



Counting the doe: an analysis of the economic, social & environmental cost of feral deer in Victoria



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Overview

In recent years the Victorian feral deer population and distribution have rapidly increased with analysis by the Victorian Department of Environment, Land, Water and Planning ('DELWP') suggesting that the population of deer could be between *"several hundred thousand up to one million wild animals or more"*¹. The dramatic increase is partially a result of the current legal status of deer,² which makes it difficult undertake strategic, large-scale management.

The challenge in managing feral deer is likely to be exacerbated in future, with populations expected to increase significantly over the next thirty years, driven by a combination of climate change, natural dispersal and deliberate releases and farm escapes.³ Our analysis estimates that even under conservative assumptions, if no significant management action is taken, by 2050 there could be 1.7 to 4.6 million feral deer in Victoria.⁴

While the number of deer in future is uncertain, what is known is the significant economic, social, cultural, and environmental cost imposed by feral deer on the Victorian community.⁵

The benefits of more substantive and sustainable feral deer management in Victoria could be significant

Frontier Economics was engaged by the Invasive Species Council to examine the economics of managing feral deer in Victoria. As part of this analysis we have identified, and where possible, valued the economic, social, cultural and environmental impacts on society of failing to manage feral deer to an ecologically sustainable level (i.e. at a level at which they are likely to have limited negative impact on the economic, social, cultural and environmental outcomes in Victoria). To the extent that controlling the feral deer population saves economic, social, cultural and environmental costs, these are considered to be an economic benefit arising from the controls.

¹ Estimate as of October 2020. See: Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy, 9. Note, this population estimate has not changed since the 2018 draft of the Strategy.

² Under the current legislative framework, authorisation under the Wildlife Act is required to control deer on Crown land every time management is to occur.

³ Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy

⁴ It should be noted that this analysis does not seek to definitively forecast future feral deer numbers in Victoria. Rather, we have sought to provide an indication of the range of potential feral deer numbers based on advice from subject matter experts, to help decision-makers understand the possible cost on the community as a result of inaction.

⁵ See for example Davis et al (2016) 'A systematic review of the impacts and management of introduced deer (family Cervidae) in Australia' *Wildlife Research* 43, 515-532; Lindeman, M.J and Forsyth, D.M (2008) 'Agricultural impacts of wild deer in Victoria', Arthur Rylah Institute for Environmental Research, Technical Report Series No. 182, Victorian Department of Sustainability and Environment; Environment and Communications Reference Committee, Parliament of Australia, *Impact of feral deer, pigs and goats in Australia* (2021); Claridge, A.W (2016) Synopsis of perceptions about introduced deer among park management ranger staff across the Australian Alps, NSW National Parks and Wildlife Service; Cripps, J (2019) 'Introduced deer and their potential role in disease transmission to livestock in Australia' *Mammal Review* 49, 60-77.



Drawing on the best available information, our analysis indicates that **the cost to the broader community of feral deer could be over \$1.5bn (7% discount rate) or \$2.2bn (4% discount rate)** in present value (PV) terms, over the next 30 years. This estimate is made up of:

- **\$245m to \$350m in economic costs from lost gross margin due to grazing** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This assumes 10% of the feral deer population are grazing on farmland, which reduces the opportunity to fully stock that land for grazing, resulting in a reduction in income for the farmer.
- **\$106m to \$144m in economic costs from resources spent managing feral deer** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This assumes a farmer spends 20 days a year managing feral deer on their properties.
- **\$269m to \$365m in economic costs from lost forestry production** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This assumes a reduction in production of plantations as a result of feral deer grazing and trampling through the forests.
- **\$576m to \$825m in economic costs from deer-related vehicle accidents** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This assumes that all future feral deer related crashes on highways within Victoria can be avoided.
- **\$308m to \$474m in social costs from reduced recreation and use values** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This is based on the assumption that uses of Victorian national and state parks for recreation will be dampened by 1% due to the impact of feral deer.

The unquantified impacts mean that the cost of feral deer may be higher than estimated

Although our analysis has sought to value the benefits (including cost savings) associated with managing feral deer in Victoria, given the availability of information these figures do not capture the full range of potentially significant costs of feral deer in Victoria. These include the impact of feral deer on:

- the other costs of management
- the cost of water supply
- the risk of disease
- indigenous cultural heritage
- biodiversity
- the health of rivers and waterways

As such, it is likely that the true economic, social, cultural and environmental costs imposed on the community as a result of feral deer in Victoria are larger than our estimate.

Understanding the change in outcomes and the appropriate price is critical to robustly value the economic, social, cultural and environmental benefits of managing feral deer within Victoria. Given the significant impact of feral deer in Victoria, there is likely to be benefit in undertaking further work to better understand the magnitude of the problem, and therefore, the benefits of action.



Decisive action is required

While there are costs associated with reducing feral deer numbers to sustainable levels, these are unlikely to outweigh the benefits of control. Our analysis suggests that if management is taken in 2022, the cost of removing all feral deer could be between \$338m and \$581m (depending on the population scenario).⁶ This cost would have to rise by around four times before the conservatively estimated benefits of controlling deer was outweighed. Having said this, we acknowledge that both the extent and approach to feral deer management will determine the level of benefits society receives, because different management strategies will have different impacts on the feral deer population, at different costs.

Our findings highlight the need for decisive action to manage the feral deer population in Victoria. The longer control is delayed the larger the population of feral deer and the greater the cost of inaction. In other words, a strategy that quickly and significantly reduces deer numbers will deliver greater benefits than a slower response, while at the same time requiring lower costs to achieve

These results are inherently uncertain and there are gaps in the available research and primary data on the impacts of specific feral deer in Victoria. However, even if these uncertainties could be resolved with more research, given the conservative approach we have taken, improved information is more likely to increase the benefits of control, thereby reinforcing the conclusion that controlling feral deer is net beneficial.

⁶ Uncertainty around the number and distribution of feral deer in Victoria makes it difficult to quantify the exact cost of the feral deer management in Victoria. The marginal cost of removing feral deer is greatly dependent on the location, density of feral deer, and management technique and some management methods are not suitable for some areas of Victoria. That being said, analysis by the Invasive Species Council estimate the average cost of removal to be \$404 per deer based on assumed effectiveness of aerial shooting.



1 Introduction

Key points

- In recent years the Victorian feral deer population and distribution have rapidly increased.
- While there is broad recognition that feral deer can impose a variety of economic, social, cultural and environmental costs on the community, the impacts of feral deer in Victoria have not been well-quantified, hindering decision-makers ability to make informed decisions about feral deer control.
- Frontier Economics was engaged by the Invasive Species Council to examine the economics of managing feral deer in Victoria. As part of this analysis we have identified, and where possible, valued the economic, social, cultural and environmental impacts on society of failing to manage feral deer to an ecologically sustainable level.
- Our analysis has not sought to value all economic, social, cultural and environmental costs imposed by feral deer. Given the data and time constraints we have focused on those impacts that are likely to be most material. Should information become available to enable the quantification and valuation of other economic costs, this will most likely strengthen the case for decisive action as we have used costs at the lower of the likely range.

1.1 Introduction

In recent years the Victorian deer population and distribution have rapidly increased⁷ with analysis by the Victorian Department of Environment, Land, Water and Planning ('DELWP') suggesting that the population of deer could be between "several hundred thousand up to one million wild animals or more".⁸

While there is broad recognition that feral deer can impose a variety of economic, social, cultural and environmental costs on the community, the impacts of feral deer in Victoria have not been well-quantified, hindering decision-makers ability to make informed decisions about feral deer control.

To make more informed decisions about the nature and extent of any intervention to manage feral deer in Victoria, it is critical to understand all the cost and benefits that arise from an intervention or conversely, inaction. This should include social, environmental and economic impacts. Converting the full range of cost and benefits imposed on the community⁹ into dollar

⁷ See for example, the Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy

⁸ Estimate as of October 2020. See: Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy, 9. Note, this population estimate has not changed since the 2018 draft of the Strategy.

⁹ This includes the local, broader Victorian and Australian communities.



values¹⁰ can help decision makers compare feral deer management options and assist them to determine whether and how to act.

When the broad range of social, environmental and economic impacts of feral deer in Victoria are not considered or monetised there is a risk that these impacts will be ignored. This can lead to suboptimal management outcomes.

Against this background, Frontier Economics was engaged by the Invasive Species Council to examine the economics of managing feral deer in Victoria. As part of this analysis we have identified, and where possible,¹¹ valued the economic, social, cultural and environmental impacts on society of failing to manage feral deer to an ecologically sustainably level (i.e. at a level at which they are likely to have limited impact on the economic, social, cultural and environmental outcomes in Victoria).

1.2 Understanding the costs of inaction requires an economic framework

As shown in **Figure 1**, our approach involved six key steps:

- 1. Forecasting future deer numbers over the period from 2022 to 2051.** This was a function of four inputs: starting population, growth rate (which includes loss from death and shooting), carrying capacity per hectare (K), and location/ area of deer habitat.
- 2. Reviewing existing literature examining the impact of feral deer in Victoria on economic, social, cultural and environmental outcomes.** This includes:
 - **use-values** – these accrue to *users*, for example, land-holders, visitors to parks etc.
 - **non-use values** – these values arise from the knowledge that the Victorian environment (including its habitats and the species it supports) exist and will continue to exist. They are different from use values because they arise whether or not the environment or park is used and as such, can be attributed to the population beyond just those who use and visit the area (e.g. the broader Victorian community).
- 3. Identifying the change in economic, social, cultural and environmental outcomes** that could arise as a result of feral deer in Victoria, over the period from 2022 to 2051.

¹⁰ Note all figures in the report are \$2021-22. Some figures are presented on a per year basis. Others are presented as present value figures, in line with Victoria Department of Treasury and Finance (DTF) guidance, which requires costs and benefits to be discount using a social discount rate. We have adopted a discount rate of 4% and 7%, consistent with DTF guidelines (The Victorian DTF recommends the use of the social discount rate of 4% for Category 1 projects and 7% for Category 2 projects) See DTF (2013), Economic Evaluation for Business Cases Technical Guidelines.

¹¹ As discussed in more detail below, there is limited scientific and economic data available on the specific impacts of alternative feral deer management approaches in Victoria. Our analysis makes reasonable, conservative assumptions where required in a data poor environment, and we have articulated caveats to the analysis as appropriate. Where quantification isn't possible with available data, we have undertaken a qualitative assessment of these impacts using case studies and other available evidence.



4. Valuing the key costs associated with failing to manage feral deer in Victoria. At a high level, this involves multiplying the change in outcomes from step 3 by the appropriate price and discounting the costs using the social discount rate of 4% and 7%.¹²

Given the timeframe available for this analysis we have adopted a benefit transfer approach (see **Box 1**). This involves drawing on existing literature to value impacts (and making any necessary adjustments to reflect the Victorian context), rather than undertaking primary research.

5. Understand how the cost of feral deer vary under alternative states of the world, for example under alternative future deer population scenarios.

6. Identifying, at a high level, the cost associated with management approaches (i.e. the financial cost of aerial shooting of feral deer)

Figure 1: High-level overview of our approach



Source: Frontier Economics

Each step has been supported by ongoing consultation with key stakeholders and subject matter experts. This included engagement with Victorian Government and Non-Government organisations, businesses, landholders and academics. For example, we held 3 workshops in April 2022 and a range of individual discussions with key stakeholders over 2021 and 2022 to assist in our understanding of the issues, and test assumptions and analysis. We have included the feedback we received from these sessions in this analysis.

Importantly, our analysis has not sought to value all economic, social, cultural and environmental costs of feral deer, rather, given data and time constraints, we have focused on those likely to be most material and where data is readily available. Should information become available to enable the quantification and valuation of other economic costs, this will likely strengthen the case for decisive action.

¹² The Victorian Department of Treasury and Finance recommends the use of the social discount rate of 4% for Category 1 projects and 7% for Category 2 projects. See DTF (2013), Economic Evaluation for Business Cases Technical Guidelines.

**Box 1:** Applying benefit transfer to value key economic, social, cultural and environmental impacts of feral deer in Victoria

Benefit transfer involves using values estimated in a source study and transferring these for use in the case of interest. For this approach to be valid, the following conditions need to be satisfied:

- The source study should be rigorous and valid
- The context and conditions pertaining in the case of interest should be similar to those occurring in the source study.
- The demographic and economic characteristics of any sampled population sampled in the source study should be similar to those in the target study.
- The extent of the changes being investigated should be similar.

A benefit of this approach is that as does not require original empirical study (scientific, survey, econometric, or other) design and execution, benefit transfer can be rapidly applied. However, the applicability will be limited to outcomes with a large body of research (where the original research is robust and the study sites are sufficiently similar) and, in this case, there are very few applicable primary studies that are well suited for use, particularly around the specific environmental impacts of feral deer in Victoria.

