	$353,466 (approx.)
SA	National Landcare Program 25th Anniversary Landcare Grants	D.S Johnson & P.F Johnson	Gosse Area on Kangaroo Island SA - Feral Pig Management Plan	Limit movement of local feral pig populations into private productive agricultural land through fencing, shooting, trapping, monitoring and coordination with other stakeholders.	2015-2016	$19,877
WA	National Landcare Program 25th Anniversary Landcare Grants	Shire of Plantagenet (sponsor of Lake Muir Denbarker Community Feral Pig Eradication Group)	Lake Muir and Denbarker - Feral Pig Control	Reduce feral pig damage in the Lake Muir Byenup Ramsar Wetlands and protect the natural habitat of threatened species.	2015-2016	$20,000
Goat						
NSW	Biodiversity Fund	Western Catchment	Landscape scale	Establish multi-property goat	2011-2017	$835,300

State	Funding Program	Organisation	Project title	Project description*	Project duration	Funding (ex GST)
		Management Authority (now Western Local Land Services)	management of feral goats to improve ecosystem resilience	management zones within which feral goat movement will be strictly controlled, enabling land managers to implement effective grazing management strategies, thereby improving their capacity to manage total grazing pressure, biodiversity and soil carbon in semi-arid rangeland ecosystems.		
SA	National Landcare Program Local Programs	SA Department for Environment and Water	Feral Goat Eradication on Kangaroo Island	Continue eradicating remaining feral goats on Kangaroo Island to reduce grazing impacts on native herbs, grasses, shrubs and trees.	2015-2017	$92,500
Vic.	Biodiversity Fund	Parks Victoria	Restoring and reconnecting Australia's Threatened woodlands in the Mallee Range	Through private and public partnerships, revegetate and restore high value sites across Victoria's Mallee parks and protect these sites from the impacts of goats, rabbits and other grazing pests.	2011-2017	$3,004,000
TOTAL						**$18,518,710**

*Note that for the purposes of brevity in this table, only the feral deer/pig/goat component is described. These projects typically have additional, related elements to achieve the overall outcome of the project.

There are approximately 32 additional projects (completed from 2016 onwards) funded through the Biodiversity Fund, 25th Anniversary Landcare Grants, 2014-15 to 2017-18 National Landcare Program Regional Funding stream and Threatened Species Recovery Fund which have invested a portion of funding in the management of feral deer, pigs and/or goats as part of a broader project. It is not possible to identify the specific amount of project funds that have been invested in managing these feral herbivores.

Murray-Darling Basin Environmental Water Knowledge and Research Project

The Commonwealth Environmental Water Office (CEWO) is funding a research project called the Murray-Darling Basin Environmental Water Knowledge and Research Project in response to a need for improved science to support environmental water management. The project is investing $10 million over five years from 2013-14 into research priorities to inform adaptive management of

environmental water in the Murray-Darling Basin. The project has four themes under which research priorities are being addressed – Waterbirds, Vegetation, Native Fish and Food webs.

The Waterbird Theme is of particular relevance to threat mitigation from feral pigs, investigating how flow regimes can best support recruitment of waterbird populations and how threats such as invasive pests, including pigs, impact on recruitment outcomes. This work is being undertaken at the Macquarie Marshes (NSW) and Barmah-Millewa (Vic). Early research results from the project are highlighting that feral animal predation (by pigs, cats, foxes and dogs) is a key factor threatening recruitment of colonial waterbirds at these sites. The impact of this predation across the Murray-Darling Basin and contribution to the overall waterbird population decline in the Basin requires further investigation and analysis.

National Environmental Science Program projects

The National Environmental Science Program (NESP) Northern Australia Environmental Resources Hub is undertaking a research project titled *Defining metrics of success for feral animal management in northern Australia.* This project will determine the impact of feral pigs, horses and cattle across aquatic systems in the context of regional and local feral animal control, local aspirations and government priorities. The project will also evaluate metrics used to assess how well control measures work in mitigating threats to aquatic ecosystems. These outcomes will be communicated using a reporting system that compares investment in control with consequent impacts on environmental values. This project received $814,200 of NESP funding.

