frontier economics

Reining in feral horses in Kosciuszko National Park

A report for the Invasive Species Council | 14 January 2021

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Overview

Kosciuszko National Park (KNP) is one of Australia's premier and most iconic National Parks. It is home to unique habitats and species, particularly in the higher alpine regions where the cold climate is atypical for Australia. It is listed on the Australian National Heritage List and is a UNESCO Biosphere Reserve. It constitutes the largest proportion of the Australian Alps and the park is the source of the Snowy, Murray and Murrumbidgee rivers and generates about 29% of the total average water yield of the Murray Darling Basin[1].

Each year KNP receives around 3 million visitors,[2] of which, close to half come from interstate or overseas,[3] making tourism to the park a key driver of economic activity in the region.

However, KNP (and thus, tourism to the area) is under continual threat from climate change and invasive species, and these threats are escalating. Feral horse numbers in KNP have been growing at a staggering rate of over 16% per year over the past 6 years, with numbers estimated to be around 14,000 today. [4] This is because the *Kosciuszko Wild Horse Heritage Act 2018* has prevented effective management of feral horses in the Park. Even assuming a conservative growth rate going forward, if no significant management action is taken, by 2040 there could be around 35,000 feral horses in the Park.[5]

The issue of feral horse management within KNP has been highly contentious (with significant debate around the appropriate management approach and level of feral horses in the park). What isn't contentious is that the Park's unique ecosystems (such as alpine and sub alpine herb fields, bogs and fens) are at particularly severe risk from the horses. Feral horses damage native habitats through both grazing and trampling, which threatens native species that rely on these habitats, fouling up water courses and accelerating erosion. [6]

1 Worboys, G.L., Good, R.B. and Spate, A (2011). Caring for Our Australian alps Catchments: A climate change action strategy for the Australian Alps to conserve the natural condition of the catchments and to minimise the threat to high-quality water yields. Australian Alps Liaison Committee and the Department of Climate Change and Energy Efficiency. Canberra

2 It is estimated that in 2018 there were 3.3 million visitors to KNP (Roy Morgan (2019), Annual Visits to NPWS Managed Parks in New South Wales, Final Report, p. 75)

3 Based on KNP visitor survey data relating to place of residence (Thredbo Valley Track Survey 2017 – Visitor Survey Results Summary).

4 A survey conducted in 2014 estimated that there were 6,000 feral horse in Kosciuszko National Park and 14,380 in 2020, reflecting a 16% per year growth rate (NSW Office of Environment & Heritage (2016), Final report of the Independent Technical Reference Group; NSW Department of Planning, Industry and Environment (2021), Tracking the wild horse population, viewed 13 January 2021, https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/tracking-the-wild-horse-population).

5 This assumes a growth rate of on average, around 4% per year.

6 See Driscoll, D.A., Worboys, G.L., Allan, H., Banks, S.C., Beeton, N.J., Cherubin, R.C., Doherty, T.S., Finlayson, C.M., Green, K., Hartley, R., Hope, G., Johnson, C.N., Lintermans, M., Mackey, B., Paull, D.J., Pittock, J., Porfirio, L.L., Ritchie, E.G., Sato, C.F., Scheele, B.C., Slattery, D.A., Venn, S., Watson, D., Watson, M. and Williams, R.M. (2019), Impacts of feral horses in the Australian Alps and evidence-based solutions. Ecol Manag Restor, 20: 63-72. doi:10.1111/emr.12357

The impact of feral horses has become all the more critical, post the 2020 bushfires which devastated a large proportion of the Park. Anecdotal evidence suggests the grazing and trampling pressure from horses has prevented recovery in many of the fire affected areas.[7]

More substantive and sustainable feral horse management would lead to significant benefits

Against this background, Frontier Economics agreed to assist the Invasive Species Council to apply an economic lens to the issue of feral horses in KNP. Specifically, we have explored what benefits society is giving up by failing to act to control feral horses numbers in KNP to ecologically sustainable levels. This has involved identifying, and where possible, quantifying and monetising the economic, social and environmental benefits to society that could arise from controlling feral horse numbers.

Drawing on the best available information, our analysis suggests the potential benefits that may come from reducing feral horse numbers in the park could be significant and in the order of **$19-$50 million per year**[8]. This estimate is conservative and made up of:

- Benefits of between $7m and $20m per year from **improved recreation and use of the KNP**. This assumes use of the park for camping, hiking and mountain biking is dampened by 1% of in the future due to the impact of feral horses.
- Between $10m and $28m per year arising from i**mprovements to riparian environments and water quality**. Assuming more substantive management of feral horses improves the health of vegetation along the waterways by 1%.
- $2m per year in benefits of **reduced car accidents**. Assuming all feral horse-related crashes in KNP are avoided in the future.

These figures do not capture the full range of potentially significant benefits associated with substantive and sustainable management of feral horses in KNP, including:

- Avoided expenditure by NSW National Parks and Wildlife Service associated with protecting species from horses, restoring areas of high conservation value within KNP and repairing park infrastructure and trails damaged by horses.
- Avoided costs incurred by adjacent landholders, for example, as a result of repairing damaged fences, lost grazing potential and the cost of controlling horses spreading to their properties.
- Increased carbon sequestration that may result from reduced damage to vegetation within the park.
- Reduced impact on aboriginal cultural values.
- Improved base flows and quality of water for downstream users.

[7] Invasive Species Council (2020), Bushfire Impacts on Kosciuszko Feral Horse Populations, available at: https://invasives.org.au/wp-content/uploads/2020/10/Report-Kosciuszko_Bushfire_and_Horses_Data_Analysis.pdf

[8] Estimate is based on the average undiscounted over the period 2020 to 2049. This is equivalent to a benefit of between $230m and $599m in present value (PV) terms, over the period to 2049.

Decisive action is needed to capture these benefits

While there are costs associated with reducing feral horse numbers to sustainable levels these are unlikely to outweigh the benefits.