Source: Frontier Economics

1.3 Structure of this report

The remainder of this report is structured as follows:

- **Section 2** provides an outline of the context and background of this analysis.
- **Section 3** provides an overview of agricultural impacts of feral deer.
- **Section 4** summarises the social impacts of feral deer.
- **Section 5** provides an overview of the environmental impacts of feral deer.
- **Section 6** provides a summary of our key findings and results



2 Context and background

Key points

- In recent years the Victorian feral deer population and distribution have rapidly increased. Our analysis suggests that feral deer numbers could grow to between 1.7 million to 4.6 million by 2050, an increase of between 103% and 217% over the next 30 years.
- While historically, the impacts of feral deer in Victoria have not been well quantified, research suggests that feral deer within Victoria have had a significant detrimental impact on a range of economic, social, cultural and environmental outcomes.
- Despite recognition of the damage caused by feral deer in Victoria, management to date has been limited. Historical approaches to management have been relatively reactive and uncoordinated, where feral deer management is undertaken to address specific issues in localised areas.
- While the number of feral deer in future is uncertain, what is clear is that decisive action is required to mitigate the potentially significant cost of feral deer in Victoria.

2.1 Feral deer numbers in Victoria are rapidly increasing

Up until the 1980s, it was relatively rare to see a deer in the wild. However, in recent years the Victorian deer population and distribution have rapidly increased¹³ with analysis by DELWP suggesting that the population of deer could be between “several hundred thousand up to one million wild animals or more”.¹⁴

As discussed in **Box 2**, four species of deer have established populations in the wild in Victoria: Sambar, Fallow, Hog and Red Deer.¹⁵

¹³ See for example, the Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy

¹⁴ Estimate as of October 2020. See: Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy, 9. Note, this population estimate has not changed since the 2018 draft of the Strategy.

¹⁵ Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy



Box 2: Types of feral deer in Victoria

Four species of feral deer have established populations in the wild in Victoria:

- **Fallow Deer** (*Dama dama*), have a patchy distribution across Victoria and have historically existed in low numbers within most occupied areas.
- **Red Deer** (*Cervus elaphus*), as with Fallow Deer, the distribution of Red Deer is fairly patchy across Victoria. For example, the largest population of Red Deer in Victoria is located within the Grampians National Park, and consists of between 300 and 500 deer.
- **Hog Deer** (*Axis porcinus*), have a limited distribution and are found in coastal areas of Gippsland, including Wilsons Promontory National Park and Nooramunga Marine and Coastal Reserve.
- **Sambar Deer** (*Cervus unicolor*), which are the most prevalent and widespread species of deer in Victoria, occurring over most of eastern Victoria, French Island and at Timboon in the south west. Recent reports indicate that Sambar Deer may be found in and around the Grampians.

Another two deer species, Chital Deer (*Axis axis*) and Rusa Deer (*Cervus timorensis*), were also released in Victoria but are mostly found on farms (although they have been successfully established in other Australian states, including New South Wales).

Source: Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy

Studies have also suggested that the population is becoming more dispersed, with feral deer becoming an increasing problem for private and public landholders across Victoria. Deer can inhabit many different habitat types from dense forest, rough mountainous terrain and alpine environments to more open-country including semi-open scrublands, pine plantations and open grazing land.¹⁶

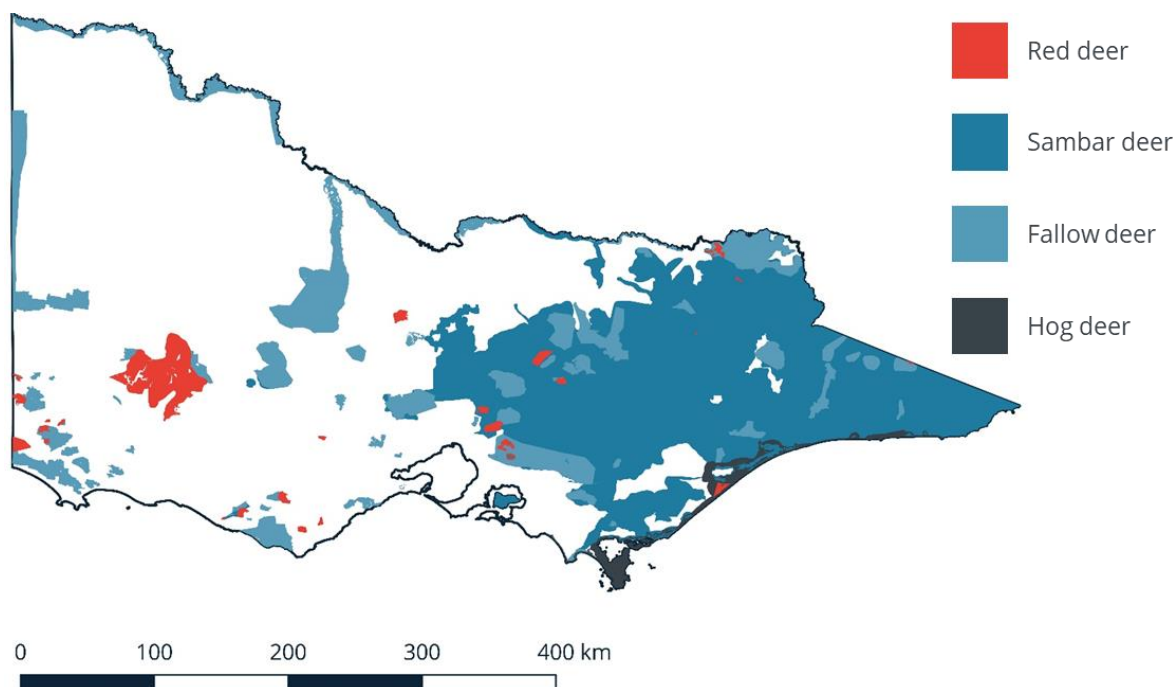
While historically feral deer were predominantly found in East and North East Victoria, as shown in **Figure 2** and **Figure 3**, they have begun to spread beyond national and state parks and forests to land that is used for productive purposes (including dryland and irrigated agriculture and plantations) and as noted by the Victorian Deer Strategy, there is potential for further spread.¹⁷

¹⁶ We note that different species are more suitable to different habitats with Fallow deer more likely to spend time on grazing land, and Sambar are more likely to be in forested areas.

¹⁷ Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy

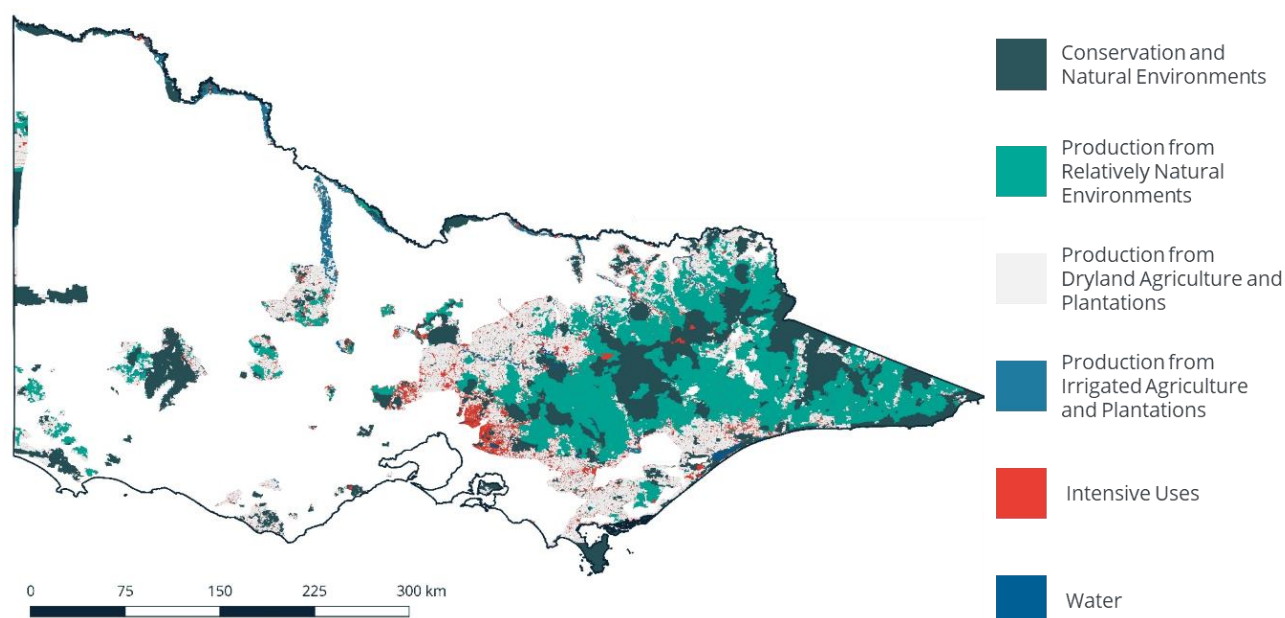


Figure 2: Deer population distribution in 2021 in Victoria, by species



Source: Frontier Economics using DELWP data. This data is sourced using anecdotal and observational evidence from landholders, community groups and park rangers along with data from the DeerScan app.

Figure 3: Deer population distribution in 2021 in Victoria, by land use



Source: Frontier Economics using DELWP and ABARES data. This data is sourced using anecdotal and observational evidence from landholders, community groups and park rangers along with data from the DeerScan app.

Note: The legend reflects ABARES classification



2.2 In the absence of further action, feral deer numbers will continue to grow

The challenge in managing feral deer is likely to be exacerbated in future, with populations expected to increase significantly over the next thirty years, driven by a combination of climate change, natural dispersal and deliberate releases and farm escapes.¹⁸ While there is uncertainty around the exact number of deer today and in future (given the lack of analysis of total deer numbers in Victoria or site specific densities), a range of studies around Australia have investigated aspects of deer populations. These include:

- Watter *et al* estimated that the annual population growth rate of Sambar deer is between 15%-24% per year based on observed reproductive patterns of the species in Victoria, which accounts for biological factors such as estimated fecundity rate, as well as deaths due to predation and recreational hunting.¹⁹
- Letherbridge *et al* and Cunningham *et al* estimated the growth rate of fallow deer in Tasmania to be between 5.4% and 11.5% per year (accounting for management and hunting).²⁰

We note that other studies (for example) have estimated the unconstrained estimated the maximum annual population growth rate (i.e. population growth in an environment with no competition for food, no predation and no other external threats). For example, Hone *et al* estimated the unconstrained population growth to be of feral deer in Victoria to be between 45% and 85% depending on the deer type.²¹

Drawing on publicly available literature and advice from key stakeholders and experts (such as DELWP and Parks Victoria), our analysis has attempted to forecast the future deer population in Victoria (see **Box 3** for further information on the assumptions behind the forecast). Given the uncertainty around the future growth rate, as shown in **Figure 4** our analysis includes a spectrum of future deer population numbers:

- Low population forecast of 1.7 million deer by 2050
- Medium population forecast of 3.1 million deer by 2050
- High population forecast of 4.6 million deer by 2050

¹⁸ Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy

¹⁹ Watter, K, White, N, Finch, N and Murray, P.J. (2020) 'Reproductive seasonality and rate of increase of wild sambar deer (*Rusa unicolor*) in a new environment, Victoria, Australia', *Animal Reproductive Science* 23.

²⁰ Ibid. See also Cunningham et al (2021) 'Dynamics and predicted distribution of an irrupting 'sleeper' population: fallow deer in Tasmania', *Biological Invasions*.

²¹ In particular, the study found the maximum annual population growth for Sambar deer to be 55%, Hog deer to be 85% and Fallow deer to be 45%. Hone, J, Duncan, R.P, Forsyth, D.M (2010) 'Estimates of maximum annual population growth rates of mammals and their application in wildlife management', *Journal of Applied Ecology* 47, 507-14, 511.

**Box 3:** Our approach to forecasting feral deer numbers in Victoria

Our forecast is a function of four inputs:

- Starting population
- Growth rate accounting for loss from death and shooting
- Carrying capacity per hectare (K)
- Location/ area of deer habitat

We have assumed that across time the population of deer will grow at a low density and disperse across a larger area, or it will grow within a confined area, with a high density. We note that this does not cover the range of possibilities of population dispersal and density patterns. However, we have included this assumption as an attempt to account for these complex dynamics across our different scenarios.

Under the medium estimate we assume that the deer remain where they are found now and grow to a high density and spread at a lower density across potential habitable areas in Victoria.

