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Draft background document for the threat abatement plan for competition and land degradation by unmanaged goats

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Draft background document for the threat abatement plan for competition and land degradation by unmanaged goats

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

Cover image

Unmanaged goat within Girraween National Park, Queensland. Image Michael Jefferies flickr (CC BY-NC 2.0)

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1 Introduction

This is the background document to accompany the draft *threat abatement plan for competition and land degradation by unmanaged goats (2023)*. It provides information on unmanaged goats (*Capra hircus* Linnaeus, 1758), including their biology, distribution and impacts. It also outlines the different economic, social, and cultural values of goats and current management practices.

The draft threat abatement plan (TAP) establishes a national framework to guide and coordinate Australia's response to competition and land degradation by unmanaged goats. It identifies the research, management and other actions needed to ensure the long-term survival of native species and ecological communities impacted by unmanaged goats. It replaces the *Threat abatement plan for competition and land degradation by feral goats* published in 2008. The key themes that emerged from the stakeholder consultation during the development of the Threat Abatement Plan (TAP) are summarised in Section 7.

The terms 'unmanaged goat' and 'feral goat' are equivalent terms, with both referring to invasive unmanaged goats. The goat meat industry commonly uses the term 'rangeland goat' for feral or unmanaged goats. The term 'wild harvest' refers to live captured unmanaged goats that are immediately transported off the property or transported via an approved goat holding depot.

The term 'managed goats' refers to securely fenced goats, legally defined as stock, under an active primary production system, with no access by unmanaged transient goats, and maintained to match market demand and supply. In some states this definition extends to goats tagged as stock (see section 1.6). With the move towards national compulsory tagging of goats, this will become part of the definition of a managed goat. There is a lot of variability in the level of goat management. There are herds that are sometimes referred to as 'semi-managed' (GICA 2021). These can be within cluster fencing or behind dog fences, have little interaction with land managers, their grazing pressure is not managed, and harvesting might be done more opportunistically, rather than planned.

1.1 Goat distribution and abundance

Goats were introduced to Australia by European colonists in the late 18th century (Parkes et al. 1996). Goats are now reported to occur in every state and territory in Australia (West 2011), although currently rare on mainland Northern Territory. Populations of unmanaged goats are found predominantly in arid and semi-arid landscapes of Queensland, New South Wales, South Australia and Western Australia (Parkes et al. 1996). They also occur on farmlands and reserves in temperate zones (Figure 1). Goats have been deliberately introduced onto many offshore islands. Australia has thousands of offshore islands, with many containing invasive plant and animal species. Data from Australian islands greater than 20 hectares indicates goats are present on at least 38 of the 523 islands (DAWE 2016). Contemporary data on the presence of unmanaged goats on islands has not been compiled for islands of any size.

The range of unmanaged goats is continuing to expand in some places, despite goat control options being well known (see section 2) (Murphy and van Leeuwen 2021). A goat population can increase between 50% and 100% per annum when no control is implemented (Parkes et al. 1996; Lethbridge

2016), and they can maintain a high reproductive rate, even under low seasonal rainfall conditions (Hacker and Alemseged 2014).

Population estimates for goats in most states are generally collected during aerial kangaroo surveys. The last Australia wide distribution and abundance estimates were compiled in 2012, from surveys conducted in 2010 and 2011 (Pople and Froese 2012). The unmanaged goat population is estimated to have grown from 1.4 million in 1997, to 4.1 million in 2008, and falling to 3.3 million in 2010. Annual aerial surveys of goats continue separately in some states, but there has been no recent national compilation of data. The surveys do not use the same methodology (see section 1.1.1), and surveys may fail to distinguish between managed and unmanaged goats.

In Queensland, it was estimated there were 90 000 ± 42 000 goats in 2021, with most in the Mulga Lands bioregion (dominated by *Acacia aneura*). The estimated number of unmanaged goats in Queensland has fluctuated greatly over time, largely in response to rainfall, and has been as low as 58 000 ± 20 000 thousand in 2018 following a long drought (Biosecurity Queensland 2022, pers. comm. 2 September 2022). In South Australia during non-drought years, it has been estimated there are between 200,000 and 400,000 unmanaged goats (SA Department of Primary Industries and Regions 2021, pers. comm. 20 September 2022). These unmanaged goats are thought to mainly occur within pastoral areas inside the Wild Dog Barrier Fence.

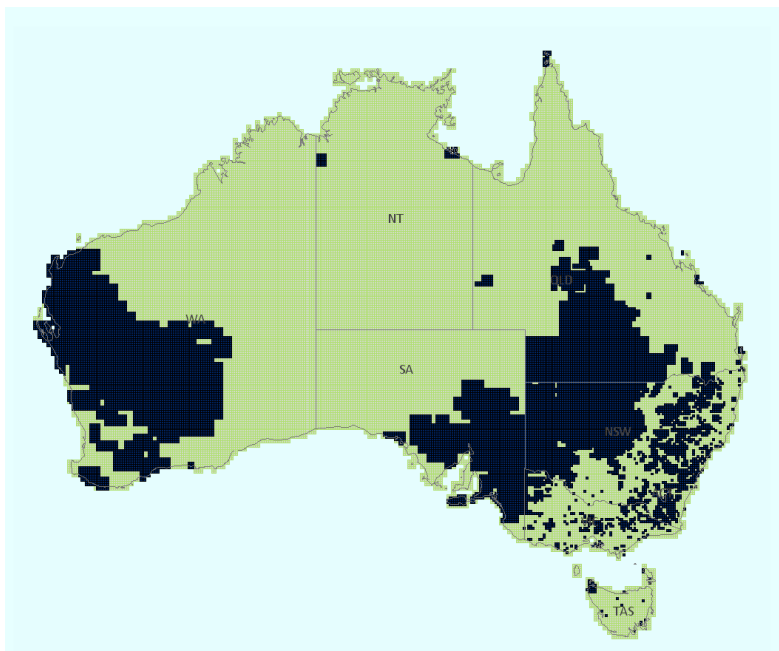
In 2015, there were an estimated 2.4 million managed and unmanaged goats in NSW (NSW DPI, unpublished data). The highest goat density was within the Mulga Lands bioregion, with 18 to 24 goats per square kilometre. The combined population of managed and unmanaged goats was approximately 5.8 million in 2016 in central and western NSW under favourable conditions (MLA 2017b). [Maps](#) of goat distribution and density in NSW are updated periodically and published, with the last update in 2016.

In Western Australia, the largest populations of unmanaged goats are found in the Shark Bay area, Carnarvon, Murchison, Yalgoo and Northampton. There are also isolated populations of unmanaged goats in the higher rainfall areas of the south-west of WA in forest and scrublands (DPIRD 2015). The size of these populations is unknown, as are the size of the unmanaged goat populations in Tasmania and Victoria.

The Atlas for Living Australia (ALA) [website](#) provides some insight about reported goat sightings across the country. Public sightings of unmanaged goats and their damage are also recorded on the [Feral Goat Scan](#) webpage and app, with some of this information feeding into the ALA.

There has been little change in land managers' perception of the scale of the problem with unmanaged goats on their property between 2016 and 2019, with a 0.1% change in the problem level rating for goats (Stenekes and Kancans 2021a). This suggests there has not been a decline in the goat population over that time. Landholders from all states and territories, apart from the Northern Territory, reported having a problem with unmanaged goats in 2019. Having reliable population estimates of unmanaged goats, using a standardised approach, across Australia would assist with prioritisation of programs and setting control targets.

Figure 1 Reported occurrence of goats in Australia using a seamless dataset at the scale of 1/8th degree reporting unit (equivalent to approximately 12.5km x 12.5km). Map reproduced from West (2011).



1.1.1 Survey consistency

Aerial surveys are the most efficient way of estimating goat density, distribution and abundance. Pople and Froese (2012) highlighted that the accuracy and comparability of population estimates in different states are hindered by inconsistency in the ways in which aerial counts are collected in different jurisdictions. Concerns included differences between the use of sightability (detection) correction factors, and the way in which the data are stored and georeferenced. Further, in some states aerial counts do not use the double-count (mark-recapture) method, which is optimal for producing accurate estimates (Tracey et al. 2008). The use of low-flying fixed-wing aircraft in heavily undulating terrain is not possible. Helicopters can fly much slower, closer to the ground in undulating terrain resulting in better detection (Scroggie et al. 2017). However, helicopters are significantly more expensive to fly. Therefore, a significant amount of goat sightings are absent from the commonly used fixed-wing kangaroo surveys carried out in NSW, SA, WA and QLD.

While more precise goat density estimates have been obtained in small areas using helicopters, including for parts of QLD (Lundie-Jenkins et al. 1999), the Flinders Ranges in SA (Lethbridge et al. 2014; Lethbridge et al. 2019), the Murray-Sunset National Park in Victoria (Lethbridge and Andrews 2016), and in NSW (Fleming and Tracey 2003), the data are collected infrequently.