Kakadu National Park

The Kakadu National Park management plan 2016-2016 and Kakadu National Park Threatened Species Strategy 2014 – 2024 recognise the threats to the park's values. The Park's Feral Animal Strategy aims to address these threats. It includes actions to reduce the impacts of pigs and buffalo in priority areas of the floodplains; and in and around priority rainforest patches. It also includes monitoring of the density and spread of invasive species density and of the effectiveness of control actions.

A park-wide feral animal control exercise was conducted in 2008–09. Since then most feral animal control programs have focused on strategic areas of high risk, with the control of feral animals funded from the Park's operational budget.

Table 4 summarises the results of activities to control pigs in Kakadu National Park from August 2015 to October 2017.

Table 4: Feral pigs controlled in Kakadu National Park between 2015 and 2017

Location	Timing	Number of animals controlled
Roads safety	August 2015	106
Mary River District and East Alligator District	September 2015	113
Wildman	October 2015	802
Kakadu Highway safety	May 2016	33
Fish Creek (East Alligator District)	September 2016	6
TSC Plots	2016	36
Goodparla	January 2017	294
Northern Roadsides Safety	June 2017	263

Northern floodplains	October 2017	2404
Total between August 2015 and October 2017		4057

Heritage sites

World and National Heritage sites have management plans that identify actions to limit the impact from feral deer, goats and pigs. These management plans identify the following types of actions:

- Deer are contained and where possible eradicated from sites.
- Pigs controlled using trapping, aerial shooting, ground shooting, selected poisoning.
- Goats are controlled using trapping, aerial and ground shooting, mustering, poisoning and fencing.
- Artificial watering points, such as ground tanks, can be strategically used to trap goats.
- Soak areas fenced off in in new areas to alleviate damage caused by goats.

At Ngarrabullgan there has been the erection of temporary barriers to prevent damage to one site by feral pigs and a gate installed to control access to the mountain.

Goats have been removed from Dirk Hartog Island and the eradication program is in the final monitoring stage prior to declaring that they have been eradicated. Of note, this includes the Heritage site, the Dirk Hartog Landing Site 1616 - Cape Inscription Area.

(d) the efficacy and welfare implications of currently available control and containment tools and methods, and the potential for new control and containment tools and methods

Australian Animal Welfare Strategy

The Australian Animal Welfare Strategy, jointly developed by the Australian Government, state and territory government, industry and the community, recognises that animals are socially, culturally and economically important for Australia. The welfare of animals and the welfare of humans are closely linked. Animal welfare reflects the ethical imperative and social expectation that any use of animals for the benefit of humans should minimise suffering of the animals involved. Welfare is related to health and wellbeing. However, it extends beyond survival to also consider the quality of an animal's life.

The Australian Animal Welfare Strategy focuses attention on key animal welfare issues and coordinated investments to deliver sustainable improvements. The strategy has relevance for the entire community. It covers all sentient animals—that is, those with a capacity to experience suffering and pleasure. Sentience is the reason that welfare matters.

The strategy provides a national framework to identify priorities, coordinate stakeholder action and improve consistency across all animal use sectors. The strategy applies to native, introduce and feral animals.

A model for assessing the relative humaneness of pest animal control methods

A model for assessing the relative humaneness of pest animal control methods (Sharp and Saunders 2011), developed under the Australian Animal Welfare Strategy, provides a process for assessing the relative humaneness of pest animal control methods. This model was developed by governments following a joint RSPCA and government hosted workshop that examined solutions for achieving humane pest animal control and identified a major weakness in the consideration of animal welfare.

Creating a suitable, workable model proved to be difficult due to the variety of control techniques used, the wide range of pest animals targeted, and the inclusion of both lethal and non-lethal methods. Hence, the model produced is a practical, general model of humaneness assessment that can be applied to any pest control method.