Table 1: Range of forecast deer population by 2050

Assumption	Low estimate	Medium estimate	High estimate
Starting population	750,000	1,000,000	1,250,000
Growth rate accounting for loss due to death and shooting	11.5%	13.25%	15%
Carrying capacity per hectare (K)	0.2	0.2 + 0.1	0.2
Location/ area of deer habitat	8 million hectares	8 million hectares + 14 million hectares	22.8 million hectares
Forecast deer population by 2050	1.7 million	3.1 million	4.6 million

Source: Frontier Economics analysis

Note: to ensure robustness we consulted with the Invasive Species Council, DELWP, Parks Victoria, Arthur Rylah Institute and other key stakeholders about these forecasts

**Figure 4:** Forecast feral deer numbers in Victoria

Source: Frontier Economics based on advice from the Invasive Species Council and key stakeholders

We understand that in practice there is likely to be large variation in population dynamics across time (including the covid impact on shooting and bushfire impacts) and there is a complex relationship between carrying capacity and deer population numbers (as discussed in **Box 4**).²² In addition, there is uncertain around potential deer habitat in Victoria.

As such, it should be noted that **this analysis does not seek to definitively forecast future deer numbers in Victoria. Rather, we have sought to provide an indication of the range of potential deer numbers to help decision-makers understand the possible cost on the community as a result of inaction.**

While the number of feral deer in future is uncertain, what is known is that decisive action is required to address feral deer in Victoria.

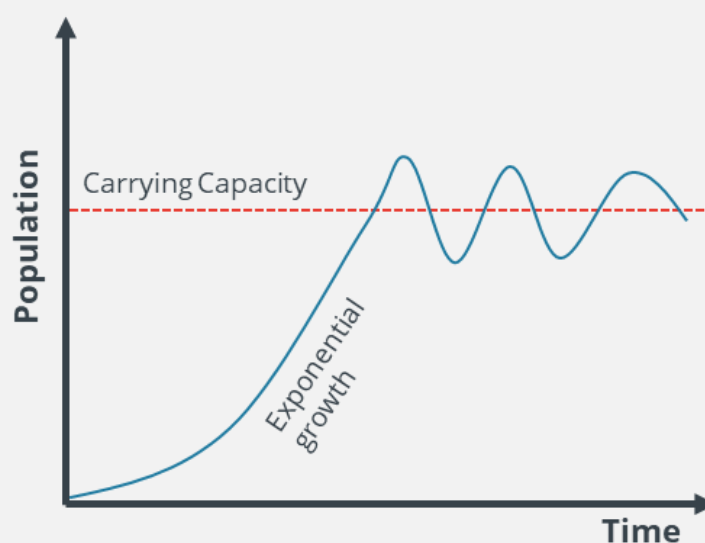
²² Stakeholder feedback was provided to Frontier Economics and the Invasive Species Council as part of a range of workshops in April 2022 and individual consultation throughout 2021 and 2022.



Box 4: Stakeholder feedback – population forecasts and carrying capacity

We note that in practice, deer population will not flatline around the carrying capacity. For example, the 2019-20 bushfires resulted in a decline in the feral deer population in Victoria. However, six to twelve months after the fires, the feral deer population increased again, as habitat and food availability increased. That is, in practice, the feral deer population fluctuates around the carrying capacity, as per **Figure 5**.

Figure 5: Exponential Growth of Population Size Over Time



Source: Frontier Economics based on information from <https://ecocity.partners/2020/03/26/carrying-capacity-viral-media-and-the-logarithmic-scale/>

However, given data availability we have adopted a simplified representation of this relationship to provide an indication of the range of potential deer numbers to help decision-makers understand the possible cost on the community as a result of inaction.

While stakeholders noted that, in practice, deer population would not flatline around the carrying capacity, there was a consensus across all workshops that the population of deer are expected to increase.

Source: Frontier Economics informed by key stakeholders

2.3 Feral deer impose a range of economic, social, cultural and environmental costs on the community

Historically, the impacts of feral deer in Victoria have not been well-quantified, however, they are believed to be significant and increasing in their extent and severity, as the population grows.²³ In

²³

Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy



particular, as shown in **Figure 6**, research suggests that feral deer within Victoria have had a significant detrimental impact on a range of economic, social, cultural and environmental outcomes (compared to an ecologically sustainable level of deer).²⁴ These include²⁵:

- **Economic-related costs, such as:**

- **Cost to the agricultural sector:**

- Damage to crops (such as cereal, nut and fruit orchards, vegetables, vineyards and plantations) and other primary production, such as fouling of pasture.²⁶
 - Cost to landholders of managing feral deer, such as the cost of ground shooting, fencing the property or replacing damaged property.
 - Competition with livestock for grazing.
 - Risk of disease as deer can transmit diseases to livestock (e.g. cattle and sheep)

- **Reduced forestry production** - Reports suggest that deer significantly reduce the quality and total volume of timber produced by Victoria's forestry industry, primarily as a result of browsing and bark-stripping.²⁷

- **Deer-related vehicle accidents** (including fatalities, accidents and vehicle-only damage)

- **Cost of managing deer by other parties**, including the Victorian Government

- **Cost of water supply, as a result of increased treatment requirements.** Melbourne Water has suggested that failure to adequately control deer in the water catchments, could result in the need to build costly water-treatment infrastructure to meet water quality standards.²⁸

- **Environmental-related costs, such as:**

- **Negative impact on biodiversity**, including spreading weeds, trampling understory, stripping and ring barking (as a result of rubbing antlers on trees), impacting the effectiveness of ecological restoration work and competing with native wildlife for food.

²⁴ See for example Davis et al (2016) 'A systematic review of the impacts and management of introduced deer (family Cervidae) in Australia' *Wildlife Research* 43, 515-532; Lindeman, M.J and Forsyth, D.M (2008) 'Agricultural impacts of wild deer in Victoria', Arthur Rylah Institute for Environmental Research, Technical Report Series No. 182, Victorian Department of Sustainability and Environment; Environment and Communications Reference Committee, Parliament of Australia, *Impact of feral deer, pigs and goats in Australia* (2021); Claridge, A.W (2016) Synopsis of perceptions about introduced deer among park management ranger staff across the Australian Alps, NSW National Parks and Wildlife Service; Cripps, J (2019) 'Introduced deer and their potential role in disease transmission to livestock in Australia' *Mammal Review* 49, 60-77.

²⁵ We note that Sambar, Red Fallow and Hog Deer have slightly different impacts due to differences in diet, size and habitat preferences. However, given the strategic nature of this report, and the lack of species-specific forecasts in Victoria, in this analysis, we discuss the impacts of deer as a whole.

²⁶ A survey conducted by the Invasive Species Council of North East Victorian landholders found that 42% of respondents reported costs associated with damage to pasture, crops and trees.

²⁷ Ward, A, White, P, Smith, A and Critchley, C (2004) 'Modelling the cost of roe deer browsing damage to forestry' *Forestry Ecology and Management* 191, 301-310. See also; Reimoser, F, Armstrong, H, Suchant, R (1999) 'Measuring forest damage of ungulates: what should be considered' *Forest Ecology and Management* 120, 47-58.

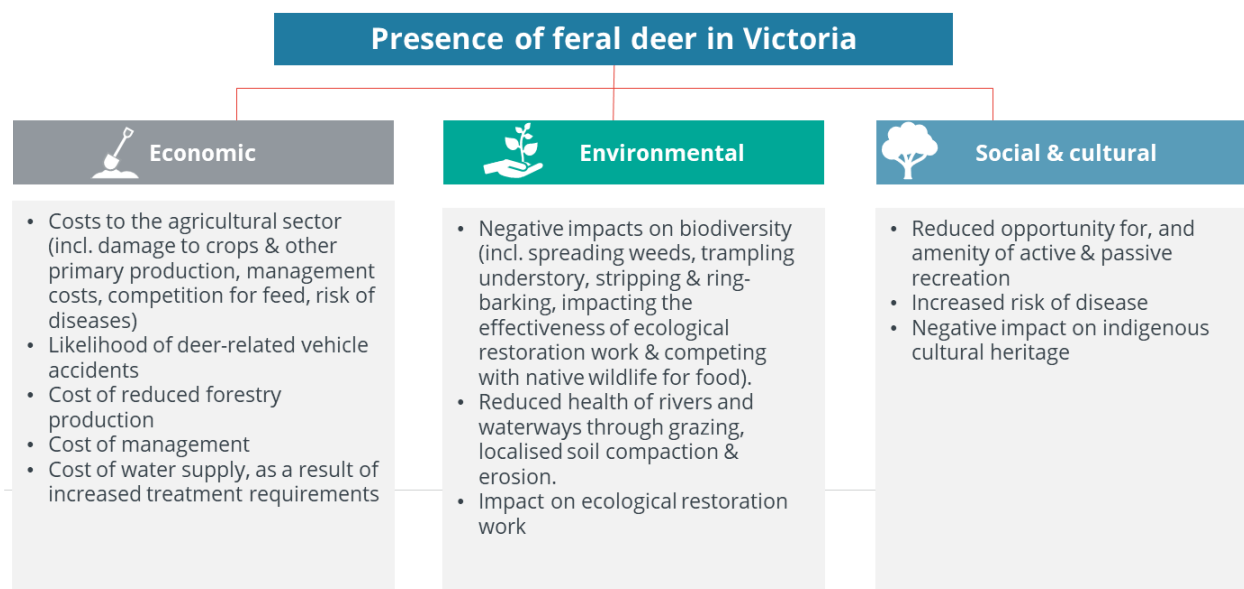
²⁸ GHD (2020), Combatting the impact of feral deer on Melbourne's protected water catchments, available at: <https://www.ghd.com/en/perspectives/combating-the-impact-of-feral-deer-on-melbourne-s-protected-water-catchments.aspx>



This is likely to be exacerbated in fire-affected areas, where the presence of deer has impeded regrowth and regeneration.

- **Reduced health of rivers and waterways**, through grazing, localised soil compaction and erosion.
- **Social-related costs, such the impact on amenity and recreation opportunities in national and local parks, including:**
 - **Reduced opportunity for, and amenity of, active recreation** (e.g. hiking and cycling) as a result of erosion of paths, increased deer-related accidents (e.g. hikers and cyclists feel less safe when they encounter large animals)
 - **Reduced amenity associated with passive recreation** (e.g. sightseeing and tours in parks) as a result of the degradation of the natural environment, such that parks have a lower aesthetic value.
 - **Risk of disease** – Deer can transmit diseases (such as cryptosporidiosis, neosporosis and leptospirosis) to humans, livestock and other animals and can lead to serious economic and social impacts.
 - **Impact on indigenous cultural heritage**, including soil compaction and erosion, damage to native plant species and competition with native species for grazing in grassy, shrubby and herb-rich woodlands.

Figure 6: Overview of the economic, social, cultural and environmental costs of feral deer in Victoria



Source: Frontier Economics

Critically, these impacts are not restricted to the state of Victoria, with modelling suggesting that dispersal of deer in the landscape is contiguous across the state borders with South Australia and New South Wales.



2.4 Management of feral deer to date, has been limited

Despite recognition of the damage caused by feral deer in Victoria, management to date has been limited, with present day hunting referred to only “a drop in the ocean” during stakeholder engagement.²⁹ Stakeholder feedback noted that historical approaches to management have been relatively reactive and uncoordinated, where feral deer management is undertaken to address specific issues in localised areas.

In particular, rather than a large-scale, strategic approach to the management of feral deer, the existing management strategy relies heavily on a combination of Government intervention and private hunting:

- Ground shooting:** The primary control method for deer is shooting, which is carried out by professional shooters, accredited volunteer hunters, commercial harvesters, and recreational hunters. Chital, Fallow, Hog, Red, Rusa and Sambar Deer are currently declared as ‘game’ under the Wildlife Act which allows them to be hunted by licensed recreational hunters. Deer hunting is a valued recreational activity undertaken by more than 38,000 licensed hunters across Victoria.³⁰ For example, in 2019 private hunting resulted in the harvesting of 173,784 feral deer in Victoria, a significant increase compared to 2009.³¹ We note that this number is uncertain, with stakeholder feedback suggesting that the number could be much higher.³²
- **Aerial shooting** - Aerial shooting is being used to deliver deer control in accessible and remote terrain where ground shooting is impractical. This is growing in use as management strategies adopt a combination of ground and aerial shooting.
- **Exclusion fencing** - Exclusion fencing is currently used by farmers to exclude deer from browsing and grazing on crops and pastures, and to protect some specific environmental values. For example, exclusion fencing is used in the Alpine National Park on the Bogong High Plains to protect threatened species and at Mount Bullfight to protect Alpine Tree Frog (threatened under the FFG Act) habitat. While deer fencing provides a long-term solution, it is only applicable to relatively small areas.
- **Trapping** (though it is not commonly adopted).

The approach to management is likely to be partially driven by the current legal status of deer, which makes it difficult undertake strategic, large-scale management. As discussed in **Box 5**, under the current legislative framework, authorisation under the *Wildlife Act* is required to control deer on Crown land every time management is to occur.

²⁹ Stakeholder feedback was provided to Frontier Economics and the Invasive Species Council as part of a range of workshops in April 2022.