1.2 Goat diet

One of the reasons goats are able to spread and establish in novel environments, is their ability to change their diet based on what food is available. Goats are ruminant, generalist herbivores that browse on shrubs and trees. Goats will switch to tree bark, grass, seedings or forbs when their preferred food is unavailable (Grant 2012; Harrington 1986).

It is a misconception that goats preferentially eat toxic plants. While they can consume plant matter with higher levels of tannins than other ruminants (e.g. Silanikove et al. 1996), tannins are complex,

and can have both beneficial and harmful effects depending on their chemical structure (Tong et al. 2022). Many native plants and weeds can have detrimental effects on goat health depending on how much they eat (Simmonds et al. 2000).

The plants goats eat are often measured on a scale of 'palatable' to 'unpalatable' and they will shift to more unpalatable species when there are fewer palatable species available (e.g., highly modified landscapes, Lethbridge et al. 2013). In addition, the plants they consume may vary depending on location. For example, in the less modified landscape of the Flinders Ranges of SA, goats will not eat *Senna artemisioides*, while in some highly modified landscapes of western NSW where more palatable plants are lacking, they will consume this plant (Lethbridge et al. 2013). While goats may tolerate eating plants that other ruminant species cannot, overall, their preferred diet overlaps substantially with that of native herbivores such as rock-wallabies.

Goats need to drink every two to three days during summer (Dawson et al. 1975, Fleming 2004), and can extract some of their water requirements from their food. In arid or semi-arid areas where goats cannot obtain enough water from forage and dew, the range of goats is centred around water sources (Fleming 2004).

1.3 Ecology and movement

Goats have two main breeding periods a year in wetter climate zones, but they have no defined breeding season in semi-arid areas (Lethbridge et al. 2013). They will often produce twins or triplets. Birth will often coincide with the optimum conditions for a mother and young. In the arid and semi-arid zones, herds or mobs of goats consist mainly of groups of 2 to 6 individuals, but can comprise up to 40 individuals in high rainfall areas (Fleming 2004).

Goats occupy a variety of habitats depending on available resources. While an extensive study of goat movement across South Australia and Victoria found no evidence for migration, unmanaged transient goats were found to have small home ranges (mainly in steep terrain) for a period, then exhibit long-distance ranging behaviour, and at times move on to new areas (Lethbridge 2016). Differences in movement patterns in different habitats relate to the availability of water and vegetation cover.

1.4 Impacts of goats

Unmanaged goats are a serious threat to biodiversity over large tracts of Australia's rangelands (Murphy and van Leeuwen 2021) and islands (Daley 2005). When left unmanaged, goat herds can build to large numbers under suitable conditions. This can adversely affect biodiversity, cultural values, and primary production. Goats can prevent the regeneration of plants leading to increased soil erosion, and directly compete for food resources and refuges with native mammals (e.g., Harrington 1979, Harrington 1986, Greene et al. 1998; Lethbridge et al. 2013). Goats are frequently reported to be the cause of general land degradation. The literature includes information on goats fouling waterholes and increasing water turbidity, but these claims appear based on general observations and do not appear to have been quantified.

Goats can cause accelerated rates of soil loss and erosion (Bayne et al 2004, Masters et al. 2018, Parkes 2021). Trampling by goats can damage soil crusts, break up soil and dislodge soil and rocks from cliffs, rocky outcrops and slopes (Bayne et al 2004, Cowen 2016). In the Greater Blue Mountains

Area of NSW, goats selectively graze on rock shelf vegetation and their hard hooves have caused considerable disturbance to fragile cliff face soils. Erosion caused by goats often occurs after, or in tangent, with overgrazing and loss of vegetation cover (Parkes 2021). This is particularly the case when continued browsing and trampling prevents regeneration of new vegetation. Even once goats are eradicated from an area, establishment of plant species can still be limited if soil physical and chemical properties are altered following vegetation degradation and exposure of subsoils (Hata et al. 2019).

There are only limited data published on the benefits of goat control for soil erosion control. One example is from the Macleay River Gorge of NSW. Erosion declined rapidly once goats were controlled, and it continued to slowly improve over 2 years as ground cover vegetation increased (Bayne et al. 2004). It can be difficult to separate the impacts of goats on vegetation and erosion from those of other browsing animals (Cowan 2016) (see section 1.7), however it could be argued that the recovery from a heavily grazed state will have commonalities across species.

Goats can survive on low-nutrient fibrous vegetation and can exert heavy grazing pressure on the shrub species they prefer, such that under drought conditions they can eliminate a species from the plant community (Doyle et al. 1984). Overgrazing by goats can disrupt seed banks and lower rates of plant recovery (Dawson and Ellis 1996, Creese et al. 2019), particularly if associated with sheet erosion. Goat impacts can go beyond individual species. At a high density for long periods, their browsing and trampling can alter the vegetation composition and structure, such as turn shrub lands into grasslands (Parkes 2021). Goats can threaten the integrity of entire native plant communities, particularly in eastern Australia where threatened ecological communities are most concentrated.

Goats have been observed to cause severe degradation and destruction of native vegetation on offshore islands within the Great Barrier Reef World Heritage Area. There are historical records of goats overgrazing island vegetation until there was little to no ground cover or mid layer vegetation, and severe erosion (Dalby 2005, DNPSR 2013a). Goats have been noted to impact a wide range of island plant species including beach and vine scrubs, heath, hoop pine and pandanus (Daley 2005; DNPSR 2013a). Goats were thought responsible for bringing ticks to some islands, and disturbing ground nesting bird sites on Lady Musgrave Island. Following goat eradication on small islands within the Great Barrier Reef, ground cover vegetation has been observed to increase, but the long-term impacts of goats on vegetation composition and threatened species is unknown (Daley 2005).

The animal species most impacted by goats appear to be those with similar habitat preferences, and/or with a diet of palatable plant species with a limited distribution. The large-eared pied bat (*Chalinolobus dwyeri*) roosts in caves and cliff locations in sandstone escarpment in NSW, Qld and the ACT. This species is currently listed as vulnerable. Goats have been observed using the same caves as the bats for shelter, and there is evidence that goats disturb roosting bats, and can destroy roosting sites (DERM 2011; Pennay 2008). Goats could be more likely to disturb the bats when they roost on the ceilings of low caves.

Goats can have detrimental effects on critical resources for rock-wallabies, even when the goats are at a low density. Both sub-species of yellow-footed rock-wallaby (*Petrogale xanthopus xanthopus* and *P. x. celeris*) and the brush-tailed rock-wallaby (*Petrogale penicillata*) are currently listed as Vulnerable (Threatened Species Scientific Committee 2016, DEWHA 2008, DAWE 2021), and are at risk of extinction where there is competition from goats for food and habitat. Goats and wallabies

both prefer higher ground such as steep cliffs, large boulders, and good vegetation cover. A study in central Queensland found goats were present at most of the surveyed sites (92%) where yellow footed rock wallabies occurred (Smith and Allen 2021). In mountainous regions, goats selectively target succulent rock plants due to their high palatability, which would otherwise sustain rock-wallabies through dry periods. Goats either browse up taller plants so that remaining foliage is out of reach of wallabies (e.g., plants like *Alectryon oleifolius*, *Hakea ednieana*, *Casuarina pauper* and *Allocasuarina* spp.), or graze/browse smaller plants (particularly juvenile plants) down to stubs (e.g., *Prostanthera* spp. and *Bursaria* spp.; Lethbridge et al. 2013).

There are approximately 128 individual species and 24 ecological communities for which goats are a known or perceived threat (see Appendix A and B in the TAP). There is still a lack of information on goat impacts for most of the listed threatened species and communities. Goat activity is a threat to several heritage values, including 2 national heritage listed sites, 6 Ramsar-listed Wetlands of International Importance and at least 25 islands within the Great Barrier Reef World Heritage Area (See Appendix C in the TAP for details).

Goats also impact a range of species that are currently not listed as threatened. They are one of several invasive animals impacting a population of the pale field-rat (*Rattus tunneyi*) in Western Australia. Over browsing by goats is opening up densely vegetated refuge areas, and the goats are trampling the rat's burrows. The pale field-rat population is unlikely to persist without effective management of the goat population (O'Neill et al. 2021). Vegetation destruction by goats is thought to be partially responsible for the shift in the range and feeding environment of the quokka (*Setonix brachyurus*) from open areas to Jarrah forest in Western Australia (Scholtz and DeSantis 2020).

Further information on the benefits of unmanaged goat control for recovery of native plants and ecological communities is required (Reddix and Forsyth 2004). Most existing research on goat impacts is for arid and semi-arid regions, and the impacts of unmanaged goats on temperate ecosystems are largely unknown. It is also still unclear how most threatened species and ecological communities recover after goat eradication, or when goat density is reduced. A challenge that was outlined in the review of the previous TAP still remains, in that goats are frequently controlled as part of a broader pest and/or weed management program such that changes cannot be attributed just to goat control.