Welfare is assessed in five domains of:

1. thirst/hunger/malnutrition;
2. environmental challenge;
3. injury/disease/functional impairment;
4. behavioural/interactive restriction; and
5. anxiety/fear/pain/distress.

The process of assessing the welfare of a pest animal control method provides a judgement on the impact of a specific control method on the specific target animal — it does not give an absolute measure of humaneness. When the model is applied to a range of different control methods for a specific target animal, they can be compared and a decision made on the choice of method that is informed by an understanding of the relative humaneness of each method being considered.

The model provides assessments of the relative humaneness of control methods for deer, pigs and goats. These are available as appendices to the report.

Model Codes of Practice and Standard Operating Procedures

Model Codes of Practice and Standard Operating Procedures have been developed for a range of pest animal species as guidance on managing the animal welfare aspects of pest animal control.

Model Codes of Practice encompass all aspects of controlling a pest animal species. A Model Code of Practice for a pest animal species provides general information on best practice management, control strategies, species biology and impact, and the humaneness of current control methods.

Standard Operating Procedures provide a uniform approach to the management of pest animals. Standard Operating Procedures detail the procedures involved for each control technique as applied to each of the major pest animal species. Standard Operating Procedures specifically address the animal welfare aspects of each technique.

There are Model Codes of Practice s for deer, pigs and goats including a generic pest animal "*general methods of euthanasia*", and Standard Operating Procedures for:

- Deer: ground shooting
- Pigs: trapping, aerial shooting, ground shooting, poisoning with 1080, use of Judas pigs
- Goats: trapping, aerial shooting, ground shooting, mustering, use of Judas goats.

As new control techniques become available, assessments of their relative humaneness are conducted and new Codes of Practice are endorsed by the intergovernmental National Biosecurity Committee.

State and territory governments who have the legislative responsibility for animal welfare draw on these model codes of practice and standard operating procedures in developing their legislative requirements. The Australian Government may mandate the use of the model codes of practice and standard operating procedures in grant or contract agreements that involve the management of feral animals.

The Codes of Practice and Standard Operating Procedures are available to all managers on the PestSmart website at www.pestsmart.org.au/animal-welfare.

(e) priority research questions

Feral deer

A National Wild Deer Workshop (Forsyth et al. 2017) was held in 2016 to identify national priorities for research and innovation to improve understanding and management of wild deer impacts in Australia. Identified priorities were:

- better information on impacts and how those impacts change with deer density,
- further development of current and potential control tools,
- understanding of whether recreational and commercial hunters can reduce the impacts of deer,
- improving tools for monitoring the distributions and abundances of deer,
- evaluating the usefulness of emerging technologies such as thermal imaging and species recognition algorithms, and
- understanding where wild deer will spread to in the coming decades.

The Workshop Proceedings, which include the identified priorities, is available on the PestSmart website (see references).

Threat abatement plans

EPBC Act threat abatement plans lay out priority research questions necessary to provide threat abatement for native species. In most cases the research requirements overlap with requirements for threat abatement to primary production and the community.

Feral pigs

The *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs* (2017) identifies that further experimental research is needed to quantify the environmental impacts of feral pigs, particularly their impacts on threatened species and ecological communities and when or how to manage the feral pigs.

The plan has six objectives, one of which is to encourage further scientific research into feral pig impacts on nationally threatened species and ecological communities, and feral pig ecology and control. The objective is accompanied by a set of actions which will help to achieve the goals of the threat abatement plan.

The Plan states further experimental research is needed to quantify the environmental impacts of feral pigs, particularly their impacts on threatened species and ecological communities. Specifically:

- the relationship between the number of pigs and the level of impact (within specific areas and ecosystems) needs to be quantified where possible, to help land managers decide how much control effort is needed;
- the impacts of feral pigs in environments where they are abundant including temperate inland river/wetland complexes. It is noted some research has been conducted already in the Wet Tropics and sub-alpine peat bogs;

- understanding the landscape factors, and interactions between these landscape factors, that drive feral pigs' ecology and their interactions/impacts with the environment. This includes understanding how feral pigs use a variety of habitats or microhabitats in a landscape, and research into their transient movements following wet seasons or inland water flows (e.g. Channel Country); and
- the development of indicators for how and when to undertake feral pig control work for a particular region or ecosystem. These indicators need to include triggers related to space and time, and may be developed as part of the research described above.