³⁰ Deer can be hunted in State forest, certain forest parks (Cobboboonee and Otway) and other unoccupied Crown land (such as Crown land that is not leased or licensed), leased Crown land (with permission of the lessee), licensed Crown land, some state game reserves and private land (with permission of the landowner/manager). Deer can also be hunted in some National, State, Coastal and Wilderness Parks, subject to varying conditions.

³¹ Moloney, P.D. and Hampton, J.O. (2020). Estimates of the 2019 deer harvest in Victoria: results from surveys of Victorian Game Licence holders in 2019. Unpublished Client Report for the Game Management Authority. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

³² Stakeholder feedback was provided to Frontier Economics and the Invasive Species Council as part of a range of workshops in April 2022.



Box 5: Current legal status of deer

While deer are protected wildlife under the Wildlife Act 1975, the extent to which they can be managed varies significantly depending on whether the land is in private or public ownership.

- **Private ownership** – On private land deer are unprotected by an order of Governor in council, which enables the conditional control of deer where they are causing damage (without a permit)
- **Public ownership** - Deer control on public land requires authorisation by DELWP under the *Wildlife Act*.

Source: Invasive Species Council

While this analysis does not purport to identify the appropriate approach to managing feral deer, we note that there are other management strategies which have yet to be implemented in Victoria, but have been considered in literature and other states, such as baiting and biological control methods.

2.5 The current approach is unlikely to be sufficient

While efforts are being made to remove deer from Victoria through varying public and private management techniques, this is insufficient to abate current and projected growth in population numbers. For example, the Victorian National Parks Association noted recreational hunting cannot be relied on as an effective management strategy as:

"...Victoria] has reached a point where population increases far exceed any huntable amount and partly because amateur hunting is unstrategic [and only] randomly reduc[es] deer numbers in easily accessible areas."³³

In 2020 the *Victorian Deer Control Strategy* was released after several years in development. This strategy is a key action under the Victorian Government's Sustainable Hunting Action Plan 2016-2020. During the strategy development process, there was significant pressure exerted by the community to change the legal status of deer from "protected wildlife" to that of a "pest animal", to appropriately recognise the population explosion and serious impacts across Victoria.

However, deer remain protected under the *Wildlife Act 1975*. This decision affords deer a level of protection which restricts the ability to effectively manage the growing population.

Given this, further action is likely to be required to manage reduce the rapid increase of feral deer in Victoria.

³³ Victorian National Parks Association (2018), Dealing with deer, available at <<https://vnpa.org.au/dealing-with-deer/>>



3 Economic (incl. agricultural) impacts

Key points

- Various studies and anecdotal evidence have found a link between the presence of feral deer in Victoria and a range of economic costs, including costs to the agricultural and forestry sectors, vehicle accidents, management costs and costs related to water supply.
- Our analysis has estimated the economic cost of feral deer to be between \$1,197m (7% discount rate) and \$1,684m (4% discount rate) (in present value terms, over the period to 2051), comprised of:
 - \$245 to \$350m in costs from lost gross margin due to grazing (7% and 4% discount rate respectively)
 - \$106m to \$144m in costs from days spent managing feral deer (7% and 4% discount rate respectively)
 - \$269m to \$365m in cost from lost forestry production (7% and 4% discount rate respectively)
 - \$576m to \$825m in costs from deer-related vehicle accidents (7% and 4% discount rate respectively).
- Given the availability of information we have sought to include other costs of managing feral deer and the cost of feral deer on water supply in our analysis qualitatively.

3.1 The link between feral deer and economic outcomes

Various studies and anecdotal evidence (see **Box 6**) have found a link between the presence of feral deer in Victoria and a range of economic costs³⁴ As shown in **Figure 7**, these include:

- **Costs to the agricultural sector**, including:
 - Damage to crops (such as cereal, nut fruit and vegetables, vineyards and plantations) and other primary production, such as fouling of pasture.

³⁴ See for example, Lindeman, M.J and Forsyth, D.M (2008) 'Agricultural impacts of wild deer in Victoria', Arthur Rylah Institute for Environmental Research, Technical Report Series No. 182, Victorian Department of Sustainability and Environment; Environment and Communications Reference Committee, Parliament of Australia, Impact of feral deer, pigs and goats in Australia (2021); Stenekes N, Kancans, R and Binks B (2017) 'Pest animal and weed management survey: national landholder survey results' Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture, Canberra; Claridge, A.W (2016) Ecological and agricultural impacts of introduced deer in the Australian Alps: A final report to the Australian Alps Liaison Committee, NSW National Park and Wildlife Service; McLeod, R. (2016). Cost of Pest Animals in NSW and Australia (2016), Report prepared for the NSW Natural Resources Commission; Davies, C, Wright, W, Hogan, F and Visintin C (2019) 'Predicting deer-vehicle collision risk across Victoria, Australia' Australian Mammalogy 42(3) 293-301.



- Cost to landholders of managing feral deer, such as the cost of ground shooting, fencing the property or replacing damaged property.³⁵
- Competition with livestock for feed. For example, the Tallangatta Valley Landcare group estimates that a mature feral deer eats approximately five times the amount of grass that a mature wether eats in a year.³⁶ When feral deer compete with livestock for their food source farmers are forced to purchase additional fodder or reduce the stocking rate on their farm to ensure that their stock are able to maintain weight, so they are viable to be sold. This additional cost reduces profit margins.
- Risk of disease as feral deer can transmit diseases to livestock (e.g. cattle and sheep). While we have not sought to value this cost, we note that the cost of an outbreak of foot and mouth disease in Australia has been estimated to be between \$6 billion and \$52 billion.³⁷
- **Cost of reduced forestry production** - Reports suggest that feral deer significantly reduce the quality and total volume of timber produced by Victoria's forestry industry, primarily as a result of browsing and bark striping.³⁸
- **Feral deer-related vehicle accidents** (including fatalities, accidents and vehicle-only damage). The presence of feral deer in Victoria have resulted in a number of crashes and accidents, with recent observational data suggesting that there are around 87 feral deer-related accidents in Victoria in 2016.³⁹
- **Cost of managing feral deer by other parties (i.e. beyond the agricultural sector)**, including the Victorian Government. For example, a survey by ABARES found that farm property owners/ operators affected by feral deer spent 20 days managing feral deer on their properties in 2019.⁴⁰
- **Increased cost of water supply, as a result of increased treatment requirements (compared to a sustainable level of feral deer)**. While other animals are known carriers of the parasite, *Cryptosporidium sporidium*, feral deer carry an increased risk as they appear in greater abundance than other host species near Victoria's protected water catchments. Melbourne Water has suggested that failure to adequately control feral deer in the water

³⁵ A survey conducted by the Invasive Species Council of North East Victorian landholders found that 42% of respondents reported costs associated with damage to pasture, crops and trees.

³⁶ See *Submission from the Tallangatta Valley Landcare Group to Senate Inquiry on Impact of feral deer, pigs and goats in Australia May 2021*, p 5.

³⁷ Davis et al (2016) 'A systematic review of the impacts and management of introduced deer (family Cervidae) in Australia' *Wildlife Research* 43, 515-532, 523.

³⁸ Ward, A, White, P, Smith, A and Critchley, C (2004) 'Modelling the cost of roe deer browsing damage to forestry' *Forestry Ecology and Management* 191, 301-310. See also; Reimoser, F, Armstrong, H, Suchant, R (1999) 'Measuring forest damage of ungulates: what should be considered' *Forest Ecology and Management* 120, 47-58.

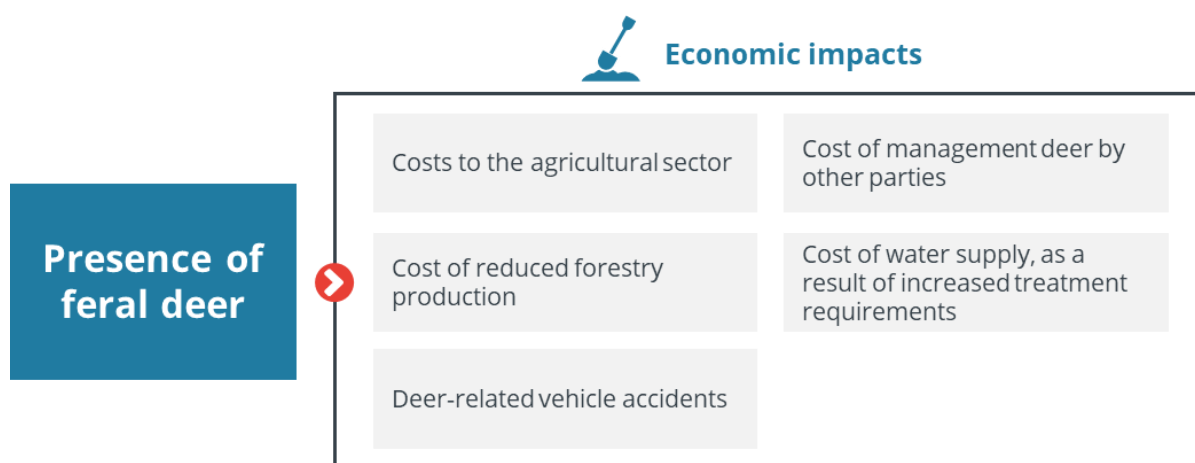
³⁹ <https://www.theage.com.au/national/victoria/the-animal-that-causes-the-most-car-crashes-in-victoria-20160412-go46rw.html>. See also Davies, C, Wright, W, Hogan, F and Visintin C (2019) 'Predicting deer-vehicle collision risk across Victoria, Australia' *Australian Mammalogy* 42(3) 293-301.

⁴⁰ Stenekes N and Kancans, R (2021) 'Pest animal and weed management survey 2016-19: national landholder survey results' Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture, Canberra 2019, 33.



catchments, could result in the need to build costly water-treatment infrastructure to meet water quality standards.⁴¹

Figure 7: How feral deer impact economic outcomes



Source: Frontier Economics

Given information availability and time constraints, this analysis has sought to value the most material economic costs, namely:

- **Costs to the agricultural sector, in the form of lost margin due to grazing and increased costs to landholders of managing feral deer.**
- **Likelihood of feral deer-related vehicle accidents**
- **Lost yield in the forestry production industry**

The following sections provide detail on the economic cost of feral deer, including our approach to valuing these key costs.

Given the lack of information on the impact of feral deer on other costs, we have not been able to robustly value the other broader economic impacts described above. As discussed below, there is likely to be benefit of further research around the impact of feral deer to understand the full cost of feral deer in Victoria.

⁴¹ GHD (2020), Combatting the impact of feral deer on Melbourne's protected water catchments, available at: <https://www.ghd.com/en/perspectives/combating-the-impact-of-feral-deer-on-melbourne-s-protected-water-catchments.aspx>



Box 6: Summary of stakeholder engagement – economic cost of feral deer

Stakeholder engagement raised a variety of economic costs associated with feral deer, specifically for crops and vineyards, such as in Healesville and Yarra Valley. In addition, Panton Hill Winery were not able to produce a chardonnay this year due to feral deer and noted:

“... Samba deer species cleaned off our entire Chardonnay crop and some of our Pinot in one night early in spring, just after fruit set. It is hard on old vines, when they have to regrow their leaves after losing their first lot to deer, in an ever drying climate. Of course we made no Chardonnay this year, one of our Flagship Wines. Samba Deer are also responsible for considerable damage to about 20 of our heritage variety apple trees.”

Dorothy and Teunis Kwak, Panton Hill Winery

Stakeholders informed that feral deer exacerbated the impact of kangaroos, as the feral deer knocked down fences which allowed the kangaroos onto the properties.