On Dirk Hartog Island, ecosystem recovery was observed within a few years of goat and sheep eradication. Positive changes included increased vegetation cover in over half the monitoring plots and reduced erosion of sand banks (Heriot et al. 2019). Threatened species were not part of the monitoring. Overseas, a goat control program in the Western Mediterranean Basin concluded that goat eradication, rather than population control, was required to allow the grasslands and shrublands to sufficiently recover (Capó et al. 2022). Eradication of goats was also required if ecological restoration was the objective of the program.

Exclusion fencing could provide a framework for research into determining goat impacts (Fleming *pers. comm.* May 2022) and the use of goat exclusion fencing and total grazing pressure fencing is on the rise (see section 2.3). Two studies in the rangelands of NSW found that exclusion of goats with fencing led to an increase in leaf litter cover (Lewis and Hines 2014, Russell et al. 2011). In one study, the number of shrub species and area of plant cover also increased after goat exclusion. The lack of

change in vegetation after goat exclusion in the other study was attributed to the continued presence of other over abundant herbivores (Russell et al. 2011).

1.4.1 How goat impact is measured

The density and activity levels at which unmanaged goats negatively affect biodiversity assets varies between different land systems, depends on the current level of degradation of the landscape, proximity to water and the scale of their activity. To assess the need for goat control, it is necessary to determine the population density at which their activity is detrimental. Unfortunately, there is little published data relating vegetation condition and goat density, particularly before and after control (Cowan 2016). This lack of knowledge has led to some agencies setting arbitrary density targets for their goat control operations (Lethbridge 2016).

The impact of a pest species is more obvious when the species is in plague proportions as the damage is severe and widespread across a land system (Lethbridge et al. 2013a). Impacts are also more apparent in drought years when diet and foraging choices are in low supply. However, at lower densities, damage may not relate directly to the pest population size (Edwards et al. 2004, Hone 1994, Lethbridge et al. 2013a, McDonald and Brandle 2009, Norris and Low 2005). Complicating this is the difficulty of distinguishing between grazing and browsing by goats and other herbivores where their ranges and diets overlap (e.g. common wallaroo or euro (*Osphranter robustus*)). Unfortunately, adverse impacts are often assumed rather than measured (Peter Fleming pers. comm. May 2022).

Goats primarily browse rather than graze, such that remote sensing data provides too little information too late in terms of detecting goat impact. Remote sensing data fails to detect which plants are being impacted and does not detect goats browsing up taller plants so that remaining foliage is out of reach of animals such as rock-wallabies. This can be the case for plants like the bullock bush *Alectryon oleifolius*, corkwood *Hakea ednieana*, and black oak *Casuarina pauper* (Lethbridge et al. 2013).

A range of landscape condition measures has been developed such as Habitat Hectares and BioCondition. These approaches allow the comparison of a suite of vegetation features in one site against a benchmark site of the same community where the vegetation is considered undisturbed. The Habitat Hectares method is less sensitive to low densities of pest herbivores impact, and may underestimate the true impact of pest herbivores on particular plant species and other specialised or sedentary native animals (Parkes et al. 2003; Lethbridge et al. 2013b). The Bushland Condition Monitoring method is also commonly used to determine pest impact (Croft et al. 2005-2009), but it can't draw a relationship between herbivore impact, the plants being impacted, and the relative density or activity of each herbivore causing that impact.

The method by Lethbridge et al. (2013a), building on the work of McDonald and Brandle (2009), has been adapted by Parks Victoria to monitor goat impacts in the Murray-Sunset National Park, and by the South Australian Arid Lands (SAAL) Landscape Board for parts of South Australia. The method involves identifying a suite of plant indicator species across the palatability range and categorising these into growth form classes and other measures with sufficient repeatability to indicate severity of impact. Impact includes the inability of plants to recruit and maintain viable age distributions. The intensity of grazing impact can be compared with other measures of pest herbivore activity or density (e.g. camera trap data and aerial counts), potentially providing a quantitative link between goat numbers and impact. This approach emphasises the need for managing goats in terms of their

impact, and not on the number of animals killed or removed (Fisher et al. 2004, Lethbridge et al. 2013a, Norris and Low 2005).

While this method is useful in determining which herbivore species are impacting what plants under a total grazing pressure scenario, the combined effects of multiple overabundant and pest herbivores are not necessarily additive and are often localised, particularly near permanent water sources. Further research is required to expand this type of work across a range of bioregions and vegetation communities to try and determine if a unified approach can be formulated Australia wide.

1.5 Goat meat industry

There are currently 2 supply chains for goat meat in Australia, farmed and 'rangeland'. The domestic market is predominantly supplied by farmed goats, whereas goats for export have historically been opportunistically sourced from unmanaged goats. Approximately 68 per cent of the national annual goat production originates from NSW (Plumbe et al. 2019).

The high live-weight price and demand for the export of goat meat from Australia has recently opened a lucrative goat meat industry, with Australia becoming one of the world's largest exporters of goat meat (Goat Industry Council of Australia 2020). This has been possible because growers have either harvested unmanaged goats from rangelands or have been able to diversify their business to include goat production operations alongside other land use.

The commercial benefits of harvesting unmanaged goats to supplement farm income has been seen by some stakeholders as a barrier to the creation of appropriate legislation to control goats (Invasive Species Council Submission 10, Bush Heritage Australia Submission 14, RSPCA Submission 49, Senate Inquiry into feral deer, goats and pigs in Australia 2018). On the other hand, there has been industry concern that unmanaged goats being perceived as 'feral pests' that degrade the environment may limit the industry's growth, and impose controls upon producers (Goat Industry Council of Australia 2020).

The position of goats as being both pests and a resource is not new, with this issue discussed in the 2008 TAP. This issue has continued to create conflict between pastoralists who rely on opportunistic goat harvesting to support their businesses, and conservationists who are keen to protect biodiversity from the impacts of goats.

Bringing unmanaged goat herds under management has gained some traction in the rangelands of NSW and Queensland, where cluster fences (perimeter fences that surround a cluster of properties), which were originally erected to exclude dingoes from sheep production areas, now also enable goat production operations. However, the evidence is unclear as to how many unmanaged goats versus managed goats occupy cluster fenced areas. Additionally, some goat herds inside these cluster fences have also been referred to as 'semi-managed' goats. There has been little, to no uptake towards having managed goats within the rangelands of South Australia.

The Australian goat export market was valued at \$242 million in 2021 (MLA 2022). The live export of goats only accounts for around 5 percent of goat export, and was valued at approximately \$6 million in 2020, a decrease from \$7.2 million in 2018–2019 (MLA 2020). In the 2021/2022 financial year, it was expected that 1.44 million goats would be processed from NSW, an increase of 35% from the previous year (NSW Department of Primary Industries 2021). The average over-the-hook price of

goats was 860 cents/kg in 2019–2020, with the price reaching a high of 940 cents in 2019 (See Price Figure from MLA 2020 in DPI NSW 2020 report).

Mustering goats for export has had some success in controlling goat populations in limited areas, and this has largely been driven by the high price for goat meat. A decline in the global demand for goat meat, and/or a price decline would decrease the incentive for many land managers to muster goats. The price of goat meat dropped significantly in January 2023, to 325c/kg carcass weight, and there has been a high supply of goat (Beef Central 2023). It is not known what direction the Australian goat export market will head in the near future.

1.6 Electronic tagging of goats

Compulsory national electronic identification of goats will come into force in 2025 as part of the National Livestock Identification System. This is being overseen by the [Sheep and Goat Traceability Task Force](#). Goats will be required to have an individual eID, which is often referred to as an e-tag. Standard goats will be tagged in their ear, while dairy, earless and miniature goats can be fitted with an eID leg-band. Implementation of compulsory electronic tagging of goats commenced in Victoria in January 2022.

The program aims to increase traceability in the event of a livestock disease outbreak. The tagging will apply to all farmed or managed goats. There is some potential for it to apply to semi-managed (managed rangeland) goats as well in the future. Electronic tagging is unlikely to be applied to unmanaged goats that are captured for immediate sale or transport to a goat depot or abattoir, due to animal welfare concerns. Unmanaged goats are wild animals and unnecessary handling could cause the animal unwarranted stress. The electronic tagging of goats could provide more reliable estimates of managed goat numbers.

1.7 Interaction with other herbivores

The presence of too many herbivores in an area leads to overgrazing and land degradation in both conservation and production areas. Domestic livestock numbers can be actively controlled by land managers within fenced areas, but feral herbivores (e.g. goats, deer, camel, rabbits) may contribute significantly to the total grazing pressure and are significantly harder to control than managed livestock. Total grazing pressure is a concept which considers the total forage demand of all vertebrate herbivores in an area relative to the forage supply (Hacker et al. 2019).