Acting decisively to substantively manage the feral horse population currently residing in KNP could cost between $1m and $71m in total depending on the density of the horse population and the management approach adopted.[9]

This pales into insignificance when compared to the potential future benefits of between $230m and $599m in present value (PV) terms, over the period to 2049.

Our findings highlight the need for decisive action to manage the feral horse population in KNP. The longer we delay the larger the population of feral horses and the greater the cost of inaction. In other words, a strategy that quickly and significantly reduces horse numbers will deliver greater benefits than a slower and tentative response, while at the same time requiring lower costs to achieve.[10]

These results are inherently uncertain and there are gaps in the available research and primary data on the impacts of specific feral horse management strategies in KNP. 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 horses is net beneficial.

We also note that while analysis in this report is focused on KNP, the broader alpine habitat for destructive feral horses is contiguous across other land tenures in NSW, ACT, and parts of Victoria. Inaction in NSW may impose further environmental, economic and social costs across the border in Victoria and the ACT and impede the ongoing efforts to control the feral horse population in Victoria. In addition, the NSW Government's recent commitment to reduce feral horse numbers in some KNP areas impacted by bushfires[11] will ultimately be a wasted investment without decisive and strategic action on longer-term feral horse control.

9 These figures assume the removal of 14,380 horses in KNP. Based on a recent study that estimated feral horse management costs are likely to range from $87 to $4,955 per horse ($2020-21) depending on the density of horses and the control method used. The lower figure assumes aerial culling of horse at high densities while the lower figure assumes trapping at a density of one horse per 0.2 km^2 (source: Beeton, N. & Johnson, C. (2019), Modelling horse management in the Australian Alps, *Special Issue: Feral horses in the Australian Alps*, 20(1), pp. 57-62.)

10 This report does not investigate or recommend the appropriate method of managing feral horses. Instead, it provides an economic perspective on the costs and benefits of feral horse management, regardless of how this is achieved. However, we note that the extent and nature of intervention will determine the level of benefits society receives, because different management strategies will have different impacts on the feral horse population at different costs.

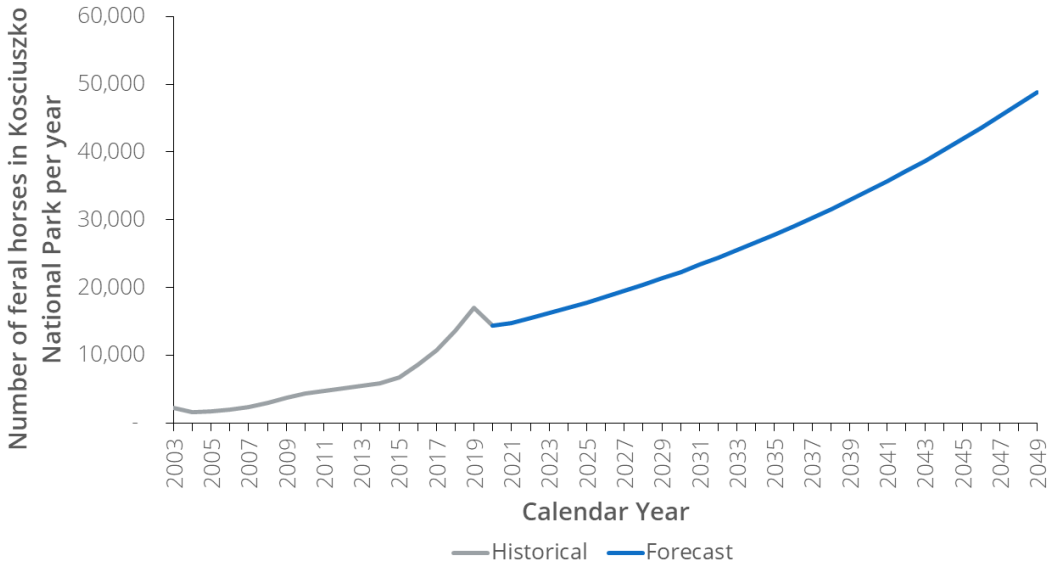
11 See Readfearn, (2020), "Thousands of feral horses to be removed from Kosciuszko national park after bushfires", *The Guardian,* Available at https://www.theguardian.com/environment/2020/feb/20/thousands-of-feral-horses-to-be-removed-from-kosciuszko-national-park-after-bushfires, accessed 30/10/2020

1 Feral horses are bad news

1.1 Feral horse numbers in Kosciuszko are increasing dramatically

As shown in Figure 1, feral horse numbers in KNP have been growing at a staggering rate of over 16% per year, over the past 6 years, with numbers estimated to be around 14,000 today.[12,13] Even assuming a conservative growth rate going forward, if no management action is taken by 2040, there could be around 35,000 feral horse in the Park.[14]

Figure 1: Feral horse numbers in Kosciuszko National Park are increasing dramatically



Sources: Walter MJ (2002), The Population Ecology of Wild Horses in the Australian Alps; NSW Office of Environment & Heritage (2008), Review of the 2008 Horse Management Plan and Wild Horse Management Program, Kosciuszko National Park; Dawson M (2009), 2009 Aerial Survey of Feral Horses in the Australian Alps; NSW Office of Environment & Heritage (2016), Final report of the

12 Recent data from the NSW Government revealed more than 14,000 horses are roaming the park in 2020, down from the 19,000 horses in 2019. The decrease is attributed to the changes in the survey design, inherent variability, and the impacts of drought, fire and the natural movement of horses in and out of the park. We note that taking into account the 95% confidence interval of the survey, the horse population could be as small as 8,798 and up to 22,555. (NSW Department of Planning, Industry and Environment (2021), Tracking the wild horse population, viewed 13 January 2021, https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/tracking-the-wild-horse-population))

13 A survey conducted in 2014 estimated that there were 6,000 feral horse in Kosciuszko National Park and 14,380 in 2020, reflecting a 16% per year growth rate (NSW Office of Environment & Heritage (2016), Final report of the Independent Technical Reference Group; NSW Department of Planning, Industry and Environment (2021), Tracking the wild horse population, viewed 13 January 2021, https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/tracking-the-wild-horse-population).