While not specifically related to feral deer in Victoria, in a submission to the Senate Inquiry, Mr Ted Rowley a farmer from Jindabyne NSW noted that the presence of feral deer increases the difficulties in maintaining his business ‘bio-security’ status’ “[farmers] need to make statutory declarations that biosecurity plans have been developed and implemented and this is becoming increasingly difficult as the presence of feral deer becomes more entrenched in the landscape”.⁴²

In addition, a range of surveys have investigated the cost to landholders of managing feral deer on their property:

- Arthur Rylah (2008), surveyed 35 ACTW holders who had acquired permits specifically for feral deer and found that the most significant cost of management was associated with building feral deer exclusion fences. Interestingly, participants viewed cost of managing via shooting as negligible because most allowed recreational hunters to hunt feral deer on their property for no cost.⁴³
- ABARES (2016-2020) found that landholders affected by feral deer spent on average 20 days per year managing feral deer at an associated cost of \$2,627 per year.⁴⁴
- A survey conducted by the Invasive Species Council of landholders in North East Victoria found that 60% of respondents reported costs associated with feral deer damaging fences on their property. Additionally, 21% of respondents reported costs associated with construction of feral deer proof fencing.⁴⁵

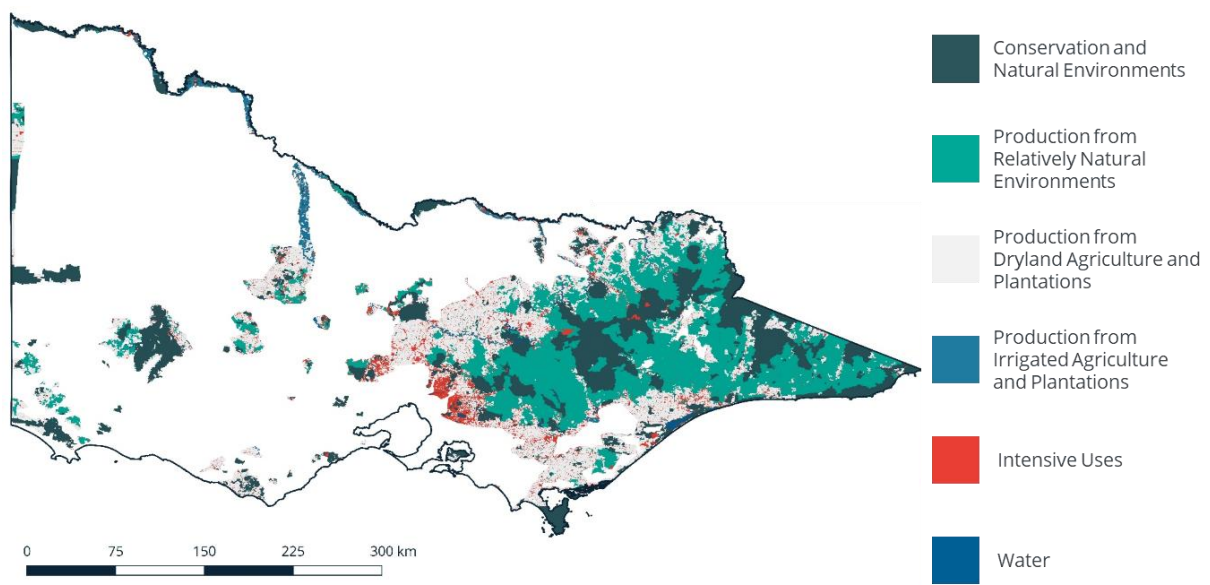
Source: Frontier Economics based on discussions with key stakeholders as part of workshops in April 2022 and one-on-one discussions; Mr Ted Rowley as part of submission 12 to the Environment and Communications Reference Committee inquiry to the impact of feral deer, pigs and goats in Australia; Arthur Rylah Institute; survey results provided by Invasive Species Council.

⁴² Submission from Mr Ted Rowley, farmer from Jindabyne NSW: Environment and Communications Reference Committee, Parliament of Australia, *Impact of feral deer, pigs and goats in Australia* (2021), p 30.

3.2 The agricultural cost of feral deer

It is widely reported that feral deer impact agricultural production values. Our GIS mapping shows feral deer in Victoria are located on the periphery of high value agricultural production land including production from relatively natural environments and production from dryland agriculture and plantations (see **Figure 8**).

Figure 8: Feral deer population distribution in 2021 in Victoria, by land use



Source: Frontier Economics using DELWP and ABARES data. This data is sourced using anecdotal and observational evidence from landholders, community groups and park rangers along with data from the DeerScan app.

Note: The legend reflects ABARES classification

As discussed in more detail below, we have sought to value this agricultural cost of feral deer by investigating in cost arising from lost margin due to grazing and increased costs to landholders of managing feral deer.

As shown in **Table 2**, our analysis indicates that the agricultural cost of feral deer, could be between \$351m (7% discount rate) and \$494m (4% discount rate) (present value (PV) terms \$2021-22).

43

Submission from Mr Ted Rowley, farmer from Jindabyne NSW: Environment and Communications Reference Committee, Parliament of Australia , *Impact of feral deer, pigs and goats in Australia* (2021), p 30.

44

Stenekes N and Kancans, R (2021) ‘Pest animal and weed management survey 2016-19: national landholder survey results’ Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture, Canberra 2019, 33.

45

Information provided confidentially by the Invasive Species Council as part of this analysis.

**Table 2:** Total agricultural cost of feral deer (PV terms, \$2021-22, \$millions)

Impact	7% discount rate (PV)	4% discount rate (PV)
Costs arising from lost gross margin due to grazing	\$245m	\$350m
Costs to landholders associated with managing feral deer	\$106m	\$144m
Total agricultural cost of feral deer	\$351m	\$494m

Source: Frontier Economics analysis

3.2.1 Cost of lost margin due to grazing

Stakeholder consultation and the literature indicated that feral deer are known for grazing on farmland. For example, a submission from a farmer to the Senate Inquiry noted that a fallow deer eats 1.8 to 2.3 times as much as a sheep (Dry Sheep Equivalent (DSE)), while a red or rusa deer eats 2.8 to 3.6 times as much as a sheep.⁴⁶ In addition, the Tallangatta Valley Landcare group estimates that a mature deer eats approximately five times as much as a mature wether sheep.⁴⁷

As shown in **Figure 9**, to estimate the lost margin due to the grazing of feral deer on a property, we multiplied together:

- **Number of feral deer grazing on farm land** (assumed to be 10% of the yearly deer population)⁴⁸
- **Feral deer's grazing DSE equivalent** - To address uncertainty around the 5 DSE number estimated by the Tallangatta Valley Landcare group (feedback from stakeholder noted that the 5 DSE could be related to sambar deer specifically and that fallow are more likely to spend time on grazing land), we have included low, medium and high estimates of 2, 3, and 5.
- **Gross Margin per DSE**, estimated to be between \$13/DSE to \$34/DSE based on Merino wethers.⁴⁹

⁴⁶ Submission from Mr Ted Rowley, farmer from Jindabyne NSW: Environment and Communications Reference Committee, Parliament of Australia, *Impact of feral deer, pigs and goats in Australia* (2021), p 30.

⁴⁷ A wether is a mature castrated or non-lactating sheep. See *Submission from the Tallangatta Valley Landcare Group to Senate Inquiry on Impact of feral deer, pigs and goats in Australia May 2021*, p 5.

⁴⁸ This is likely to be a conservative assumption and was supported by stakeholders.

⁴⁹ To be conservative, we have assumed a lower estimate for gross margin per DSE. Prime lambs return a gross margin of between \$78/DSE to \$86/DSE. See GDRC (2022), 2022 Farm Gross Margin and Enterprise Planning Guide, https://grdc.com.au/resources-and-publications/all-publications/publications/2022/farm-gross-margin-and-enterprise-planning-guide/21112.01-Gross-Margins-Guide-2022_WEB.pdf?utm_source=website&utm_medium=download_link&utm_campaign=pdf_download&utm_term=South&utm_content=2022%20Farm%20Gross%20Margin%20and%20Enterprise%20Planning%20Guide



Figure 9: Approach to valuing the agricultural cost of lost grazing caused by feral deer



Source: Frontier Economics

Our analysis indicates that the cost of lost margin due to grazing for farmers in Victoria is up to \$245m using a 7% discount rate and \$350m using a 4% discount rate (in present value (PV) terms over the next 30 years).

3.2.2 Cost of days spent managing feral deer

An ABAREs survey and discussions with landholders raised that there is an increased cost to landholders (for properties on the periphery of feral deer habitat) of managing feral deer. This management includes the cost of ground shooting, fencing the property or replacing damaged property. ABAREs estimated the number of days spent managing feral deer as 20 per year for affected landholders.⁵⁰

As shown in **Figure 10**, to estimate the cost of the days spent by farmers of managing feral deer, we multiplied together:

- Days per year spent managing feral deer per property, as based on the ABARES survey
- Value of a farmers day, as estimated to be \$40 per hour⁵¹
- Number of properties impacted by feral deer (assumed to be 10% of Victoria's grazing farms)

Figure 10: Approach to valuing the agricultural cost of time spent managing feral deer



Source: Frontier Economics

Our analysis indicates that the cost of time spent managing feral deer in Victoria is up to \$106m using a 7% discount rate and \$144m using a 4% discount rate in PV terms over the next 30 years.

⁵⁰ Stenekes N and Kancans, R (2021) 'Pest animal and weed management survey 2016-19: national landholder survey results' Australian Bureau of Agricultural and Resource Economics and Sciences, Department of Agriculture, Canberra 2019, 33.

⁵¹ Note that \$40 an hour is a conservative estimate. Victorian Department of Treasury and Finances' Time-Cost Calculation tool for Regulatory Impact Statements suggest that a wage rate in 2022 could be between \$76/hour to \$130/hour depending on the skill level. See <https://www.dtf.vic.gov.au/sites/default/files/2018-02/Victorian%20Government%20time%20cost%20calculator.xls>



3.3 Cost of reduced forestry production

Reports suggest that feral deer significantly reduce the quality and total volume of timber produced by Victoria's forestry industry.⁵² Current feral deer distribution mapping shows that there are established feral deer populations on large areas of both commercial plantation forests and production native forests (see **Figure 8**). The main impacts of feral deer in forests are browsing and bark-stripping.

Browsing has little impact on individual tree survival, especially after the first five years of growth.⁵³ Nevertheless, it has a significant economic impact, because it increases the establishment period and management burden for affected trees.⁵⁴ Damage from browsing leads to a decrease in growth rate, deformation of trees and increased need of replanting. The effect of this is widespread across the forestry industry, with certain forests in north-eastern Victoria showing browsing damage of up to 30% of trees under five years of age.⁵⁵

Bark-stripping occurs when feral deer bite and rub their antlers against the trunks of mature trees. This degrades the overall health and quality of the tree. Reimoser *et al* concluded that bark stripping or 'peeling' leads to *"wound rot, grading losses, increased harvesting costs, increased manipulation costs, additional management measures, increased danger of blowdown... [and] artificial instead of natural regeneration"*.⁵⁶

As shown in **Figure 11**, to estimate the cost of reduced forestry production, we multiplied together:

- **Volume of forestry production lost due to feral deer** - The current annual harvest volume of Victoria's forestry industry is 9 million cubic metres.⁵⁷ Given the impact that feral deer have in forests, this volume does not reflect the industry's total production capacity. We have assumed that 40% of Victoria's forests experience a 5.5% yield loss from deer.⁵⁸
- **Mill price** calculated as between \$72/m³ and \$129/m³⁵⁹

⁵² Ward, A, White, P, Smith, A and Critchley, C (2004) 'Modelling the cost of roe deer browsing damage to forestry' *Forestry Ecology and Management* 191, 301-310. See also; Reimoser, F, Armstrong, H, Suchant, R (1999) 'Measuring forest damage of ungulates: what should be considered' *Forest Ecology and Management* 120, 47-58.

⁵³ Ward, A, White, P, Smith, A and Critchley, C (2004) 'Modelling the cost of roe deer browsing damage to forestry' *Forestry Ecology and Management* 191, 301-310.

⁵⁴ Reimoser, F, Armstrong, H, Suchant, R (1999) 'Measuring forest damage of ungulates: what should be considered' *Forest Ecology and Management* 120, 47-58; Ward, A, White, P, Smith, A and Critchley, C (2004) 'Modelling the cost of roe deer browsing damage to forestry' *Forestry Ecology and Management* 191, 301-310.

⁵⁵ Deborah Kerr, CEO Victorian Forests Products Association, available at <https://www.timberbiz.com.au/time-to-manage-feral-deer-in-victoria/>.

⁵⁶ Reimoser, F, Armstrong, H, Suchant, R (1999) 'Measuring forest damage of ungulates: what should be considered' *Forest Ecology and Management* 120, 47-58.

⁵⁷ Victorian Department of Jobs, Precincts and Regions (2022), Victoria's forestry industry, available at <https://djpr.vic.gov.au/forestry>.

⁵⁸ Ward, A, White, P, Smith, A and Critchley, C (2004) 'Modelling the cost of roe deer browsing damage to forestry' *Forestry Ecology and Management* 191, 301-310. These values were supported in stakeholder consultation.

⁵⁹ In FY22. See NSW DPI, Forestry, available at <https://www.dpi.nsw.gov.au/about-us/publications/pdi/2020/forestry>.

Figure 11: Approach to valuing lost forestry production



Source: Frontier Economics

As shown in **Table 3**, our analysis indicates that the cost of feral deer-related lost forestry production could be between \$269m (7% discount rate) and \$365m (4% discount rate), in PV terms, over the next 30 years.