As mentioned in section 1.4, the impacts of goat grazing are poorly known. As goats are generalist herbivores their impacts may be greater than other herbivores. This can be the case during periods of drought when they can contribute significantly to land degradation. Decisions about the effective allocation of resources to control unmanaged herbivores in an area require an understanding of the interactions between the individual herbivore species present. Stocking rates or dry sheep equivalent ratings have been estimated for goats, but the estimates have been crudely derived and are for a specific vegetation type. Many factors will influence the stocking rate or carrying capacity of an area including the vegetation community, soil type, climate, the composition of the herd (e.g. males, breeding does, kids) and the abundance and composition of the entire herbivore community. The TAP includes actions for developing goat metrics and goat impacts so that land managers can better estimate density impact relationships to inform goat control.

2 Current options for controlling unmanaged goats

Control methods for unmanaged goats have varied with time, geography, jurisdiction, accessibility, funding, and acceptability (humaneness). Successful eradication programs recently published in the scientific literature all use multiple control methods (e.g. mustering, ground shooting, aerial shooting, water point closure and/or trap yards) and multiple animal detection methods (e.g. motion-sensor cameras, Judas goats, tracks, scats, aerial monitoring, and/or ground monitoring) (Algar et al. 2020, Heriot et al. 2019, Masters et al. 2018, Southgate et al. 2022). Similarly, reported successful control programs on individual agricultural properties used conventional control methods. What appears key, is the way that these methods were implemented, such as the order in which each strategy was applied, or if they are applied simultaneously (Cale et al. 2014a, *pers. comm.* Scott Jennings 2021).

Landscape characteristics and vegetation type can change the effectiveness of different control options and these need to be taken into consideration (Cale et al. 2014). For example, ground shooting was more effective than aerial shooting by Parks Victoria staff in natural areas with high tree canopy cover, as the vegetation inhibited the visibility of goats from a helicopter (Parks Victoria 2021). The objectives of a program (e.g. control to a certain population density, minimise specific impacts, or eradication) and the scale of operation (e.g. local, regional, island) also influence the best approach to take. In other words, a 'one size fit all' approach to goat management is not feasible, and tailored approaches are needed to accommodate different regions and land-systems.

Russell et al. (2008) proposed three unmanaged goat management zones within NSW, based on climate, topography and land use. The eastern zone covered higher rainfall areas along the NSW coast and ranges where goat populations typically have small home ranges and are scattered in rugged terrain removed from predators. Access for control activities can be difficult and domestic goats can provide new population sources. The central zone covered the wheat/sheep belt of NSW where unmanaged goats occur in distinct isolated populations, often in islands of native vegetation within an agricultural landscape. In the western zone, food and water typically limit goat populations, and artificial watering points aid their survival (Russell et al. 2008). The western zone is one area where a different approach to goat management is most needed due to the prevalence of the rangeland goat meat industry. This zoning principle could potentially be applied to other states and territories, for well-targeted goat management objectives and techniques suitable for each zone to address the different challenges and stakeholders within them.

Eradication of unmanaged goats may be feasible from some islands, peninsulas, and isolated patches of habitat with low risk of re-colonisation by goats. Goats have been the target of over 60 island eradication programs in Australia (DIISE 2018), with one of the world's largest successful goat eradication programs taking place on Kangaroo Island in South Australia (Masters et al. 2018). Eradication programs for multi-tenure islands, and landscapes mixed with adjacent conservation and production land could benefit from collaborative approaches including sociologists and educators to aid positive engagement with local inhabitants (Campbell and Donlan 2005, El Hassan 2019). The success of some goat control programs, such as those carried out in Kangaroo Valley NSW, and

Kangaroo Island, were attributed to the good relationships between the different organisations involved, and continued community engagement and support.

Most of the information available on goat control is from rangelands and semi-arid vegetation. There is either a lack of evaluated goat control programs, or published information from goat control programs on the east coast of Australia and temperate regions of southern Australia. On Indigenous Protected Areas and jointly managed reserves, a combination of control approaches is often used, but in general no one approach on its own has been seen to benefit the biodiversity assets targeted for protection. There appears to either be a lack of monitoring in goat control programs, and/or a lack of reporting of monitoring data. Appropriate monitoring (e.g. before, after, control sites) needs to be encouraged as part of any control program.

2.1 Mustering

On public and private reserves with high-value biodiversity assets, where eradication is not currently feasible, mustering and culling operations are needed to control unmanaged goat populations. The increase in the live weight price of rangeland goats has incentivised mustering of goats. Mustering is labour-intensive and is most effective on flat terrain unless aircraft are used. In the right season, mustering can be one of the most cost-effective ways to remove unmanaged goats (Sharp 2012a). In the Flinders Ranges of SA, mustering was found to account for two-thirds of all goats removed from the landscape (Lethbridge et al. 2013). While mustering is considered to cause some stress to goats (Sharp and Saunders 2011), a social study conducted on the perception of control techniques found mustering was still viewed as one of the most acceptable methods (Sinclair et al. 2020).

Areas where unmanaged goats have been removed by mustering or trapping have been observed to be recolonised by new goats from the surrounding country (Hacker and Alemseged 2014). Mustering, and trapping of goats by landholders may temporarily reduce goat numbers, but there is often no financial incentive for landholders to remove all the goats from their local area as their income could be dependent upon future wild harvesting. There have been reports of some harvesting operators deliberately releasing young and female animals back into the wild to maintain a breeding population, which hinders control efforts (Bush Heritage Australia, Submission 14, and CSIRO Submission 61). Harvesting also becomes economically unviable at low goat densities (Cale et al. 2014a). Therefore, commercial harvesting of 'rangeland goats' is not adequate for achieving conservation outcomes as a control method used on its own. The review of the previous unmanaged goat TAP found that the use of multiple contractors on a rotational basis to harvest goats for conservation outcomes, increased the competition between contractors, and increased the harvest size. This approach has also been used with success in other parts of western NSW (OEH 2013).

2.2 Water-point management

Controlling water access (e.g. decommissioning dams) and the use of barrier fencing can greatly assist with goat control (e.g. Russell et al. 2011). A recent study showed that active control and waterpoint closure needs to extend more than 15 km from property boundaries to be successful (Moseby et al. 2020). Closing artificial watering points and conducting regular trapping and mustering around remaining waters can reduce goat density, but these techniques are not adequate for controlling small herds that often remain after control operations, with additional targeted control required (Moseby et al. 2020). Waterpoint trap yards are more effective in dry periods when goats

congregate around limited resources (Sharp 2012b). However, during drought is often when landholders have fewer resources.

Waterpoint trap yards make use of self-mustering methods like those used by pastoralists for sheep and cattle. Goat-proof fences with a one-way gate or ramp are constructed around water points. Goats enter the gate or ramp to access the water and are then trapped inside the fence. Three trap types are considered the most effective according to Sharp (2012b); jump-down traps, spear gate traps and swinging one-way gate traps. When trapped, unmanaged goats are usually sold for slaughter or live export, offsetting the cost of the traps. The potential profit is dependent on the sale price of goats, and accessibility for transportation to abattoirs or sale yards for live export. There can be little to no financial gain when transporting a small number of goats a long distance.

Water point trapping can impact non-target animals, for example by preventing native species from accessing water. To avoid this, traps should not be built around natural water points such as springs. Additionally, the traps must be monitored for off-target trapping. If native animals such as kangaroos are trapped at the fenced location, the fencing must be moved. The construction of fencing should also minimise potential harm to native animals, for example the mesh used for fencing should not be of a size where macropods are likely to get their hind legs caught when attempting to jump the fence.

The need to monitor and maintain trap yards can be a deterrent to their use. A Standard Operating Procedure (SOP) exists for humane trapping and includes animal welfare measures like ensuring that there is a 3–4 day period for goats to rest and feed, with adequate shelter and water, before they are transported (Sharp 2012b).

Water point goat traps combined with landscape scale fencing have been successfully deployed to exclude unmanaged goats from critical mallee fowl breeding habitat (Lewis and Hines 2014). The fencing and traps enabled goat traffic to be controlled and reduced the impact of goat grazing in high conservation value habitat.

2.3 Goat exclusion fencing and the transition to managed goats

Key biodiversity assets can be protected from goats in the short to medium term using goat exclusion fencing. It may be beneficial to fence off areas containing threatened species and ecological communities while an eradication campaign is underway, to permanently limit the access of unmanaged goats to areas of high biodiversity significance, or to exclude unmanaged goats from accessing water points (see section 2.2) (Parkes 1990, Parkes et al. 1996). The entire population of endangered Araluen zieria (*Zieria adenophora*) has been fenced with goat proof fencing, to protect the plants from being trampled and browsed by goats, and to allow seed production (DCCEEW personal communication March 2023, NSW NPWS 2001). The fence needs ongoing inspection and maintenance to address damage to the fence through incidents such as treefall, and to avoid goat access.