14 This forecast assumes a growth rate of on average, around 4% per year. It is based on an approach similar to that used in N.J. Beaton (2019), Modelling horse management in the Australian Alps.

Independent Technical Reference Group; NSW National Parks and Wildlife Service (2020), Kosciuszko National Park wild horse management, viewed 23 October 2020, https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management; NSW Department of Planning, Industry and Environment (2021), Tracking the wild horse population, viewed 13 January 2021, https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/tracking-the-wild-horse-population); Forecasts based on method applied in N.J. Beaton (2019), Modelling horse management in the Australian Alps.

We note that while there are other introduced animals such as pigs, deer and horses within the park, they are being controlled by separate strategic and integrated pest control programs. [15]

1.2 What does this mean for the park and its use?

Research has suggested that feral horses within KNP have had a significant detrimental impact on a range of economic, social and environmental outcomes within and outside the park, including:

- **Visitors' use and enjoyment of KNP**— research suggests that feral horses negatively impact amenity and water quality in the park and reduce visitor safety, impacting visitor use and enjoyment of the park for hiking, camping, mountain biking and fishing (see section 2).
- **The ecosystems and environment within KNP** — scientific research has shown that feral horses are extremely destructive to KNP ecosystems, which protect water quality in tributaries to the Murray, Snowy and Murrumbidgee rivers (see section 3). Trampling and grazing by feral horses have been found to:
  - cause damage to various ecosystems in KNP, such as bogs, wetlands, peats and meadows, some of which could take many years to recover;
  - destroy habitat for native species, many of which are vulnerable or endangered and are found nowhere else on earth (wild horses, in contrast, are abundant across Australia and in other countries);
  - erode streambanks and riverbanks;
  - cause water pollution; and
  - threaten Aboriginal cultural and heritage value.
- **Property / infrastructure within and outside KNP** — Anecdotal evidence suggests feral horses damage signage, fences and trails within KNP and can also impose costs on adjoining land holders when they inevitably escape from KNP boundaries and either graze their pastures, damage their fences or require control (see section 4).
- **Likelihood of road accidents within KNP** – analysis suggests feral horses are increasingly causing road accidents on highways within the Park (see section 4).

[15] NSW Government (2020), Kosciuszko National Park wild horse control, viewed 27/10/2020, available at < https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/wild-horse-control>

- **Water catchments outside KNP** – changes in water flows and water quality within KNP can impact the health of water catchments downstream of the KNP. For example, the ACT Government places a large importance on water quality entering their lakes and waterways and flowing downstream into the Murrumbidgee River system with their ACT Healthy Waterways Initiative.

The impact of feral horses is likely to become all the more critical, given the 2020 bushfires which devastated a large proportion of the Park. While these bushfires burned around 32% of KNP,[16] anecdotal evidence suggests the grazing and trampling pressure from horses has prevented recovery in the fire affected areas. In addition, the fires caused a reduction in the primary food source meaning feral horses will now be competing for scarce food with the park's native animals.

Horses are an invasive species. They have a significant impact on economic, social and environmental outcomes. Both the NSW and Victorian Governments have acknowledged feral horses as a top environmental threat to the Australian Alps, and feral horses are listed as a priority pest in the NSW South East Regional Strategic Pest Animal Management Plan. [17,18,19]

1.3 Management of feral horses to date, has been limited

Critically, despite recognition of the damage caused by feral horses in KNP, management has been limited. This is primarily due to the introduction of the *Kosciuszko Wild Horse Heritage Act 2018* aimed at recognising the cultural significance and heritage value of the feral horses in KNP. It prohibited the culling of feral horses, while recognising the need to control and manage feral horses to protect the environmental values of the park.[20] The Act does not dictate management methods and instead sets out a process for identifying the heritage value of horse populations in the park and how this will be protected via a *Wild Horse Heritage Management Plan*. Such a plan would replace any horse management plan already in place. Since its introduction, very few feral horses have been removed from the park, most of which were rehomed.[21] Aerial and ground

16 Invasive species council (2020), Bushfire Impacts on Kosciuszko Feral Horse Populations Bushfire & horse data analysis (2020).

17 NSW Government Office of Environment and Heritage, Threats, available at https://www.environment.nsw.gov.au/threatenedSpeciesApp/threats.aspx; Victoria State Government (2017), Protection of the Alpine National Park: Feral Horse Strategic Action Plan 2018-2021.

18 For example, in 2018, The NSW Government listed habitat degradation from feral horses as a key threatening process under Schedule 4 of the Biodiversity Conservation Act 2016. The listing details endangered, critically endangered and vulnerable ecological communities threatened by feral horses under both the Biodiversity Conservation Act 2016 and the commonwealth Environment Protection and Biodiversity Conservation Act 1999 (NSW Threatened Species Scientific Committee, (2018), Notice of and reasons for the Final Determination. Available at https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Scientific-Committee/Determinations/2018/habitat-degradation-loss-feral-horses-equus-caballus-final-determination.pdf?la=en&hash=8A5823ECF07BA2DA637B698DC21BE68E6DFD2D6C, accessed 30/10/2020).

19 NSW Local Land Services (2018), South East Regional Strategic Pest Animal Management Plan. Available at https://www.lls.nsw.gov.au/__data/assets/pdf_file/0007/820789/20200517-SELLS_Strategic-Pest-Plan.pdf , accessed at 21 Nov 2020.

20 Barilaro J. (2018) NSW Parliament Legislative Assembly Hansard – 23 May 2018, Second reading speech, Kosciuszko Wild Horse Heritage Bill 2018. Available from URL: https://www.parliament.nsw.gov.au/Hansard/Pages/HansardResult.aspx#/docid/HANSARD-1323879322-102131

21 Since 2002, 3922 horses have been removed from KNP and 1202 horses have been rehomed (Analysis by ISC, based on a compilation of data from review of the 2008 Horse Management Plan and Wild Horse Management

shooting of feral horses in NSW national parks has not been undertaken as a control method since 2000.[22]

The *Wild Horse Management Plan* is due to be finalised in 2020 and will replace the current management plan, *the 2008 Kosciuszko National Park Horse Management Plan* under the National Parks and Wildlife Act.[23,24] Since the 2016 draft plan was not finalised, management of feral horses in the park continues in accordance with the 2008 *Wild Horse Management Plan* which was developed when the KNP horse population was much lower. The 2008 plan limits control methods to trapping and rehoming or trapping and transport to the knackery.