Importantly, further research should be undertaken into the effectiveness of feral pig control methods. The results of this research need to be communicated to land managers so that they can adopt these methods and achieve better outcomes for threatened species and ecological communities.

Understanding and quantifying the environmental impacts of feral pigs on threatened species and ecological communities works towards the goals of the threat abatement plan, by providing a better understanding of how feral pigs can be controlled, or how other measures can be taken to lessen the impact of feral pigs. Understanding the potential opportunities for range expansion and population growth and therefore impacts across all areas of Australia, particularly south-eastern Australia, will also be important.

The four actions of the Plan are research into:

1. impacts on nationally threatened, and near-threatened, species and ecological communities
2. feral pig population dynamics and ecology;
3. spatial and temporal use of landscapes by feral pigs; and
4. the effectiveness of feral pig control methods.

Feral goats

The *Threat abatement plan for competition and land degradation by unmanaged goats* (2008) has two objectives related to research, specifically :

- improve knowledge and understanding of unmanaged goat impacts and interactions with other species and other ecological processes; and
- improve the effectiveness, target specificity and humaneness of control options for unmanaged goats

A review of this Plan in 2013 concluded that the issues raised in the 2008 threat abatement plan and the objectives are still valid in 2012 and likely to be into the future. The review also provided comment on ongoing research needs.

The review suggested further work on control methods – especially a toxin system that excludes non-target species, integrating control with other landscape factors (e.g. closure of water points in rangelands), effective/strategic fencing or similar tools, and reliable monitoring techniques that can effectively distinguish goats from other herbivores are research priorities for the future.

(f) the benefits of developing and fully implementing national threat abatement plans for feral deer, pigs and goats

Benefits of developing threat abatement plans

Threat abatement plans made under the EPBC Act provide a mechanism at a national scale to guide threat abatement. They provide guidance on the research, management, and any other actions necessary to reduce the impact of a listed key threatening process on native species and ecological communities. Implementing plans should assist the long term survival in the wild of affected native species or ecological communities.

Beyond the pure legislative requirements of the EPBC Act, the formal identification of key threatening processes and the making of threat abatement plans are viewed by stakeholders as playing an important role in raising public awareness about key threats to biodiversity and specifically in the potential processes and strategies to abate these key threats.

Threat abatement plans are viewed as useful documents in that they provide a framework for shared implementation of threat abatement actions across jurisdictions and provide clear direction for research at a national level.

Implementation of threat abatement plans

Under the EPBC Act, the Australian Government must implement threat abatement plans to the extent they apply in areas under Australian Government control and responsibility; and seek the cooperation of the affected jurisdictions in situations where a threat abatement plan applies outside Australian Government areas in states or territories, with a view to jointly implementing the threat abatement plan.

The successful implementation of threat abatement plans depends on a high level of cooperation between landholders, community groups, local government, state and territory conservation and pest management agencies, and the Australian Government and its relevant agencies. Success depends on all participants assessing what is required to abate the impacts and allocating adequate resources through available funding channels, programs, etc. to achieve effective on-ground control, improve the effectiveness and humaneness of control programs, and measure and assess outcomes. Various programs in natural resource management, at national, state and regional levels, can make significant contributions to implementing the plans.

Beyond EPBC Act threat abatement plans

The Department also uses mechanisms beyond the EPBC Act to achieve effective threat abatement for key threatening processes.

National Action Plans are developed for species identified as an Established Pest of National Significance under the Australian Pest Animal Strategy. This provides for a plan to be agreed between all governments covering environment, primary production, infrastructure and social issues. The National Feral Camel Action Plan is an example. A national action plan may be a suitable alternative to a threat abatement plan for deer, pigs or goats.