Exclusion fencing is expensive and responsibilities for funding, building, and maintaining these fences is sometimes unclear. Containment and exclusion fences are unsuitable for use in high-relief terrain

like the Flinders Ranges of SA, where rocky, mountainous terrain rises steeply more than 100–200 metres.

Bringing goats under management in production systems has been suggested as one threat abatement strategy. For example, in grazing landscapes in western NSW and QLD, the practice of transitioning from unmanaged goats to containing them using existing cell or cluster-fencing has merit, providing there are no detrimental effects to biodiversity. However, some stakeholders suggest this will not work in all regions.

Total grazing pressure (TGP) fencing is promoted by the Meat and Livestock Association (MLA 2018b) as a tool for managing pasture over large areas. A transition to managed (i.e. fenced) goats is a recent development in goat control on the Australian mainland and MLA has acknowledged that landscape-scale impacts from fencing have been difficult to monitor across large pastoral properties. They have identified an urgent need to monitor impacts of TGP management on groundcover both inside and outside of these fences and have proposed an industry relevant TGP database of current knowledge, which would also include the condition and diversity of natural assets (MLA 2018).

There has been a promising trend of producers transitioning to a semi-managed system of goat husbandry, especially in the Western NSW rangelands, (El Hassan 2019, NSW Department of Primary Industries 2021, Plumbe et al. 2019,). This includes moving away from damaging practices such as releasing young goats back to the wild after mustering, which effectively keeps the pressure on resources in the landscape (Khairo et al. 2013). Some producers are ready to invest in fencing due to the favourable goat meat market. Once goats are contained (managed), the goat industry also has an opportunity to breed-out bad temperaments, which also minimises fence breaches. For example, Boer and Boer-cross goats have a calmer temperament.

In the Murchison region of Western Australia, north of the wild dog barrier fence, the area of newly erected cell fencing is approximately 65,000 km² over 55 pastoral leases. In this region, stakeholders indicated there was currently little appetite for managing goats within the wild dog barrier fence, but properties may transition the unmanaged herds in this region to managed goats in the future. In South Australia, there has been less take up of cluster fencing or TGP fencing. Instead, landholders are largely favouring the use of holding depots to enable them to remove small numbers of unmanaged goats at a time.

Exclusion fencing built to control pest species other than goats, or manage grazing pressure, could have a role in threatened species conservation on agricultural land, with a range of threatened species under threat due to overgrazing and predation (Smith et al. 2020b). A recent study found the area under exclusion fencing in central and western Queensland covered 18 biogeographic subregions and may contain 28 threatened mammals, bird and reptile species. An average of 9 threatened species or their habitats were identified per fencing cluster, and over three quarters of these species are threatened by at least one threat that is being actively managed within the enclosed land (Smith et al. 2020b).

Cluster fencing could have positive and negative outcomes for native species (Smith et al 2020 and Smith et al. in review). For example, these fences have prevented the movement of the yellow-footed rock-wallaby (Smith et al. in review), and this may put them at risk of behavioural change, disrupt natural movement between colonies and restrict gene flow. The current rapid expansion of

pest-exclusion fencing has the potential to divide native animal colonies which previously relied on movement for maintenance of genetic diversity. The impact of exclusion and TGP fencing on native mammals at a landscape scale is unclear (Bradby et al. 2014, Smith et al. 2020, Wilson and Edwards 2019), and more research is needed broadly on the effects of fencing on wildlife, both inside and outside fences.

2.4 Culling

Aerial culling and ground culling of unmanaged goats occurs on public and private reserves. Off-reserve there is lower support for culling because of the high sale price of goats and the perceived waste of a resource. On government-managed reserves, aerial culling is undertaken by trained and accredited aerial shooters. Ground shooting is sometimes better for controlling small, isolated populations and is predominantly undertaken by professional shooters.

In areas that are less accessible, aerial shooting is more commonly used. While effective, this method is more expensive than ground-based shooting. In a few instances a mixed private-public approach has been used off-reserve, where commercial operators have first been given the opportunity to remove goats (sometimes with a subsidised mustering helicopter) before an aerial or ground culling program by government agencies commences. For example, a NSW control program involved helicopter-aided mustering, ground mustering with trained dogs, and Judas goat-assisted helicopter shoots in difficult terrain. Money raised from the sale of mustered goats went towards the cost of the helicopter hire and ammunition (Peter Fleming *pers. comm.* May 2022).

The history of aerial culling in an area can impact the success of aerial culling. Goats can develop evasive behaviour after repeated exposure to aircraft. Bayne et al. (2000) found that culling success dropped from 59% success to 21% success where there had been a history of aerial shooting at Chandler River Gorge near Armidale, NSW.

Culling is often still required following mustering, especially when managing goat numbers for biodiversity outcomes. This is because mustering does not remove all goats, or not enough of the goat population to meet the objectives of the program. Goats can scatter during mustering operations, and it is common to have small numbers of goats in inaccessible areas or dense vegetation where they are hard to muster or trap. These goats are sometimes referred to as 'sticky goats'.

Goat control methods using dogs have been refined over time and have been used effectively in Australia and New Zealand. Dogs have long been used to muster goats, but they have been effectively used to detect small numbers of goats in dense vegetation towards the end of eradication programs. In New Zealand, teams of hunters and dogs have been deployed aiming to kill all goats at first encounter to prevent development of learned behaviour in the surviving goats (Parkes 2021). Bailing dogs can be trained to locate and bail up animals, barking constantly once they locate a goat. In contrast, indicator dogs track the goats and lead the hunter to the group of goats without disturbing them. The dog provides a physical indication to the hunter of the direction of the goats (Gardiner 2011). The bailing and indicator dogs are highly trained and are taught not to harm the goats. Some dogs are also given aversion training to avoid threatened species (Parkes 2021).

Some concerns have been raised about the role of amateur shooters and recreational hunters in goat control, because at times they may not always meet humane standards (The Senate 2021). However,

where these events are organised, supervised and part of an integrated control strategy, there have been little or no animal welfare concerns raised. For example, in South Australia and Victoria, branches of the Sporting Shooters' Association of Australia (SSAA), such as the Conservation and Wildlife Management Branch contribute to approximately 8% of goat removals (Lethbridge 2016). While a seemingly small percentage, this does present large cost savings over many years. Importantly, volunteer shooters from these branches must undertake training and accreditation processes which includes firearms proficiency, prior to being involved in culling operations. On reserves, these operations are coordinated and implemented under an approved plan by the relevant government department and are delivered in a defined timeframe. In undertaking these operations, volunteers are overseen by accredited park rangers which includes debriefs, adherence to procedures, strict animal welfare guidelines and risk assessments.

2.5 Judas goats

The method of using a Judas goat to locate additional animals in a widely dispersed goat population capitalises on the sociable behaviour of goats. A satellite collar is attached to a specific goat, which is then released to find a wild herd. The Judas goat is sometimes desexed before release. Location of this goat is tracked, and managers are then able to locate and destroy the herd. This technique is generally used in areas where goat numbers are considered low, as the Judas goat can locate herds in inaccessible rocky terrain or dense vegetation, which are hard to spot from an aircraft. This technique is expensive due to the equipment and monitoring needed, but it is one of the most viable options for locating small herds after other control methods have taken place. Judas goats were a key part of the successful goat eradication program on Kangaroo Island (Masters et al. 2018).

The tracking of Judas goat movements has also been shown to provide important habitat preference information, which can help inform priority areas for goat control remote from water sources (Moseby et al. 2020).

The 'Mata Hari Judas' goat is a refinement of the Judas goat technique (Campbell et al 2005, 2007). This technique involves surgically and hormonally manipulating the reproductive system of does. It can also be used to prolong the duration, or increase the frequency of oestrus, such that does actively seek out bucks and bucks actively seek out these does. The use of hormones and sterilisations in Judas goat can increase the efficacy of control operations and eradication campaigns when goats are in low density (Campbell 2006) but these techniques can be expensive.

2.6 New monitoring and control techniques

A range of different technologies have been successfully deployed in the management of other invasive vertebrates in Australia, such as cats and pigs. There are potential avenues for technology used for other invasive vertebrates to be modified to improve goat control. Drones have been used to conduct aerial surveys of a range of animals. They have also been fitted with thermal cameras to improve animal detection during culling and are being tested for use with drone assisted ground shooting. Drones can also be used to help move an animal towards the ground shooter. It is currently not known if goats can be adequately detected with thermal cameras.

There has been an increase in the use of camera traps to detect invasive vertebrates and monitor the progress of control programs. Manual identification of camera trap images is time consuming, but Artificial Intelligence software has been developed, and continues to be developed, which automates

the identification process to process information more rapidly. Some platforms (e.g. eVorta's platform) are capable of sending a message in real time to a land manager when key pest animals are detected.