Table 3: Total cost of lost forestry production (PV terms, \$2021-22, \$millions)

Impact	7% discount rate (PV)	4% discount rate (PV)
Costs arising from lost forestry production	\$269m	\$365m

Source: Frontier Economics analysis

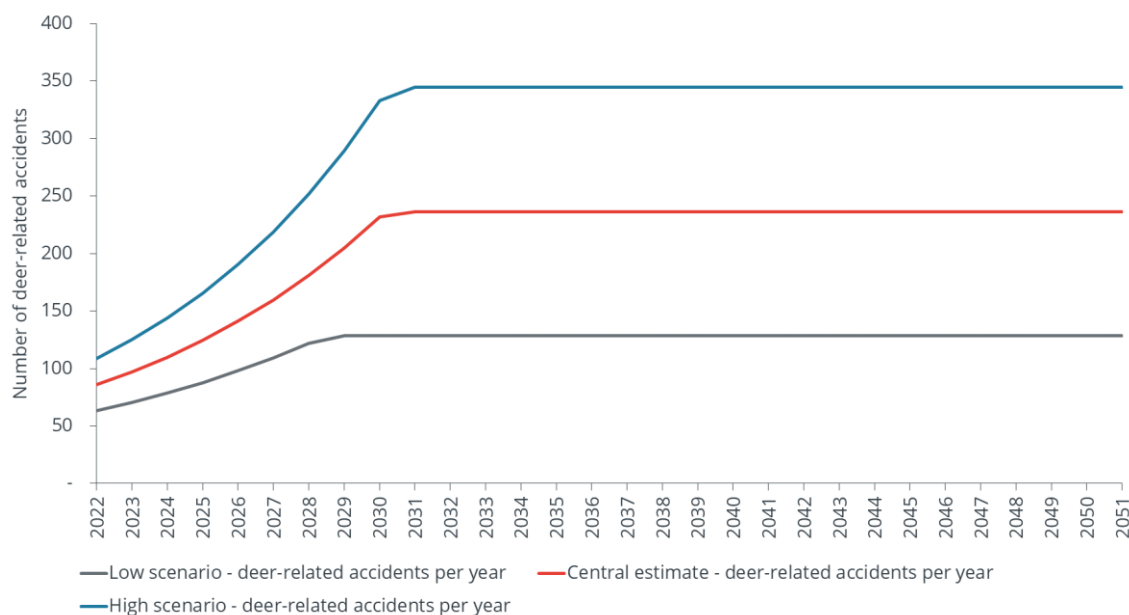
3.4 The cost of increased likelihood of feral deer-related vehicle accidents

As discussed above, evidence from the RACV suggests that the presence of feral deer in Victoria have resulted in a number of vehicle crashes and accidents, with 87 car accidents attributed to feral deer in 2016.⁶⁰ Feral deer may charge or kick people if they feel threatened and given their size, they can cause significant and even fatal injuries if they are struck by a vehicle.

While recent data suggests that there are around 87 feral deer-related accidents in Victoria annually, this number is likely to increase significantly with feral deer population growth. As shown in **Figure 12**, based on our forecast feral deer population and assumed rate of road utilisation, feral deer-related accidents could be as high as 345 per year by 2050.⁶¹

⁶⁰ <https://www.theage.com.au/national/victoria/the-animal-that-causes-the-most-car-crashes-in-victoria-20160412-go46rw.html>. See also Davies, C, Wright, W, Hogan, F and Visintin C (2019) 'Predicting deer-vehicle collision risk across Victoria, Australia' *Australian Mammalogy* 42(3) 293-301.

⁶¹ Using the high population scenario. It could be as low as 142 accidents (using a low population scenario).

**Figure 12:** Forecast number of feral deer-related accidents per year

Source: Frontier Economics

As shown in **Figure 13**, to estimate the potential future cost of these feral deer-related vehicle accidents, we multiplied together:

- A forecast of the number of feral deer-related accidents per year, absent any further management interventions. This is a function of forecast feral deer population and assumed rate of road utilisation (which in turn, depends on the rate of human population growth).
- The proportion of total accidents that were fatal, non-fatal and vehicle-only accidents in 2019, based on information from VicRoads.⁶²
- An estimate of the standard cost of crashes from ATAP.⁶³ These estimates include both the human cost (e.g. injuries) and the financial cost of crashes, including:
 - Costs associated with repair the damaged vehicle.⁶⁴
 - Cost of time associated with any resulting delays.
 - Costs to drivers and passengers associated with injuries.
 - Costs to families and friends of victims of accidents, associated with caring for the victims.

While there are well-established, publicly available information around the cost of various types of vehicle accidents from ATAP, stakeholder consultation raised that the cost of vehicle repair for feral deer-related accidents was significantly larger than for a kangaroo due to its

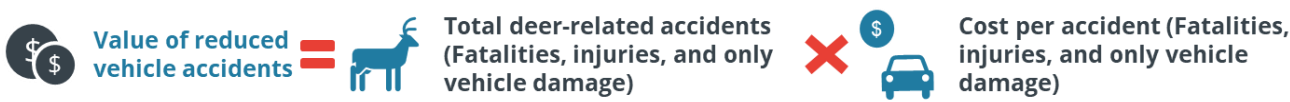
⁶² VicRoads (2019), Interactive Crash Statistics, available at: https://public.tableau.com/views/CrashstatMainlandingpage/Mainpage?:embed=y&:display_count=yes&:showTabs=y&:showVizHome=no&:Adisplay_count=yes&:Atoolbar=no&:Arender=false#1

⁶³ ATAP (2013), Crash costs, available at: <https://www.atap.gov.au/parameter-values/road-transport/4-crash-costs>

⁶⁴ This is currently \$11,000 based on ATAP parameters. Stakeholder consultation raised that this could be closer to \$30,000 due to the size of the animal.

size - \$30,000 compared with \$2,000 to \$4,000. ⁶⁵ As such, while our analysis adopts the ATAP estimates as our central estimate, we have also included sensitivity analysis around the cost of crashes.

Figure 13: Approach to valuing feral deer-related accidents per year



Source: Frontier Economics

As shown in **Table 4**, our analysis indicates that the cost of increased likelihood of feral deer-related vehicle accidents, could be between \$576m (7% discount rate) and \$825m (4% discount rate), in PV terms, over the next 30 years.

Table 4: Total cost of feral deer related accidents (PV terms, \$2021-22, \$millions)

Impact	7% discount rate (PV)	4% discount rate (PV)
Costs arising from feral deer related accidents	\$576m	\$825m

Source: Frontier Economics analysis

3.5 Accounting for uncertainty

As discussed above, given information availability, our analysis is subject to a range of uncertainties. Consistent with best practice, to account for this uncertainty, our analysis includes sensitivity and scenario analysis around the key assumptions.

The results of the sensitivity and scenario analysis are presented in **Table 5**, and grouped into a low scenario (which represents a lower estimate of the economic cost imposed by feral deer) and a high scenario (which represents a higher estimate of the economic cost imposed by feral deer).

⁶⁵ Stakeholder feedback was provided to Frontier Economics and the Invasive Species Council as part of a range of workshops in April 2022.



Table 5: Economic cost of feral deer – results of the sensitivity and scenario analysis (PV terms, \$2021-22, \$millions)

Impact	7% discount rate (PV)	4% discount rate (PV)
Low scenario		
Costs arising from lost gross margin due to grazing	\$50m	\$71m
Costs to landholders associated with managing feral deer	\$96m	\$130m
Costs associated with increased likelihood of feral deer-related vehicle accidents	\$86m	\$121m
Costs arising from lost forestry production	\$175m	\$237m
Total	\$407m	\$558m
High scenario		
Costs arising from lost gross margin due to grazing	\$787m	\$1,134m
Costs to landholders associated with managing deer	\$117m	\$158m
Costs associated with increased likelihood of feral deer-related vehicle accidents	\$1,168m	\$1,683m
Costs arising from lost forestry production	\$330m	\$447m
Total	\$2,402m	\$3,422m

Source: Frontier Economics analysis



4 Social and cultural impacts

Key points

- Various studies and anecdotal evidence have found a link between the presence of feral deer in Victoria and a range of social and cultural impacts, including reduced opportunity for and amenity of recreation, risk of disease and impact on indigenous cultural heritage.
- Our analysis has estimated the social cost of feral deer to be between \$308m (7% discount rate) and \$474m (4% discount rate) (in PV terms, over the period to 2051), comprised of costs from reduced opportunity for recreation opportunities.
- Given the availability of information we have sought to include the impact on the risk of disease and indigenous cultural heritage in our analysis qualitatively.

4.1 The link between feral deer and social and cultural outcomes

Various studies have found a link between the presence of feral deer in Victoria and a range of social and cultural costs.⁶⁶ As shown in **Figure 14**, these include:

- **Impact on amenity and recreation opportunities in national and local parks, including:**
 - **Reduced opportunity for, and amenity of, active recreation** (e.g. hiking and cycling) as a result of erosion paths, increased feral deer-related accidents (e.g. hikers and cyclists feel less safe when they encounter large animals). Analysis suggests that the extensive damage to the natural environment caused by feral deer can negatively affect visitors hiking, camping and sightseeing experiences.
 - **Reduced amenity associated with passive recreation** (such as sightseeing and tours in parks) as a result of the degradation of the natural environment, such that parks have a lower aesthetic value.
- **Increased risk of disease** – Deer can transmit diseases (such as cryptosporidiosis, neosporosis and leptospirosis) to humans, livestock and other animals and can lead to serious economic and social impacts.
- **Impact on indigenous cultural heritage**, including soil compaction and erosion, damage to native plant species and competition with native species for grazing in grassy, shrubby and herb-rich woodlands.

⁶⁶ See for example Claridge, A.W (2016) Synopsis of perceptions about introduced deer among park management ranger staff across the Australian Alps, NSW National Parks and Wildlife Service; Brown, D, Thomas, E, Herbert K and Primrose K (2016) 'Evaluating the effects of feral deer management on endangered alpine peatlands: The Alpine National Park deer control trial' *Plant Protection Quarterly* 31(2) 63-66; Davis et al (2016) 'A systematic review of the impacts and management of introduced deer (family Cervidae) in Australia' *Wildlife Research* 43, 515-532.



Figure 14: How feral deer impact social and cultural outcomes



Source: Frontier Economics

While our analysis focuses on the cost imposed by feral deer, we note that there may be benefits associated with the presence of feral deer in the landscape (for example, arising from hunting of feral deer). However, to adequately model these benefits would require understanding the ‘tipping point’. That is, the number of feral deer that need to be present in the landscape to deliver these benefits. As discussed below, there is likely to be value in undertaking further work to understand the impact of feral deer in Victoria.

Given information availability and time constraints, this analysis has sought to value the most material social costs where information is readily available, namely, the reduced opportunity for and amenity of active and passive recreation. Given timing constraints we have relied on a travel cost study that valued recreation in parks in Victoria. This is explained in further detail below.

4.2 The cost of feral deer on recreation opportunities in parks in Victoria

Parks in Victoria are valuable resources in part because it is used for a wide range of recreational activities. Parks Victoria publish visitor numbers regularly with 57.3 million visitors report in 2020-21.⁶⁷ The purpose of the visits to the park and activities undertaken include:

- Physical activity or sport (75%),
- Sightseeing and spectating (35%)
- Socialising & children’s play
- Journey or tour (20%)
- Eating and drinking
- Overnight stays

⁶⁷ Parks Victoria Annual Report 2020-21. This report includes the number of visits to all parks (including metro parks). We are assuming that visits to national and state parks make up two thirds of this total visits number, given the historical composition of total visits, as reported in previous annual reports



Not all visitor activities are impacted by feral deer or impacted to the same extent. Given the impacts of feral deer in parks in Victoria, the activities most materially affected by feral deer are likely to be physical activity, sightseeing and spectating, and journeying and touring. Participants in these activities are therefore most likely to benefit from a reduction in feral deer numbers.

As shown in **Figure 15**, we have estimated the value of recreation-related impacts of feral deer by multiplying together:

- Number of park visitors and population affected by feral deer - To forecast adult visitor numbers we adjusted the historical, total visitor numbers for national and state parks in Victoria,⁶⁸ and assumed an annual growth rate in adult visitor numbers of 6% going forward.⁶⁹ Only those activities (or reasons for visiting) that are likely to be affected by the presence of feral deer. On this basis we have only included physical activity, sightseeing and spectating, and journeying and touring.⁷⁰
- Indicative recreation values per visit – We have drawn on information provided by Parks Victoria (**Box 7**)
- Reduction in park visitors as a result of feral deer – While the increasing presence of feral deer will not prevent all physical activity, sightseeing and spectating, and journeying and touring from taking place, growing feral deer numbers may discourage, or reduce the quality of, some of recreational activity at the margin. As feral deer spread to cover new areas of the park, additional recreational users will be impacted. This may manifest in lower rates of visitation or at a lower associated benefit per visit (i.e. lower willingness to pay to engage in the recreation activity) than might otherwise have occurred.
- Visitor population affected by feral deer – to be conservative, we have assumed more ecologically sustainable levels of feral deer in Victoria would either increase visitor numbers to parks in Victoria or increase the enjoyment of existing users (who would otherwise be affected by feral deer) by 1%.⁷¹

Figure 15: Calculating the value of lost recreational opportunities from managing feral deer



Source: Frontier Economics

⁶⁸ Parks Victoria Annual Reports 2012-13 to 2020-21.