Biosecurity Plans are similar in providing a nationally agreed approach to enhance Australia's capacity to manage an ongoing threatening process. These plans cover the biosecurity spectrum

from pre-border where there are threatening species that are not present in Australia through to ongoing management for established species.

The Department also uses non-statutory threat abatement advices where the Minister decides that a threat abatement plan is not a feasible, effective and efficient way to abate the key threatening process. Threat abatement advices were recommended in the Independent review of the EPBC Act 1999 (Hawke, 2009). A threat abatement advice can provide guidance on what actions and research are required to be undertaken to abate the key threatening process. It is not limited to what is the Commonwealth's jurisdiction and does not state who should undertake the actions or research. There is a threat abatement advice for Novel biota and their impact on biodiversity which broadly covers the threat from feral deer.

(g) any other related matters.

A challenge with abating the threat from feral deer, pigs and goats to biodiversity is that these are also valued species and cannot be considered in isolation from their primary production, cultural and social uses and impacts.

Deer, pigs and goats were all brought to Australia for their production value and are still important species for meat (and milk and fibre for goats) production. Their hardiness in various environments make them suitable as a production animals as well as having the characteristics that make a successful invasive species. In many parts of Australia, areas of production lie adjacent to, or are part of, areas that have high biodiversity value. This can create difficulties where the outcomes desired from the land and deer/pig/goat management (e.g. for biodiversity protection or primary production) are different. These contradictions in biodiversity versus primary productivity outcomes can occur on both private and public land, particularly in the rangelands where there may be tracts of land that have not been modified to any extent.

Feral deer, pigs and goats impact on Indigenous managed areas, including Indigenous Protected Areas. Feral pigs in particular are targeted on some country because of their impact on Indigenous values. An example is the impact on ephemeral wetlands in northern Australia, with the feral pigs digging up plants including the water lily and eating long-necked turtles. Feral animal management on country can be complex with the requirement to balance various biodiversity and cultural values.

Hunting for deer, pigs and goats is a popular recreation activity in Australia. Regulators and land managers need to understand and balance the recreational hunting and conservation aspects of these species.

However, there are also examples where there is good cooperation between land managers to overcome these potentially conflicting objectives.

REFERENCES

Cresswell ID and Murphy HT (2017) *Australia State of the Environment 2016: biodiversity*. Independent report to the Australian Government Minister for the Environment and Energy. Available at: soe.environment.gov.au. Accessed October 2018.

Forsyth D, Pople T, Page B, Moriarty A, Ramsey D, Parkes J, Wiebkin A, & Lane C (Eds) (2017). *2016 National Wild Deer Management Workshop Proceedings, Adelaide, 17-18 November 2016*. Invasive Animals Cooperative Research Centre, Canberra, Australia. Available at: www.pestsmart.org.au/2016-national-workshop-deer-management-proceedings/. Accessed October 2018

Hawke A (2009) *The Australian Environment Act: Report of the Independent review of the Environment Protection and Biodiversity Conservation Act 1999* Review for the Minister for the Environment, Heritage and the Arts. Available at: http://www.environment.gov.au/resource/australian-environment-act-report-independent-review-environment-protection-and. Accessed October 2018.

Invasive Plants and Animals Committee (2016) *Australian Pest Animal Strategy 2017 to 2017*, Australian Government Department of Agriculture and Water Resources, Canberra

Sharp T and Saunders G (2011) *A model for assessing the relative humaneness of pest animal control methods* (Second edition). Australian Government Department of Agriculture, Fisheries and Forestry, Canberra, ACT. Available at: www.agriculture.gov.au/Style%20Library/Images/DAFF/__data/assets/pdffile/0008/929888/humaneness-pest-animals.pdf. Accessed October 2018

West P (2011) *National mapping of the abundance of established, new and emerging pest animals to improve decision-making and the assessment government investment programs*. Report for the Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture, Fisheries and Forestry. NSW Department of Primary Industries. Available at: www.pestsmart.org.au/wp-content/uploads/2015/05/PWest2011_Mapping_PEST_ANIMALS.pdf. Accessed October 2018.