Automated species detection and identification technology has been developed to operate an autonomous gate trap, which only allows goats to enter the gate (CISS, 2021). This system has the potential to be integrated into water point fence traps or ungulate specific bait feeders, minimising off target impacts.

Environmental DNA (eDNA) can provide presence/absence information on vertebrate pests in a waterway over a long period of time. New eDNA tools to improve detection are under development (CISS 2022). The relative abundance and presence/absence of pig eDNA in waterways on Kangaroo Island, SA has been used to monitor the proof of freedom phase of a pig eradication program (NFPAP 2021), and this technique could potentially be used for goat eradication programs.

A prototype of a goat specific toxic bait delivery system that excludes non-target native species was developed some time ago (Hunt et al. 2014). The box feeder works by exploiting the morphological differences of goats and native herbivores. There are currently no toxins registered for goat control in Australia, and this gap requires investigation, in addition to further testing of the system. A goat specific bait feeder could help maintain the benefit of aerial shooting between aerial programs, and could be used in areas where mustering and aerial culling are difficult. A deer specific toxic bait delivery system is also under development which is similar to the goat specific feeder. Lessons learnt in the testing of the deer aggregator could be transferred to the goat aggregator.

2.7 Acceptability of control methods and animal welfare considerations

The overarching expectation with any animal control program is that the suffering associated with a selected management method is minimised where possible. Selecting the most appropriate control technique depends on location, timing (temperature and kids at foot) and terrain, but should also consider what is most humane and least likely to cause suffering (Sharp and Saunders 2011, Sharp 2012a, Sharp 2012b, Sharp 2012c, Sharp 2012d). Careful planning of vertebrate pest species control operations assists to mitigate risks of pain and suffering to individual animals.

Sinclair et al. (2020) conducted interviews with stakeholders to determine public attitudes on goat control in Australia. Overall, the most accepted control method was trap yards at water points, followed by ground mustering, with the least accepted methods noted as excluding access to water, and ground and aerial shooting (Sinclair et al. 2020).

A trial involving dingoes fitted with GPS tracking collars to eliminate goats was carried out on Pelorus Island in Queensland after trapping and shooting had limited success due to steep terrain and dense vegetation cover (Allen et al. 2021). Within 18 months the dingoes reduced the herd of around 300 goats to approximately 7. Aerial and ground shooting removed all but one or two male goats. The project demonstrated that dingoes could be a vertebrate biocontrol tool against unmanaged goats (Allen et al. 2021), but such an approach lacked support from some members of the public. There were attempts to stop the project after it had started due to community concerns regarding animal welfare and off target impacts (Probyn-Rapsey and Lennox 2020).

PestSmart, an initiative of the Centre for Invasive Species Solutions, has developed Standard Operating procedures (SOPs) for each method of goat control based on Sharp and Saunders (2011). A matrix for comparing the relative humaneness of different control methods has been created (see Appendix 12 in Sharp and Saunders 2011). However, SOPs do not override legislation for each specific state or territory jurisdiction and serve only as guidelines (Sharp and Saunders 2011). Further, their adoption is not consistent across jurisdictions and across control methods. For example, each state government agency adheres to animal welfare SOPs for aerial culling of all species, but only some states have SOPs in place for the use of Judas collars to minimise stress to the collared animal.

The rangeland goat industry in Australia is starting to capture and rear unmanaged goats under semi-intensive or intensive conditions to allow more efficient production and predictable supply. Consequently, best practice management and welfare assessment protocols for the transition from rangeland to intensive conditions are needed (Miller et al. 2018).

3 Legislative and policy environment

Factors that have confounded the consistency of controlling unmanaged goats to date includes differences in the legal status of goats in various jurisdictions, ambiguity about who is responsible for goat control, and different land management practices in place in different states.

3.1 Legal status of goats

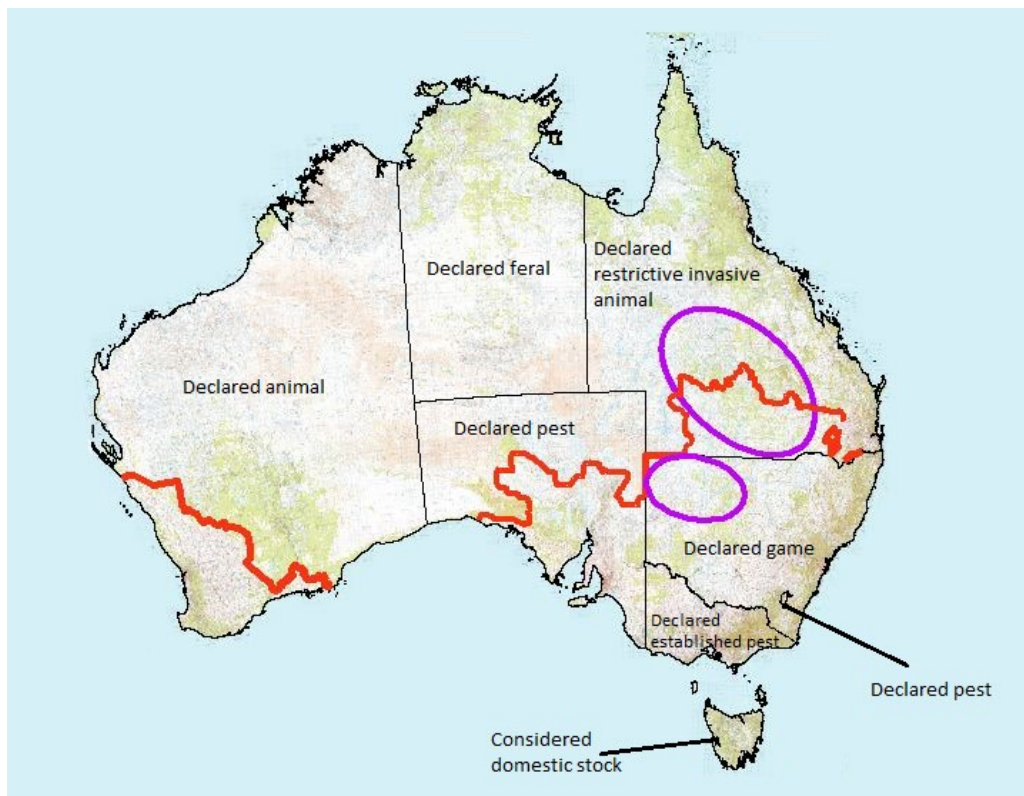
Unmanaged goats are present in every state and territory, but each state and territory has their own legislation that covers unmanaged goats (Table 1 and Figure 2). For some jurisdictions, goats fall under multiple pieces of legislation, whereas in Tasmania, goats are not a declared pest at all (Table 1). One of the issues that has been raised with the increase in managed and semi-managed wild goats, is deciding when these goats stop being ‘unmanaged’ and are no longer a pest. There is now some ambiguity as to who is responsible for unmanaged goats and their control under different situations, and this needs to be resolved.

Table 1 The pest status of unmanaged goats in each jurisdiction in Australia

Jurisdiction	Status	Control obligations
Western Australia	Declared animal under the <i>Biosecurity and Agriculture Management Act 2007</i>	Subject to restrictions on entry and keeping, and subject to control.
Northern Territory	Declared a feral animal under <i>Territory Parks and Wildlife Conservation Act 1976</i> Classified as stock under the <i>Stock Diseases Act 1994</i>	Subject to control or eradication.
South Australia	Declared animal pest under the <i>Landscape South Australia Act 2019, Landscape South Australia (General) Regulations 2020, Livestock Regulations 2013, Live Stock Act 1996</i> and SA Declared Animal Policy: Feral Goats	Landholders must control to acceptable level.
Queensland	Declared category 3, 4 and 6 restrictive invasive animal under the <i>Biosecurity Act 2014</i>	General control required.
New South Wales	Declared game animal. Competition and habitat degradation by feral goats <i>Capra hircus</i> listed as a Key Threatening Process under <i>NSW Biodiversity Conservation Act 2016</i>	No control obligation. Biosecurity requirements for holding goats as stock.
ACT	Declared as pest animals under <i>Pest Plants and Animals Declaration 2016</i>	Neither notifiable nor prohibited.
Victoria	Declared as an established pest animal under the <i>Catchment and Land Protection Act 1994</i> . Soil degradation and reduction of biodiversity through browsing and competition by feral goats listed as a Potentially Threatening Process under the <i>Flora and Fauna Guarantee Act 1988</i>	Landholders have the responsibility to take reasonable steps to prevent the spread of goats and as far as possible eradicate established pest animals on their land.
Tasmania	Not a declared pest. Considered domestic stock and ownership to be determined prior to destroying animals	–

Figure 2 Map indicating the different statutory pest status of unmanaged goats for each state and territory

Barrier fences and wild dog fences are indicated by thick lines. Managed and semi-managed goats are likely to be present on some properties in the circles where cluster fencing and total grazing pressure fencing are found, and where state legislation allows unmanaged goats to be brought under some form of management. The map does not include farms with specialised goat breeds, or the recent fencing developments in WA (Murchison cluster), north of the barrier fence where the goats are currently considered unmanaged.