⁶⁹ To adjust the historical visitor numbers and estimate adult visitor numbers, we started with historical estimates from Parks Victoria annual reports. We then forecast visitor numbers using a historical CAGR moving forward.

⁷⁰ For the low scenario we have excluded visitors who use the park for physical activity, we have assumed one quarter of visitors who use the park for physical activity are impacted by feral deer under the central scenario, we have assumed one third of visitors who use the park for physical activity are impacted by feral deer under the high scenario.

⁷¹ While the negative impact of feral deer may differ across recreational activities in the park, the available research does not enable us to extrapolate specific impacts by activity. To account for this limitation, we have adopted a conservation estimate of the incremental impact of feral deers (1%).

Box 7: Understanding the recreational cost of feral deer

Parks Victoria (2015) published the indicative recreation values per visit to Parks Victoria as \$32 per visit for national parks and \$11 for state parks.⁷² These values were based on the travel cost method study by Read Sturgess (1999).⁷³ The travel cost method, uses data collected from park users about their place of residence, purpose of visiting, frequency of visits, cost of visiting and other socio-economic information to derive the relationship between visitation and travel cost. Together this information reveals people’s preferences for certain recreational experiences and a minimum estimate of their willingness to pay for the activity – based on the costs of travelling to the site for that experience. This method has frequently been used to estimate the value of tourism and recreation at existing parks.

This study can be used to generate estimates of the cost of feral deer populations on the value of recreational opportunities in Parks in Victoria. We have adjusted this analysis to only focus on adult visitor numbers over the next 30 years.⁷⁴

As shown in **Table 6**, our analysis indicates that the cost of reduced opportunity for, and amenity of, recreation from feral deer could be between \$308m (7% discount rate) and \$474m (4% discount rate), in PV terms, over the next 30 years.

Table 6: Total social cost of feral deer (PV terms, \$2021-22, \$millions)

Impact	7% discount rate (PV)	4% discount rate (PV)
Cost of reduced opportunity for, and amenity of, recreation	\$308m	\$474m

Source: Frontier Economics analysis

4.3 Accounting for uncertainty

As discussed above, given information availability, our analysis is subject to a range of uncertainties. Consistent with best practice, to account for this uncertainty, our analysis includes sensitivity and scenario analysis around the key assumptions.

The results of the sensitivity and scenario analysis are presented in **Table 7**, and grouped into a low scenario (which represents a lower estimate of the economic cost imposed by feral deer) and a high scenario (which represents a higher estimate of the economic cost imposed by feral deer).

72

Parks Victoria (2015) 'Valuing Victoria's Parks Report: Accounting for ecosystems and valuing their benefits', p. 107

73

Read Sturgess and Associates 1999. Economic assessment of the recreational values of Victorian Parks. Consultancy undertaken for Department of Natural Resources and Environment. April 1999.

74

It is likely that the value of recreation estimated using the travel cost method includes an estimate of the opportunity cost of time, based on earnings (which are higher for an adult, than a child). As such, to be conservative, we have only included adult visitor numbers in our estimate, and therefore, our estimate of future visitor numbers can be thought of as a lower bound.

**Table 7:** Sensitivity analysis for social cost of feral deer (PV terms, \$2021-22, \$millions)

Impact	7% discount rate (PV)	4% discount rate (PV)
Low scenario		
Cost of reduced opportunity for, and amenity of, recreation	\$117m	\$181m
High scenario		
Cost of reduced opportunity for, and amenity of, recreation	\$497m	\$765m

Source: Frontier Economics analysis



5 The environmental cost of feral deer

Key points

- There is a range of literature and anecdotal evidence to suggest that the feral deer in Victoria are having a significant negative impact on the ecosystems and environment in national and state parks in Victoria.
- However, there is a significant gap in the literature of studies attempting to value this non-use benefit through willingness to pay studies in Victoria or a similar jurisdiction.
- Given the availability of information, we have sought to include this potentially significant environmental cost of feral deer in our analysis qualitatively.

5.1 The link between feral deer and environmental outcomes

There is significant literature and anecdotal evidence (see Box 8) to suggest that the feral deer in Victoria are having a significant negative impact on the ecosystems and environment in national and state parks in Victoria. As shown in **Figure 16**, these include:

- **Negative impact on biodiversity**, including spreading weeds, trampling understory, stripping and ring barking (as a result of rubbing antlers on trees) and competing with native wildlife for food. This is likely to be exacerbated in fire-affected areas, where the presence of feral deer has impeded regrowth and regeneration.
 - For example, Sambar Deer were listed as a potentially threatening process to native vegetation under Victoria's Flora and Fauna Guarantee Act 1988 (FFG Act) in 2007. At this time, the species was considered a threat to at least 13 threatened flora species and 12 ecological communities, some of which are threatened, including Alpine Sphagnum Bogs and associated fen.⁷⁵
- **Reduced health of rivers and waterways**, through grazing, localised soil compaction and erosion and by transplanting foreign soil / faeces into bogs and peatlands.

⁷⁵ Department of Environment, Land, Water and Planning (2020), Victorian Deer Strategy, p 10.

**Figure 16:** How feral deer impact environmental outcomes

Source: Frontier Economics

Box 8: Summary of stakeholder engagement – environmental cost of feral deer

Analysis by DELWP as part of the *Victorian Deer Control Strategy 2021* suggests that over a thousand species of flora and fauna would benefit from feral deer control efforts across the state. Feral deer populations can significantly reduce the health of natural ecosystems, by contributing to shrub and ground layer disturbance, plant and habitat destruction through grazing, localised soil compaction and erosion, degradation of waterways and the spread of weeds into new areas. These impacts collectively disrupt the overall viability and function of ecosystems and landscapes in which feral deer are present.

At some rainforest sites in Victoria, feral deer threaten ‘key structural species’, such as Yellowwood (*Acronychia oblongifolia*) and Mutton-wood (*Rapanea howittiana*). Reduction in these individual plants implies a much broader environmental impact. Seedlings and plants with new shoots are particularly attractive to feral deer, and their reduction will result in changed vegetation structures and reduced species diversity.

Feral deer were also found to have a negative impact of alpine bogs and fens in the Alpine National Park which are listed as an endangered ecological community under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999. A study to the Australian Alps Liaison Committee found evidence of feral deer at 80% of monitored bog sites. Feral deer damage bog sites by trampling the native vegetation, browsing and dissipating weeds into the sites. Wallow formation because of feral deer turn the bog sites into muddy quagmires which has material negative implications for water quality.

Source: DEWLP (2020), *Victorian Deer Strategy*; Pitcock J and Finlayson M (2018), ‘Impacts to water: feral horse impacts and water resources in southern eastern Australia.’ 64-67. Abstract from *Feral horse impacts: the Kosciuszko Science Conference, Canberra*; and Claridge, A.W. (2016), *Ecological and agricultural impacts of introduced deer in the Australian Alps. A final report to the Australian Alps Liaison Committee. NSW National Parks and Wildlife Service, Queanbeyan NSW, Australia.*

In particular, studies and stakeholder consultation found that feral deer damage the function and value of bogs (see for example, **Figure 17** and **Figure 18**, which illustrate the negative impact of feral deer on peatlands and bogs in Victoria). Sphagnum bogs in the Australian Alps provide habitat and refuge for many plants and animals, some of which are rare and threatened species,



(e.g., the Alpine Marsh Marigold).⁷⁶ Furthermore, bogs and peatlands in the Australian Alps serve an important function in the surrounding network of rivers including those in the Murray Darling Basin and the Snowy River. The 'water storage and release from alpine Sphagnum bogs ameliorates seasonal variations to sustain a higher volume and quality of base flow in the Murray Darling and Snowy rivers.'⁷⁷

Figure 17: Impacts of feral deer on peatlands and bogs in Alpine National Park, Victoria



Source: Invasive Species Council

⁷⁶ For an expansive list of the species refer to the EPBC Act list of threatened species and the National Recovery Plan for the Alpine Sphagnum Bogs and Associated Fens. See Department of the Environment (2015) 'National recovery plan for the Alpine Sphagnum Bogs and Associated Fens ecological community'. Department of the Environment, Canberra.

⁷⁷ Pitcock J and Finlayson M (2018), 'Impacts to water: feral horse impacts and water resources in southern eastern Australia.' 64-67. Abstract from Feral horse impacts: the Kosciuszko Science Conference, Canberra.



Figure 18: Feral deer wallow Warrandyte



Source: Invasive Species Council

Feral deer are threatening environmental function by mainly grazing and browsing and being a physical disturbance. This results in a loss of plant biomass, decline in plant diversity and comprised regeneration. The movement of feral deer compacts the soil and results in the creation of tracks which facilitates frost heave and erosion. The tracks also facilitate weed spread by creating gaps in the vegetation for weeds to germinate.

The presence of feral deer is also affecting the ability of Victoria's natural environment to regenerate after the 2019-20 bushfires. We note that, to address this, Parks Victoria and DELWP are implementing a large-scale, coordinated feral deer and other feral animal control program in parks and reserves across Eastern Victoria and in the Budj Bim National Park in Western Victoria.⁷⁸

5.2 Estimating the environmental cost of feral deer

Importantly, the likely significant detrimental impact of feral deer on habitats, water quality, ecosystems and species within parks in Victoria, is not solely linked to the use value of the park (discussed above). Separate from the use that a visitor derives from using the park or area, the community derives a benefit associated with environmental assets regardless of whether they use it. These are known as non-use values.

Unfortunately, non-use values are often more difficult to monetise than use-values. Often it requires a rigorously prepared contingent valuation survey that can clearly articulate to the respondent the change in outcomes they are being asked to value (in this case the impact of reducing feral deer numbers on environmental outcomes).

⁷⁸

<https://www.parks.vic.gov.au/projects/deer-and-feral-animal-control-in-response-to-bushfire>



There is a significant gap in the literature of studies attempting to value this non-use benefit through willingness to pay studies in Victoria or a similar jurisdiction. While some studies have attempted to investigate the communities' willingness to pay for environmental outcomes (non-use benefits), given the limitations discussed in **Box 9**, these are likely to represent a lower-bound of environmental costs related to feral deer.

Given these limitations, we have sought to include this cost qualitatively in our analysis.

Box 9: Understanding the environmental cost of feral deer

A 2019 study attempted to value this non-use benefit through a study, valued the community willingness to pay for ecological restoration in Australia. However, we note that, as this study was a general willingness to pay study for ecological restoration in Australia, rather than ecological restoration of specific parks in Victoria, there are a few limitations which mean that applying this study to the Victorian feral deer context is unlikely to accurately measure the full environmental cost imposed by feral deer in Victoria. These include:

- The study was based on a park of a specific size, rather than all parks in Victoria;
- The activities involved in ecological restoration were not specifically tied to actions related to feral deer;
- The study was not tied to specific ecological costs of feral deer.

For these reasons, it is likely that this willingness to pay study represents a lower-bound of the environmental (non-use) cost associated with feral deer.

Source: Wilson, K.A, Davis, K.J, Matzek, V and Kragt, M.E (2019) 'Concern about threatened species and ecosystem disservices underpin public willingness to pay for ecological restoration' Journal of the Society for Ecological Restoration 27(3), 513-519, 516-517



6 Results

Key points

- The benefits of more substantive and sustainable feral deer management could be significant, with our analysis indicating that the cost of feral deer could be over \$1.5bn (7% discount rate) or \$2.2bn (4% discount rate) (in PV terms, over the next 30 years).
- Although our analysis has sought to value, as much as is practicable, the benefits associated with managing feral deer in Victoria, as discussed above there are a range of unquantified impacts in this analysis. This suggests that the true cost to the community of feral deer in Victoria could be larger.
- As the population of feral deer is increasing, acting decisively and quickly is the most cost-effective way to remove feral deer, as there is less feral deer to remove. If action to address feral deer is taken in 2022, the cost of removing feral deer could be between \$338m and \$581m (depending on the population scenario).