1.4 Understanding the costs of inaction requires an economic framework

To make more informed decisions about the nature and extent of any intervention to manage feral horses, 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 community[25] into dollar values[26] can help decision makers to compare feral horse management options and assist them to determine whether and how to act.

When the broad range of social, environmental and economic impacts of feral horses in KNP are not considered or monetised there is a risk that these impacts will be ignored. This can lead to a suboptimal management outcomes. Decision makers need to be aware of the scale of the potential benefits that will be lost should the *Wild Horse Heritage Management Plan* for KNP fail to result in a reduction in feral horse numbers in the park to sustainable levels.

Against this background, Frontier Economics was engaged by the Invasive Species Council to apply an economic lens to the issue of managing feral horses in KNP. As shown in **Figure 2**, in this report we have identified, and where possible,[27] valued the economic, social and

Program, Kosciuszko National Park 2008, NPWS and additional updates from NPWS in 2018, 2019 and 2020). Most recently, 68 horses were rehomed from the spring 2019 control program (NSW Government (2020) and 178 were rehomed between 23 July and 1 October 2020 as part of the bushfire recovery program (NPWS newsletter (7 Oct 2020), Rehome a Kosciuszko wild horse, available at https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/rehome-a-wild-horse.)

22 This could be the result of an aerial cull of feral horses that took place in Guy Fawkes River National Park in the northern tablelands of NSW and subsequent publicity of at least one shot horse that remained alive after several days.

23 Department of Environment and Climate Change (NSW) (2008), 2008 Kosciuszko National Park Horse Management Plan.

24 NSW Department of Planning, Industry and Environment (2020), Kosciuszko National Park wild horse management, available at: https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management

25 This includes the local, broader NSW and Australian communities.

26 Note all figures in the report are $2020-21. Some figure are presented on a per year basis. And others are identified as present value figures. These represent the total value of the impact in question for a period of time based on an 30-year analysis period from 2020 to 2049 and applying a discount rate of 7%.

27 As discussed in Section 5, there is limited scientific and economic data available on the specific impacts of alternative feral horse management approaches in KNP. Our analysis makes reasonable, conservative assumptions where required in a data poor environment, and we have articulated caveats to the analysis as

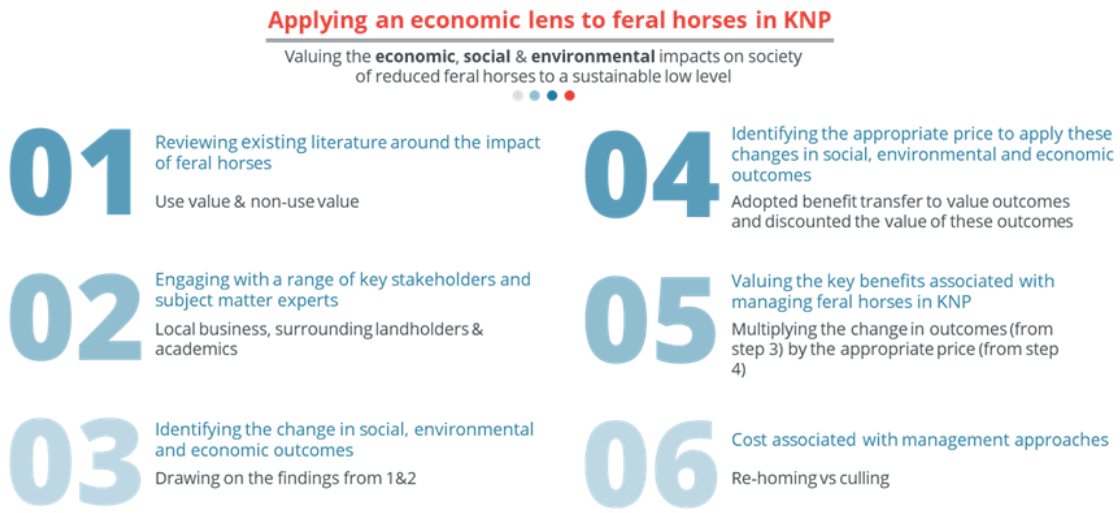
environmental impacts on society of reducing feral horses to an ecologically sustainably low level (i.e. at a level at which they are likely to have limited impact on the environmental and cultural values of the Park).

Our approach involved:

1. Reviewing existing literature examining the impact of feral horses in KNP on economic, social and environmental outcomes. This includes:
   - use-values – these accrue to users of the park.
   - non-use values – these values arises from the knowledge that the park (including its habitats and the species it supports) exist and will continue to exist going forward (see Box 1). They are different from use values because they arise whether or not the park is used and as such, can be attributed to the population beyond just those who use and visit the park (e.g. the broader NSW community).
2. Engaging with a range of key stakeholders and subject matter experts to understand the costs imposed by feral horses in KNP. This included engagement with local businesses, surrounding landholders and academics to ensure our findings reflected a broad range of views.
3. Drawing on the findings of steps #1-2, and, where possible, identifying the change in these social, environmental and economic outcomes that could arise as a result of managing feral horses in the park at sustainable levels.
4. Where feasible, identifying the appropriate dollar value to apply to these changes in social, environmental and economic outcomes. Given the timeframe available for this analysis we have adopted benefit transfer approach (see detail in Box 2). This involves drawing on existing literature to value impacts (and making any necessary adjustments to reflect KNP's context), rather than undertaking primary research.
5. Where appropriate, valuing the key benefits associated with managing feral horses in KNP at sustainable levels. At a high level, this involves multiplying the change in outcomes from step #3 by the appropriate price in step #4.
6. Identifying, at a high level, the cost associated with alternative management approaches (i.e. the financial cost of rehoming, compared to culling, feral horses)

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.