3.2 Cultural issues

The cultural value placed on unmanaged goats varies in accordance with the observer's own value system. Australia's unique fauna and flora is widely valued by society, and many perceive unmanaged goats to be a threat to the native fauna and flora. Some people, however, see goats as a resource to be maintained. A key component of any control program is consideration of the differing cultural values attached to domestic and unmanaged goats and the social licence for control activities.

There is a stigma around farming goats in some parts of the community, with farmed goats being perceived as inferior to sheep by some people (El Hassan 2019). A cultural bias against goats has been identified in livestock producers, bureaucrats and policy makers in developing countries, and this bias is thought to exist in Australia to some extent (Hacker and Alemseged 2014).

There is some overlap in the views of Indigenous and non-Indigenous people regarding unmanaged goats, they can be perceived as either a resource or a pest, or somewhere in between depending upon the context. First Nation peoples' perceptions of introduced animals can vary with location, and

their experiences with the animal species, and can be far more complex than an introduced pest animal 'belonging' or 'not belonging' in Australia (Vaarzon-Morel and Edwards 2012).

Engagement with First Nation peoples during the development of this plan revealed their determination to reduce goat impacts, but they also raised the complex set of issues they face around employment and land management in general. Some First Nation peoples hunt goats for food, while others participate in commercial harvesting of unmanaged goats, either as landowners or contractors. The Nantawarrina Rangers removed over 9 000 goats from their Indigenous Protected Area (IPA) over 2017 and 2018, to help look after their Country (NIAA 2018). Goats are the main invasive animal within this IPA, and they have been observed eating the same vegetation as the yellow-footed rock wallaby and the emu, as well as eating bush tucker (e.g. bush tomatoes and bush oranges). The rangers control the goat population by mustering, and selling them for export. The sale of the goats provides only a small income after covering transport and mustering costs

3.3 Current and ongoing biodiversity strategies

Biodiversity strategies are essential in guiding and assisting with species management. Where goats impact threatened ecological communities and native species corridors, regional recovery plans are likely to be more appropriate because they can better address connectivity issues for a range of species, both on and off reserves. Legislative policy can impact the level of unmanaged goat control across Australia, but also influence more localised programs which could adopt similar strategies or approaches from other jurisdictions. Having policies or initiatives in place can encourage local programs and strategies to be implemented at the same level of standard and commitment as national initiatives. For example, programs such as the *Bounceback* initiative SA, now running 30 years, and the more recent *Bounceback and Beyond* initiative consider managing biodiversity assets at a broad landscape level. They encapsulate three contiguous broad-scale, fenceless biodiversity corridors across multiple land tenures in SA including pastoral land. Here the production properties compliment the core biodiversity asset areas by providing connectivity between reserves. They also support biodiversity assets directly on their properties. This has enabled species like the yellow-footed rock-wallaby (*P. x. xanthopus*) to both increase in numbers and expand back into its historical range over very wide large areas of the state in the threat abatement footprint.

Recovery plans for rock wallaby species in NSW, WA, and Victoria have focused only on managing local populations, rather than consider a broad landscape-level approach, and unlike SA these states have needed to consider translocations to maintain genetic and demographic robustness for *P. x. xanthopus* and other wallaby species. In Queensland, a decline in the area of occupancy, extent of occurrence and quality of habitat has left *P. x. celeris* vulnerable and the remaining geographic distribution is precarious for its survival (Threatened Species Scientific Committee 2016). Dispersal between existing colonies is limited, especially where intervening habitat is unsuitable. This outcome is in stark contrast to *P. x. xanthopus* in SA.

4 Glossary

Term	Definition
Biodiversity	The variety of all living organisms on Earth at all levels of organisation. It includes organisms that occur on land, in the sea and in fresh water, and includes bacteria, viruses, fungi, plants and invertebrate and vertebrate animals. The definition of biodiversity also encompasses the diversity of genetic material within each species and the diversity of the ecosystems they inhabit, as well as the diversity of ecological and evolutionary processes that are performed by genes and species, and the interactions among them (Cresswell and Murphy 2017).
Dry sheep equivalent (DSE)	A method of standardising an animal unit and is the amount of feed required by a 2 year old, 50kg Merino wether to maintain its weight. Applying this principle, one 50kg dry goat is equivalent to one DSE.
Eradication	The complete destruction of something. In the context of pest species, the complete destruction or removal of a species from an area.
Key threatening process	A process listed under the EPBC Act that threatens, or has the potential to threaten, the survival, abundance or evolution of a native species or community.
Managed goats	Securely fenced goats, legally defined as stock, under an active primary production system, with no access by unmanaged transient goats, and maintained to match market demand and supply. In some states this definition extends to goats tagged as stock.
Over-the-hook	Refers to livestock sales in which change of ownership occurs at the carcass weighing scales and where purchase price is determined based on the weight and description of the carcass (MLA 2021).
Rangeland goats	Rangeland goats may be unmanaged or managed as part of primary production.
Recovery plan	The research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities with the aim to maximise the long-term survival of a species or community in the wild.
Ruminant	Ungulates comprising of cattle, sheep, goats, antelope, deer, giraffe which chew the cud regurgitated from the rumen.
Semi-managed goats	A loose term for goats which are often within the confines of a fenced area, but are not specifically managed by a landowner as stock.
Threatened species	A species which is listed under the EPBC Act as being vulnerable, endangered, or critically endangered.
Threatened Ecological Community	An ecological community listed under the EPBC Act as either vulnerable, endangered or critically endangered
Unmanaged goats	Goats not managed as part of a production system, which are also termed 'feral' or 'wild'.

5 Acronyms and abbreviations

Term	Definition
ALA	Atlas of Living Australia
BCM	Bushland Condition Model
DAWE	Department of Agriculture, Water and the Environment
DEWHA	Department of Environment, Water, Heritage and the Arts
DPI	Department of Primary Industries
EPBC	Environment Protection and Biodiversity Conservation Act
GICA	Goat Industry Council Australia
ILC	Indigenous Land Corporation
IPA	Indigenous Protected Area
KTP	Key threatening process
MLA	Meat and Livestock Australia
NP	National Parks
SAAL	South Australian Arid Lands
SOP	Standard Operating Procedure
TAP	Threat Abatement Plan
TGP	Total Grazing Pressure
WoC	Working on Country

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7 Appendix

7.1 Stakeholder engagement

Stakeholders were engaged during 2022 in all states of Australia where unmanaged goats present a threat to gain an understanding of the current issues and perceptions around unmanaged goats. Information and views obtained in this engagement process informed development of the objectives and actions of the 2023 TAP. The engagement process gave interested parties that deal with unmanaged goats the opportunity to reflect on the impacts, opportunities, impediments, and gaps surrounding goat management (see list of stakeholders in section 7.4). Several other overarching themes and emerging issues were identified during the stakeholder engagement in 2022. The key stakeholder feedback is summarised in section 7.2.

7.2 Overarching themes and emerging issues

7.2.1 A shift in emphasis in the TAP to a risk assessment model

The stakeholder feedback favoured moving to prioritising actions around EPBC Act-listed species, and threatened ecological communities listed under the Act. This does not preclude reinvesting in past control projects that have demonstrated capacity-building and growth, but would prioritise new projects based on updated conservation strategies. However, ecological communities have not always been clearly identified with respect to goat impact. It is also clear that many biodiversity assets are affected by more than one threatening process. The habitat corridor requirements of different species and the threats goats pose to these corridors can also be unclear, sometimes because the issues differ between the states.

On reserves (private and public), where there are high-value biodiversity assets, the message from stakeholders is that culling programs and permitted muster operations must continue (sometimes in tandem) to keep unmanaged goats to low levels, and in some areas, like islands or peninsulas, the aim should be to eradicate.

Off-reserve, many stakeholders agreed that the best method to control or transition towards managed goat operations depends on both the land system and the practicality of the approach, and that commercial production operations can operate profitably in threatened ecological communities using innovative approaches including incentive-based schemes and fencing inclusion or exclusion methods. For example, the Emissions Reduction Fund (ERF) incentives like the proposed AL-MAP method (Carbon Market Institute 2021) may have longer-term benefits for some pastoralists in reducing unmanaged goats, particularly where they already have already diversified. In fact, over 400 properties in Australia have already adopted the Human-Induced Regeneration (HIR) carbon farming methodology, an approach which captures carbon through changes in land management practices to facilitate pasture and native vegetation regeneration. This can include reducing unmanaged goats. This methodology attempts to increase the economic value of natural assets and the resilience of the agricultural industry through diversification. However, more research needs to be conducted to better understand the long-term benefits to biodiversity and the economics for production systems. HIRs are also being used in Aboriginal Carbon Farming initiatives.