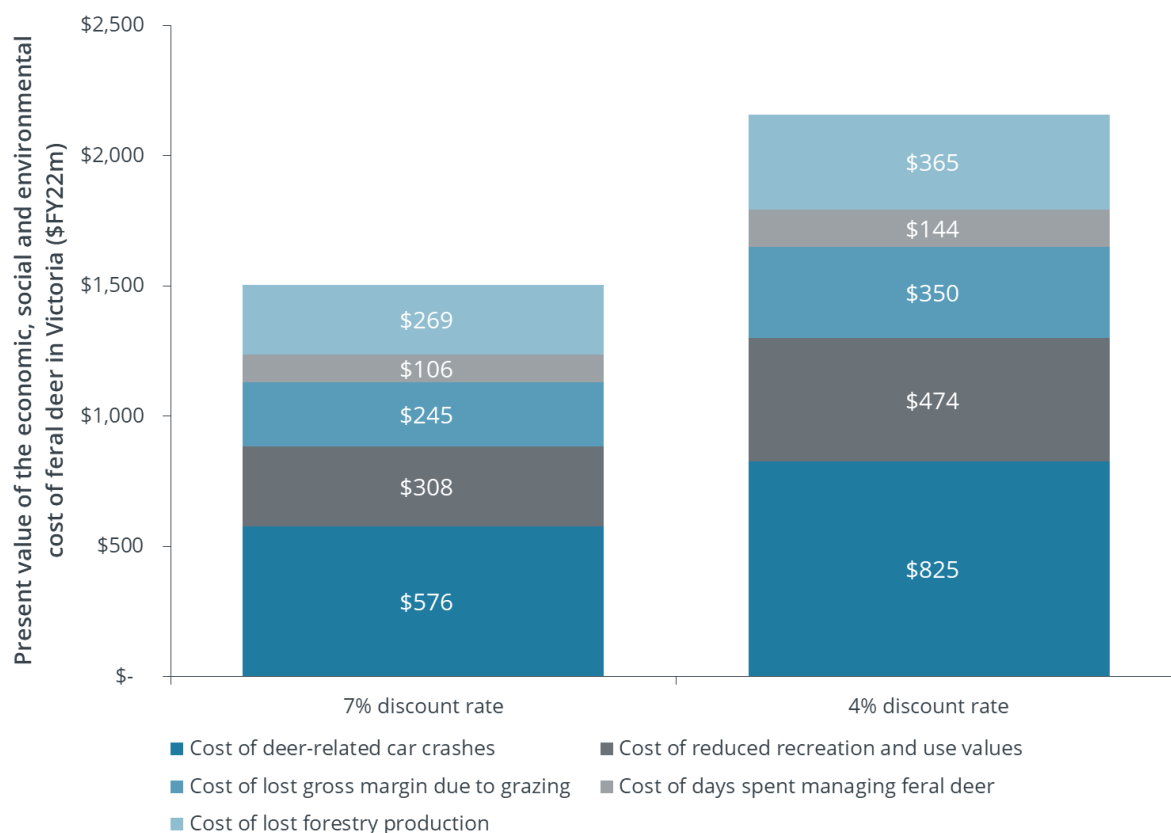
6.1 The benefits of more substantive and sustainable feral deer management could be significant

As shown in **Figure 19**, depending on the discount rate, our analysis estimates that the economic, social, cultural and environmental cost of feral deer in Victoria to be **\$2.2bn** (4% discount rate) or **\$1.5bn** (7% discount rate), in PV terms over the next 30 years. This is made up of:

- **\$245m to \$350m in costs from lost gross margin due to grazing** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This is based on the assumption that 10% of the feral deer population are grazing on farmland which takes away the opportunity for a farmer to fully stock that land for grazing, meaning the farmer loses the income they would have received from extra stock on their land.
- **\$106m to \$144m in costs from days spent managing feral deer** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This is based on a farmer spending 20 days a year managing feral deer on their properties.
- **\$269m to \$365m in costs from lost forestry production** in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This is based on the reduced forestry production due to grazing and trampling of feral deer through plantations, meaning forests are not producing at their full potential.
- **\$576m to \$825m in costs from feral deer-related vehicle accidents** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This assumes that all future feral deer related crashes on highways within Victoria can be avoided.
- **\$308m to \$474m in costs from reduced recreation and use values** (in PV terms, over the next 30 years, 7% and 4% discount rate, respectively). This is based on the assumption that uses of Victorian national and state parks for recreation will be dampened by 1% due to the impact of feral deer.



Figure 19: Economic, social, cultural and environmental costs of feral deer in Victoria over the period to 2051 (\$millions, \$2020-21, PV terms)



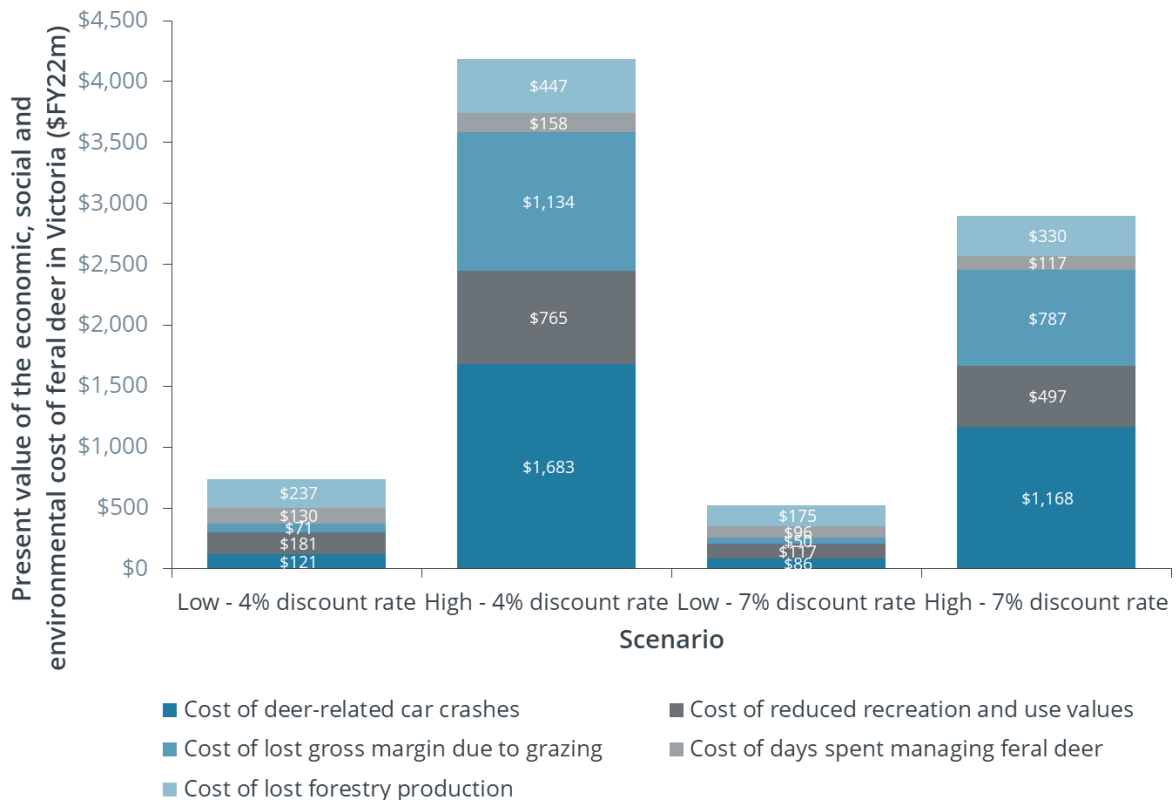
Source: Frontier Economics

As discussed above, given information availability, our analysis is subject to a range of uncertainties. Consistent with best practice, to account for this uncertainty, our analysis includes sensitivity and scenario analysis around the key assumptions.

The results of the sensitivity and scenario analysis are presented in **Figure 20** and grouped into a low scenario (which represents a lower estimate of the economic cost imposed by feral deer) and a high scenario (which represents a higher estimate of the economic cost imposed by feral deer). **The findings of our scenario analysis suggest that the cost of feral deer could be between \$525m to \$2.9bn (in PV terms, 7% discount rate) and \$739m and \$4.2bn (PV terms, 4% discount rate).**



Figure 20: Sensitivity analysis: Economic, social, cultural and environmental benefits associated with feral deer management in Victoria over the period to 2051 (\$millions, \$2020-21)



Source: Frontier Economics

6.2 The unquantified impacts mean that the cost of feral deer may be higher than estimated

Although our analysis has sought to value, the costs of feral deer in Victoria, as discussed, given data availability (around both the change in outcomes and the appropriate willingness to pay or cost), this figure does not capture a range of potentially significant costs of feral deer. These include the impact of feral deer on:

- cost of managing feral deer by other parties
- cost of water supply
- risk of disease
- indigenous cultural heritage
- biodiversity
- health of rivers and waterways

As such, it is likely that the true economic, social and environmental cost imposed on the community as a result of feral deer in Victoria is larger than estimated as part of this report.



We have sought to include these impacts qualitatively given gaps in the literature and data constraints, including:

- Insufficient baseline scientific research and data around the magnitude of change in key social, cultural and environmental outcomes and how this relates to growing feral deer populations in Victoria.
- Limited primary economic data around the community's willingness to pay for changes in key social and environmental outcomes related to the presence of feral deer in Victoria (such as changes in environmental outcomes)
- Lack of information on other impacts such as the impact of feral deer on maintenance and replacement costs in Victoria's parks.
- The benefit derived from hunting feral deer (including amenity and social values) and the number of feral deer necessarily to deliver this benefit.

Understanding the change in outcomes and the appropriate price is critical to robustly value the economic, social and environmental benefits of managing feral deer within Victoria. Given the significant impact of feral deer in Victoria, there is likely to be benefit in undertaking further analysis to better understand the magnitude of the problem and therefore, the benefit from action.

However, even if these uncertainties could be resolved with more research, given the conservative approach we have taken, improved information is more likely to increase the benefits of control, thereby reinforcing the conclusion that controlling feral deer is net beneficial.

6.3 The costs of acting quickly and decisively to remove feral deer will be lower than the cost of feral deer on the community

Management of feral deer will include the cost of the management action itself, and the broader social costs associated with their removal, including the lost amenity and non-use value given reduced feral deer numbers (e.g. the 'feel good factor' from the existence of feral deer).

However, the uncertainty around the number and distribution of feral deer in Victoria makes it difficult to quantify the exact cost of the feral deer management in Victoria. As discussed in **Box 10**, the marginal cost of removing feral deer is greatly dependent on the location, density of feral deer, and management technique, and some management methods are not suitable for some areas of Victoria. That being said, analysis by the Invasive Species Council estimate the average cost of removal to be \$404 per feral deer (taking into account the average number of feral deer controlled per hour from aerial shooting).⁷⁹

⁷⁹

Estimated by the Invasive Species Council (2022) based on information provided by Parks Victoria and the Department of Environment, Land, Water and Planning.



Box 10: Indicative cost of removing feral deer

As discussed in **Section 2.4**, there are a range of methods available to control feral deer numbers, many of which are currently adopted in Victoria. Each of these methods is likely to be associated with different costs.

For example, analysis by the Invasive Species Council estimates the average cost of removal to be \$404 per feral deer. This is based on information provided by Parks Victoria and DELWP around the cost of hiring a helicopter, labour and ammunition and assumptions around the number of feral deer controlled per hour.

Evidence suggests that the effectiveness of control methods will vary depending on the type of feral deer. For example, analysis has found helicopter-based shooting has an effectiveness of between 5% to 75% for fallow deer, and between 48% to 88% for chital deer.

In addition, an American organisation 'White Buffalo Inc' estimated the cost of controlling feral deer under different control mechanisms in America, to be:

- Fertility control: \$700 to \$2,101 AUD per doe treated, including the cost of manpower and materials
- Sharpshooting: \$280 to \$560 per deer for sharpshooting, and processing is an additional \$70-\$125 per deer
- Managed hunts: \$140 to \$280 per deer (depending on the manpower required).

Note: Exchange used for calculation is \$1 USD equal to \$1.40 AUD as per exchange rate on 27 May 2022

Source: Invasive Species Council; <https://www.publish.csiro.au/WR/justaccepted/WR21156>;

<https://www.whitebuffaloinc.org/deer-management>

As the population of feral deer is increasing, acting decisively and quickly is the most cost-effective way to remove feral deer (as there is less feral deer to remove). If management is taken in 2022, the cost of removing feral deer could be between \$338m and \$581m (depending on the population scenario).⁸⁰ This pales into insignificance when compared to the potential cost of feral deer in Victoria if action is not taken.

Our findings highlight the need for decisive action to manage the feral deer population in Victoria. The longer we delay the larger the population of feral deer and the greater the cost of inaction. In other words, a strategy that quickly and significantly reduces feral deer numbers will deliver greater benefits than a slower and tentative response, while at the same time requiring lower costs to achieve

It should be noted, this report does not investigate or recommend an appropriate method of managing feral deer. Instead, it provides an economic perspective on the costs and benefits of feral deer management, regardless of how this achieved.

We note that both the extent and approach to feral deer management will determine the level of benefits society receives, because different management strategies will have different impacts on the feral deer population at different costs. However, it is likely that a strategy that quickly and

⁸⁰ Based on analysis by the Invasive Species Council that suggests the average cost of managing feral deer is \$404 per deer based on an aerial shooting effort.



significantly reduces feral deer numbers will deliver greater benefits than a slower and tentative response, while at the same time requiring lower costs to achieve.

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