Figure 2: High-level overview of our approach



Source: Frontier Economics

Box 1: Potential non-use values in KNP

The environment in KNP can be associated with non-use values for a range of reasons, including:

- Individuals may consider that KNP ecosystems and/or individual species have intrinsic worth that merits their ongoing existence and protection from harm or extinction. This is typically termed 'existence value'.
- Individuals may value knowing that the habitat will be available for them to visit in the future. This is known as 'option value'.
- Individuals may consider that future generations should have the same access to healthy KNP ecosystems as they did. This is called 'bequest value'.
- Individuals consider that KNP, it's ecosystems, species, landscapes, and built infrastructure remains (for example sites containing aboriginal artefacts, huts built by early Europeans) hold historic, cultural or heritage value. And finally,
- Individuals may want to preserve the habitat in order to gain more information about the impact of horses or the importance of the park habitats and species over time.

Source: Frontier Economics

Box 2: Applying benefit transfer to value key economic, social and environmental impacts of feral horses in KNP

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 horses in KNP.

Source: Frontier Economics

1.5 Structure of this report

The remainder of this report is structured as follows:

- **Section 2** provides an overview of the impact of feral horses on visitors use and enjoyment of the park;
- **Section 3** outlines the impact of feral horses on the park environment;
- **Section 4** summarises the broader economic impact of feral horses in KNP;
- **Section 5** provides an overview of key findings of our report and outlines a range of next steps to address the data gap; and
- **Appendix A** summarises our approach to valuing use and enjoyment of the park.
- **Appendix B** summarises provides further detail around the impact of feral horses on the environment and heritage in KNP.

2 The impact of feral horses on visitor use and enjoyment of the park

2.1 How are visitors to KNP affected by feral horses?

KNP is a valuable resource in part because it is used for a wide range of recreational activities. Visitor surveys show that park visitors enjoy a range of activities including snow sports, touring and sightseeing, bushwalking, hiking, camping, fishing, horse riding, mountain biking, canoeing and kayaking. The NSW Park Visitor Survey for the NSW section of the Southern Ranges[28] found that:

- Hiking and camping are two of the most popular recreational activities within KNP, with surveys estimating that 62% of visitors to the NSW section of the Ranges are walkers, and 4% are campers.
- Around 5% of visitors to the NSW section of the Southern Ranges (and KNP particularly) primarily come to fish. The park is home to trout and native fish such as Murray cod and golden perch, and fishing in most rivers and streams is permitted from October to the June long weekend.
- Mountain biking and road cycling is a popular recreation activity within the park, with 4% of visitors to the NSW section of the Southern Ranges reporting that their main recreational activity in the park is cycling.

Not all visitor activities are impacted by feral horses, or impacted to the same extent. Given the known impacts of feral horses in the park, the activities most materially affected by feral horses are likely to be hiking, camping, fishing and mountain biking. Participants in these activities are therefore most likely to benefit from a reduction in feral horse numbers. In particular, as shown in **Figure 3**, feral horses in KNP are likely to lead to:

- **Reduced amenity for hikers and campers** - Feral horses impact how these visitors experience the natural beauty and key features of the park. Analysis suggests that the extensive damage to the natural environment caused by feral horses (including spreading weeds, trampling and opening bare ground, collapsing streambanks and degrading water quality) can negatively affect visitors hiking and camping experiences.[29]
- **Reduced safety for hikers and campers –** Studies suggest that the increasing prevalence of feral horses in KNP may be impacting the safety of recreational users of the park. For

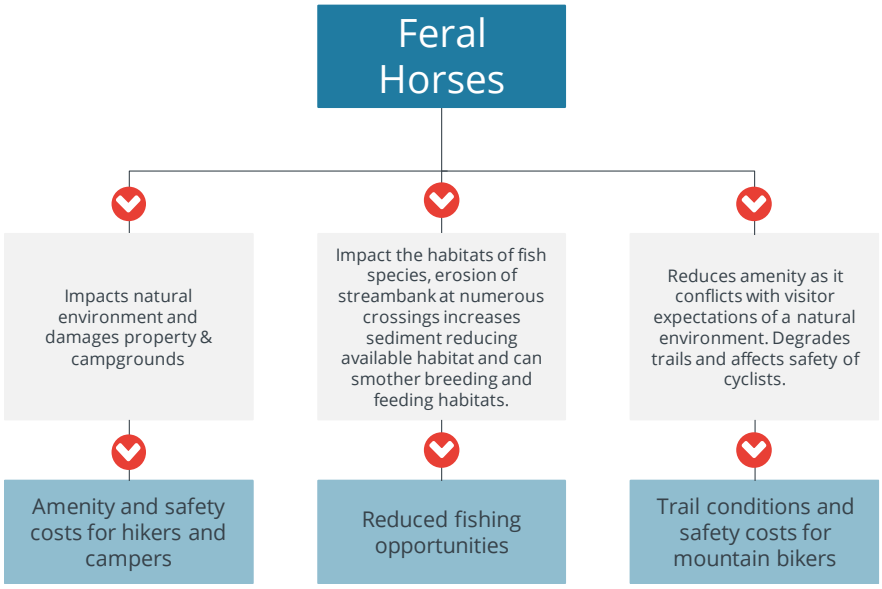
[28] NSW Government (2019), Park Visitor Survey Summary Southern Ranges Branch, full data available at: https://www.environment.nsw.gov.au/research-and-publications/our-science-and-research/our-research/social-and-economic/social/domestic-visitation

[29] Parks Victoria, Feral Horses, available at: https://www.parks.vic.gov.au/get-into-nature/conservation-and-science/conserving-our-parks/feral-animals/feral-horses

example, a freedom of information request found by *Reclaim Kosci* reported that a teenage boy was injured by a feral horse entering a campsite in KNP in November 2018.[30]

- **Reduced fishing opportunities** — Studies have shown that feral horses impact the habitats and food source of fish species within the park, which reduces the quality of, and availability of, fishing opportunities in KNP. In particular, the abundance of feral horses around catchments is causing erosion of stream banks at numerous crossings. This degradation increases sediment in stream, which in turn, reduces available spawning habitat, can smother and kill fish eggs, impact feeding habitats and decreases water quality (see Section 3.1.1 for more detail).[31] In addition, feral horses are damaging streamside vegetation, which is known to be a food source for many freshwater fish.[32]
- **Degraded trail conditions for mountain bikers** - The presence of feral horses in the park can reduce the amenity and enjoyment of mountain bikers as they conflict with visitor expectations of a natural environment.[33] For example, feral horses may degrade the mountain bike trails reducing amenity and affecting the safety of cyclists. An unexpected encounter with a feral horse when biking has the potential to cause injury.