Conversely, in other areas where the landscape is already highly modified, the terrain is suitable, and land does not fall inside high-value biodiversity corridors or threatened ecological communities, QLD and NSW have encouraged cluster and Total Grazing Pressure (TGP) fencing to assist in the removal of unmanaged goats and allow growers to transition to managed systems.

7.2.2 Evidence-based decision making

Most stakeholders indicated that the new TAP should ensure that decisions on managing goats are evidence-based and scientifically supported. Stakeholders emphasised the importance of running trials, both with government and in cooperation and collaboration with landholders. Suggested trials include different control methods, improvement of research on goat impact, and increasing funding toward research on unmanaged goats overall. Ensuring that the control of unmanaged goats is evidence-based could minimise future conflict between sectors. Localised research into goat behaviour, diet and impact, rather than relying on extrapolating from information in other regions, could potentially reduce misinformation and incorrect assumptions about their impact and the need for control more broadly.

Government agencies in QLD and NSW, together with MLA and GICA have been more broadly promoting TGP fencing as a tool for managing pasture at a broad scale but acknowledges that landscape-scale impacts from this method have been difficult to monitor across large pastoral properties. To this end, MLA have identified an urgent need to monitor impacts of TGP management on groundcover both inside and outside of these fences and have proposed an industry relevant TGP database of current knowledge, which would also include the condition and diversity of natural. Many stakeholders consulted in the development of the 2022 TAP suggested that research and development is also needed to assess long-term grazing trials in these systems to determine whether there are co-benefits to both biodiversity assets and primary production outcomes. This would give all parties more certainty about the costs and benefits of cluster fencing.

More generally, the need for impact-density relationship metrics (perhaps translated to a Dry Sheep Equivalent – DSE index) in each region or property was a notable topic of discussion among most stakeholder groups and individuals. For unmanaged goats, defining and implementing metrics would allow those harvesting goats to work to density targets shown to significantly limit goat impacts. But this should also include studies looking at the positive and negative impacts of transitioning unmanaged goats to managed systems in TGP and cluster fencing environments as highlighted by MLA (2018a). Impact-density relationship metrics would also assist reserve managers.

7.2.3 Partnership models for dealing with unmanaged goats

A “one-size fits all” approach to goat management is not feasible, and tailored approaches will be needed to accommodate different regions, states, policy frameworks and landsystems. Local and/or regional differences will also dictate how partnerships could work. Stakeholders considered that under any model, there would always be a need to use incentives or a commercial value to either control or transition away from unmanaged goats. For example, for landholders who want to conserve high biodiversity assets on their property, funding for any transition (e.g. fencing, targeted removals) was acknowledged as an inhibiting factor.

Management zones could be utilised for goat management across the country, where tailored guidelines suited for each climate/topography and jurisdictional differences are formed to assist in best management practices. For example, Russell (2008) proposed three feral goat management

zones in NSW, split into an Eastern zone, Central zone and Western zone (high rainfall, wheatbelt, and rangeland respectively). Due to the differences in landscape, creating a guide for management practices and the most appropriate and relevant Actions and priorities set out in the TAP could be a useful tool. This would require organisations, landholders and management control to work collaboratively within their zones, for example, where goats are viewed as a resource more than a pest, suggested management strategies may be tailored more towards transitioning unmanaged goats to managed, whereas another zone may benefit from Actions and priorities for control and culling. However, the management of goats varies dependent on many other variables other than climate and landscape. Therefore, other influences such as biodiversity of the area, or cultural significance and values would need to be considered as a part of the guidelines.

In South Australia, several Landscape Boards have come together and are using a 'common cause' engagement method (Holmes et al. 2011) to explore a range of unmanaged goat control/management options with stakeholders. The common cause method "helps cause-based organisations engage the values that support a more equitable, sustainable and democratic world" (Holmes et al. 2011). While the method was developed for cause-based organisations, it is widely becoming adopted across industries with the aim to both activate pro-social and pro-environmental attitudes and avoid intrinsic values which suppress these values (Holmes et al. 2011). This approach needs to be strongly evidence-based as a foundation from which to seek common values between all stakeholders in multi-land use regions having biodiversity assets and/or biodiversity corridors. Differing values, beliefs and attitudes of the stakeholder groups can create barriers to drivers of change.

In Victoria, where most feral goat issues occur on reserves since most of Victoria consists of more intensive use farm country, government agencies simply provide landholders adjacent to parks with infrastructure to trap goats, while special interests like the Sporting Shooters assist Parks staff with culling.

Within the footprint of the *Bounceback* program in SA, and in other parts of the country, adjacent landholders are generally provided with either the opportunity or incentives to trap/muster on their properties first, but when numbers are high, Park culling operations are sometimes required.

In NSW and QLD, growers together with representative groups and agencies are taking the opportunity to move towards goat production systems. In these areas, fencing goats out (or in) from biodiversity assets has a great deal of traction.

7.2.4 Managing actions and the relationship between the TAP and EPBC Act/recovery plans

A GIS database linking goat management approaches to specific threatened species recovery plans and survey data would help with understanding which native species are impacted, the severity of this impact, and the importance on ensuring that goat populations are managed.

7.2.5 Collaboration

Better collaboration and understanding between sectors involved with goats was repeatedly mentioned by stakeholders. The previous TAP focused on education for landholders, managers and for the public about unmanaged goats and control methods. While it is still important to ensure

there is education and information flow between all parties and the public, in the new TAP collaboration between sectors should be a primary focus.

A key example of a successful collaborative model for landscape management is SA's *Bounceback* program, and its allied *Bounceback and Beyond* program. This is one of the largest unfenced broadscale landscape rehabilitation projects in Australia and involves collaboration across all forms of tenure to protect and connect key habitat corridors that link the Gawler Ranges, Flinders Ranges and Olary Ranges. The program has been operating successfully for 30 years, and goat control is one component of its success. Similar models operate in Western Australia under the Western Shield and Fitzgerald Biosphere programs. These programs exemplify what can be achieved with cooperation at the landscape scale. For example, since the inception of *Bounceback*, the threatened Yellow-footed Rock-wallaby has expanded its range considerably through these corridors, from once relatively isolated remnant populations on reserves and pastoral properties. A recent genetic study showed that in the Gawler Ranges, wallaby colonies had expanded out into their historic habitats some 15 km in under 15 years (Smith et al. in review).

7.3 Indigenous engagement

There were 81 declared IPAs covering around 85 million ha, or 49.6% of the National Reserve System in May 2022 (National Indigenous Australians Agency 2022). The great majority of IPA's, lease agreements and Aboriginal Lands fall outside of wild dog barrier fences. In the SA rangelands where unmanaged goats exist, two IPAs, Nantawarrina and Yappala, fall in areas south of the wild dog barrier fence. In QLD, the Jamba Dhandan Duringala IPA is found towards the south of cluster fenced properties. A further four IPAs are in central NSW (Toogimbi, Mawonga, 'Brewarrina Ngemba Billabong', and Weilmoringle).

Outside of IPAs, there are also native title claimed areas, landuse agreements, leaseback agreements and joint management agreements (e.g., Paroo-Darling NP, Mutawintji NP, Ikara-Flinders Ranges NP, Vulkathunha-Gammon Ranges NP) that are also impacted by goats. Goat control work is also being conducted in the Central Mallee reserves, part of Ngiyampaa Country, roughly bounded by the Darling, Barwon, Bogan and Lachlan rivers (Department of Planning, Industry and Environment 2021). The Barkandji Native Title Group Aboriginal Corporation in the western region of New South Wales, south of Menindee is also conducting control work and on Dja Dja Wurrung jointly managed Parks in Victoria.

In a Native Title claimant area over Ngemba, Ngiyampaa, Wangaaypuwan, and Wayilwan, a broad area of mallee country in Western NSW including many reserves, south of the Darling River, goats have had major impacts on natural and cultural assets throughout the reserves, including impacting on Malleefowl (*Leipoa ocellata*) (DPIE 2019; Department of Planning, Industry and Environment 2021).

In 2022, input was sought through approaches to a board range of Indigenous representative organisations. Respondents mainly focussed on Indigenous Protected Areas (IPAs). Previous studies have suggested that Indigenous Australians perceived goats as a part of the landscape rather than a pest species (Rose 1995). However, engagement of Indigenous communities during development of the new TAP revealed that this is not a mainstream perception, and interviews with Indigenous

stakeholders reveal a determination to keep goat impact down but point to complex set of issues they face around employment and land management in general.

Indigenous rangers are funded through a range of sources with the most significant being the Australian Government's Working on Country (WoC) program. Aside from the significant environmental benefits of WoC, these jobs also have many social and economic benefits. While our Indigenous stakeholders welcomed recent announcements to introduce more Indigenous ranger positions and IPA funds, the lower salaries, and part-time positions prevalent in smaller IPAs, means they are often under-resourced to sustain goat removal activities.