Figure 3: How feral horses impact on the use and enjoyment of KNP



Source: Frontier Economics

30 Reclaim Kosci (2019), Feral horse hospitalises teenager camping in Kosciuszko National Park, available at: https://reclaimkosci.org.au/2019/03/06/feral-horse-injuries/

31 Allen and Lintermans (2020), Fish: Impacts of Feral Horses – Stocky Galaxias The Threat from Feral Horses to a critically endangered fish, Kosciuszko conference abstracts, pg. 88

32 Perry (2018), Critically endangered fish fighting upstream battle against brumbies, University of Canberra, available at: https://www.canberra.edu.au/about-uc/media/newsroom/2018/june/critically-endangered-fish-fighting-upstream-battle-against-brumbies

33 Parks Victoria, Feral Horses, available at: https://www.parks.vic.gov.au/get-into-nature/conservation-and-science/conserving-our-parks/feral-animals/feral-horses

2.2 The value of improved recreation opportunities in KNP

There are a range of methods that can be applied to help understand, in dollar value terms, the lost recreation opportunity or quality from ongoing unchecked feral horse population growth in KNP (see **Appendix A** for more detail about alternative approaches).

One method, the Travel Cost Method (TCM), 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. For example, a travel cost study by Stoeckl & Mules (2006) analysed the recreational use value attributable to the Australian Alps and found that the total value of recreational use of the Australian Alps lies somewhere between $12 billion and $270 billion.[34]

Using benefit transfer, this study and its results can be leveraged to generate estimates of the cost of feral horse populations on the value of recreational opportunities in KNP.[35] However, this value cannot be directly interpreted as the benefit of improved recreation opportunities associated with feral horse management in KNP, as:

- The study covers the entire Australian Alps, rather than just KNP;
- The study uses visitor numbers from 2006, rather than 2020; and
- As discussed above, only a subset of activities in KNP (hiking, camping, fishing and mountain biking) are likely to be affected by high and increasing feral horse numbers.

As such, to value the benefit of improved recreation opportunities associated with feral horse management, we adjusted the analysis to account for:

- only the KNP proportion of the Australian Alps.
- adult visitor numbers over the next thirty years. [36] To forecast adult visitor numbers we adjusted the historical, total visitor numbers for KNP[37] and assumed an annual growth rate in adult visitor numbers of 4% going forward[38]

[34] The lower bound estimate uses a $0.10 per km consumer supply estimate which is multiplied by the total visitor number to each region and then multiplied by 0.8. The upper bound estimate used $0.30 per km per-person, and scaled upwards by a factor of 1.2. The recreational use value uses the lower bound estimate and a 10% discount rate, while the upper bound estimate is used with a 2% discount rate

[35] The study examines the same site and a substantially similar community, making this a good starting point for the application of a benefit transfer approach.

[36] 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.

[37] Roy Morgan (2019), Annual Visits to NPWS Managed Parks in New South Wales Final Report.

[38] To adjust the historical visitor numbers and estimate adult visitor numbers, we started with historical estimates from the 2018 *NSW Park Visitation Survey* (which include estimates of visitor numbers for KNP and total and adult visitor numbers for all NPWS parks). We then estimated historical, adult visits to KNP by assuming the

- only those activities (or reasons for visiting) that are likely to be affected by the presence of feral horses. On this basis we have only included walkers, campers, fishers, and mountain bikers (estimated to be 77% of visitors to KNP).[39]

Of course, the increasing presence of feral horses will not prevent all walking, camping, fishing and mountain bike activity from taking place. However, it is reasonable to expect that growing horse numbers may discourage, or reduce the quality of, some of this recreational activity at the margin. As horses 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.

If we assume more ecologically sustainable levels of feral horses in KNP would either increase visitor numbers to KNP or increase the enjoyment of existing users (who would otherwise be affected by feral horses) by 1%,[40] **this would generate a benefit of, on average over the period 2020 to 2049, between $7m and $20m per year**.[41] This benefit would otherwise be lost through failure to manage feral horses to ecologically sustainable levels.

proportion of adult visits to total visits in KNP is the same as the proportion of adult visits to total visits for all NPWS parks (Roy Morgan (2019), Annual Visits to NPWS Managed Parks in New South Wales Final Report).

39 NSW Government (2019), Park Visitor Survey Summary Southern Ranges Branch, full data available at: https://www.environment.nsw.gov.au/research-and-publications/our-science-and-research/our-research/social-and-economic/social/domestic-visitation

40 While the negative impact of feral horses 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 conservative estimate of the incremental impact of feral horses (1%).

41 The lower bound represents a $0.1/km of estimation of cost of travel to KNP (and thus recreation benefit), while the upper bound represents a $0.30/km estimation of cost of travel to KNP (and thus recreation benefit). Although some visitors to KNP are likely to be interstate visitors, to be conservative, we have adopted the NSW value and applied it to all visitors.

3 The impact of feral horses on the environment and heritage in KNP

3.1 How is the environment and heritage in KNP affected by feral horses?

KNP is home to habitats and species not found anywhere else in Australia. It contains the only true alpine zone in mainland Australia, has Australia's highest mountains and has the most extensive peatlands in the Alps. However, peer-reviewed evidence indicates that feral horses are having a significant negative environmental impact on flora and fauna within KNP. Specifically, feral horses in KNP have been found to:

- **Damage habitats within the park**, including alpine bogs, peat systems waterways, wetlands, streambanks, drainage lines and sensitive dryland ecological communities, such as the dry white cypress pine woodlands of the Lower Snowy.[42]
- **Negatively impact water quality** of key rivers and streams within the park.

In addition to these well documented impacts, anecdotal reports suggest that feral horses may pose a risk to Aboriginal heritage areas within the park through trampling and degrading vegetation.

While each impact is discussed in more detail below, we note that, given the environmental outcomes within KNP are affected by a range of other factors, it can be challenging to model the impact of a single, albeit highly destructive, invasive species like feral horses.

3.1.1 Impact on habitats within KNP

There is significant evidence to suggest that the feral horses in the Park are having a significant, negative impact on a number of habitats in KNP, primarily as a result of grazing, trampling and pugging. Studies have found that feral horses damage:

- Alpine bogs and peat systems.
- Riparian environments such as wetlands, streambanks, drainage lines. The abundance of feral horses has been found to cause erosion of stream banks at numerous crossings, compared to sites free of feral horses.[43] The presence of feral horses has been correlated with poorer and more variable vegetation condition, composition and structure.[44, 45] A

42 ITRG (2016), Final report of the Independent Technical Reference Group: Supplementary to the Kosciuszko National Park Wild Horse Management Plan, report by the Independent Technical Reference Group to the Office of Environment and Heritage NSW, Sydney, p8

43 See Robertson, G.(2019) et al *An assessment of feral horse impacts on treeless drainage lines in the Australian Alps*, Ecological Management and Restoration Vol 20, No. 1, January 2019

44 Porfirio, L.L., Robertson, G., Hugh, S., Gould, S.F. and Mackey, B. (2014). Monitoring the impact of feral horses on vegetation condition using remotely sensed fPAR: a case study in Australia's alpine park.

45 Wild, A. and Poll, M. (2012) Impacts of feral horses on vegetation and stream morphology in the Australian Alps: Feral horse exclusion plot monitoring and analysis. Report to the Friends of the Cobberas, Parks Victoria and the

number of studies have found that soil and stream stability was significantly worse in sites grazed and trampled by horses when compared to horse-free sites.[46] The degradation increases sediment in-stream and can also affect streamflow.

- Aquatic environments. Erosion and damage to riparian environments ultimately reduces available spawning habitat and can smother and kill fish eggs, smothering breeding and feeding habitats, and decreasing water quality. [47] We further discuss the impacts of feral horses on water quality in Section 3.1.2.

This damage appears to be widespread. Robertson et al (2019) assessed 185 treeless drainage lines sites in the Park and found that of these 128 showed signs of horses being present while only 57 seemed to be horse free.[48]

In addition, a 2013 observational study estimated that feral horses had significantly impacted more than 43 kilometres of rivers and streams primarily located within KNP (these rivers and streams are part of the headwaters of the Snowy and Murray Rivers). [49] The authors also suggest that this damage was much greater and more pervasive than they had witnessed in the previous 40 years of intermittent observations.

The impact of feral horses is likely to become all the more critical, given the 2020 bushfires which devastated a large proportion of the Park. Horses have been grazing on resprouting vegetation and competing with native herbivores for resources which were scarce immediately after the fires. Anecdotal evidence suggests the grazing and trampling pressure from horses has prevented recovery in many of the affected areas.[50]

Finally, anecdotal evidence also suggests feral horses within the park have significantly changed the ecology of the park (see Box 3).

Australian Alps Liaison Committee. Robertson, G., Wright, J., Brown, D., Yuen, K. and Tongway, D. (2015). An Assessment of Feral Horse Impacts on Treeless Drainage Lines in the Australian Alps. Australian Alp national parks Cooperative Management Program.

46 See Robertson, G.(2019) et al *An assessment of feral horse impacts on treeless drainage lines in the Australian Alps*, Ecological Management and Restoration Vol 20, No. 1, January 2019

47 Allen and Lintermans (2020), Fish: Impacts of Feral Horses – Stocky Galaxias The Threat from Feral Horses to a critically endangered fish, Kosciuszko conference abstracts, pg. 88

48 See Robertson, G.(2019) et al *An assessment of feral horse impacts on treeless drainage lines in the Australian Alps*, Ecological Management and Restoration Vol 20, No. 1, January 2019

49 Worboys, G.L. and Pulsford, I. (2013) Observations of Pest Horse Impacts in the Australian Alps, Canberra, Available at: www.mountains-wcpa.org

50 Invasive Species Council (2020), Bushfire Impacts on Kosciuszko Feral Horse Populations, available at: https://invasives.org.au/wp-content/uploads/2020/10/Report-Kosciuszko_Bushfire_and_Horses_Data_Analysis.pdf

Box 3: Some observations on the impact of feral horses in KNP on environmental outcomes

Anecdotal evidence also suggests feral horses within the park have significantly changed the ecology of the park.

Colin de Pagter has been flying helicopters over KNP for almost two decades and has noticed significant changes in the environment in areas of the park with a significant feral horse population. He noted that around twenty years ago there were limited feral horses in the North Currango plain area of the park and the ecosystem supported a large carex fen (around five hectares in size), which occur in areas of water inundation. However, in October 2020, he found that the fen had completely disappeared, it had transitioned into a poa tussock grassland and the ecosystem now resembled a dry grassland (a completely different ecosystem to the fen). He suggested that this is because the feral horses have trampled and damaged the natural vegetation, and horse hoof action has changed the hydrology that drained the fen, which has allowed the grassland species to take root.

He also noted that the feral horse population is spreading to areas of significant biodiversity, previously untouched by feral horses. This includes the Nungar plain in the Northern part of KNP, which, around half a decade ago did not have any feral horses.

Richard Swain of Alpine Adventures has been running river rafting trips in the KNP for many years. He too has observed significant and worsening damage to ecosystems within the park. He highlights the prevalence of horses within the park. On one 5-day trip he estimates he saw around 300 feral horse within the Park and very few native animals.

He considers horses are responsible for the reduction in native animals sightings because they are consuming significant areas of pasture in the meadows which is leading fewer kangaroo, wallabies and emu sightings. In addition, he considers horses are damaging waterways and riverbanks meaning he is now observing very few platypi. Richard notes that *"international tourists don't come to see a horse. They come to see what is unique to this country and are increasingly disappointed by lack of native wildlife sightings".*

As a river guide Richard has observed a constantly degrading river environment. In the areas he operates his tours, he suggests there are very little undamaged phragmites or reed beds along riverbank. On trips in the past he used to teach tourists how to make string out of young Kurrajong tree saplings but he can now no longer do this as it is impossible to find a young Kurrajong tree that has not been eaten up to horse height with all fresh shoots and saplings gone.

He surmises that the damage feral horses are doing to riparian environments is also impacting river flows. He highlights that when he started his rafting business in the upper Murray, 3 inches of rain would ensure enough water in the river to enable him to book trips 3 weeks in advance, however, now 3 inches of rain only ensures enough water for 3 days. He has seen massive erosion events in areas such as Byadbo Creek with *"sections of the river getting carved out like the grand canyon".*

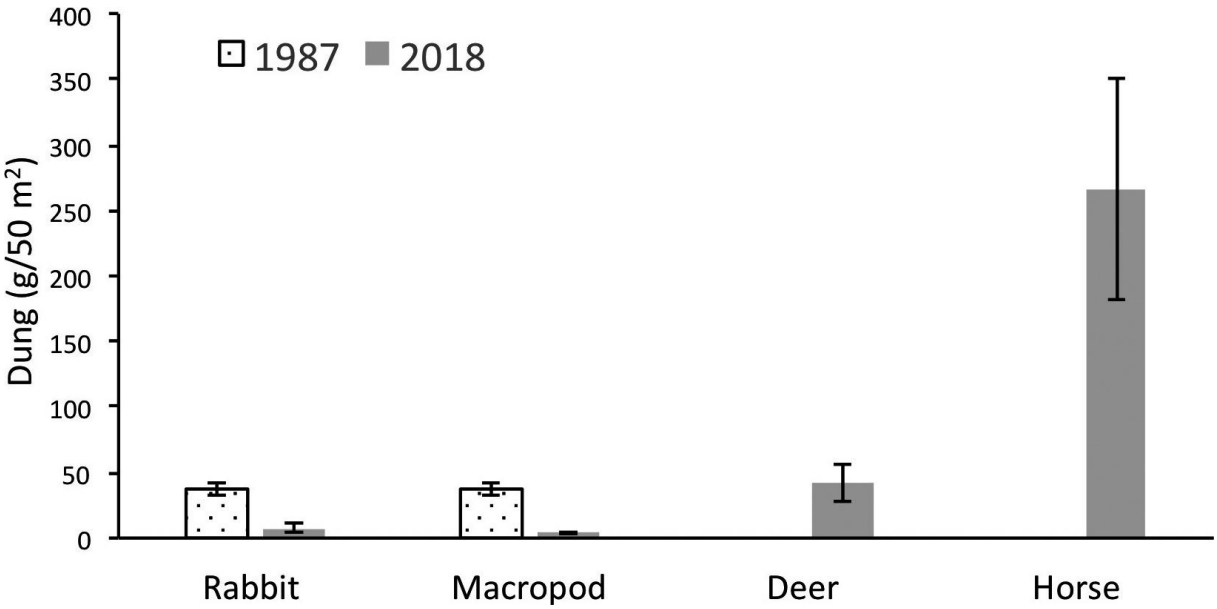
Finally, he has observed the impact of feral horses on Aboriginal cultural sites within the KNP. These sites are typically in meadows and so in the same places as horse inhabit. The result being he often has to *"sift through horse dung to show a cultural site or stone artefact."*

Source: Pers Comm Richard Swain , Alpine Adventures, 17 November 2020 & Colin de Pagter, 2020

The damage to ecosystems within KNP will impact on fauna, who live in these sensitive areas. Unique species that may be threatened by feral horses damaging these habitats include the endangered Alpine Spiny Crayfish, Alpine She-oak Skink, Northern Corroboree Frog and Alpine Tree Frog and the critically endangered Southern Corroboree Frog and Stocky Galaxias.[51] Further evidence of the environmental damage caused by horses is contained in Appendix B.

While other hooved animals could be responsible for the damage to these ecosystems, there is evidence to suggest that feral horse are by far the most damaging. **Figure 4** below shows the relative prevalence of feral horses as compared to dear and rabbits, on a surveyed area of endangered woodland in KNP. In 2018 feral horses where found to be by far the most prevalent invasive species.

Figure 4: Relative prevalence of feral horses and other species on an endangered woodland in KNP



Source: Ecological Management & Restoration, Volume: 20, Issue: 1, Pages: 37-46, First published: 30 January 2019, DOI: (10.1111/emr.12353)

3.1.2 Impact on water quality within the Park

There is a range of evidence to suggest feral horses have a negative impact on in-stream water quality in KNP.

First, as discussed above, studies have found that feral horses can cause increased erosion of streambanks and poorer and more variable vegetation quality. This damage is likely to result in streambank sediment loss and increased erosion,[52] which in turn, is likely to:

[51] See for example Robertson, G., Brown. D, Yuen. K and Tongway. D. (2019) An assessment of feral horse impacts on treeless drainage lines in the Australian Alps, available at https://onlinelibrary.wiley.com/doi/10.1111/emr.12359.

[52] Wild, A. and Poll, M. (2012) Impacts of feral horses on vegetation and stream morphology in the Australian Alps: Feral horse exclusion plot monitoring and analysis. Report to the Friends of the Cobberas, Parks Victoria and the Australian Alps Liaison Committee

- drive higher levels of sediment in the stream bed and higher amounts of suspended solids in the streams; [53] and
- increased the amount of nutrients and organic matter making its way into streams which could further degrade the aquatic habitat.

Second, feral horses could be contributing to changes in flow regimes. In particular, permeable soils and thick vegetation can hold greater volumes of water and enable this water to slowly flow toward rivers and streams through subsurface flow. [54] Peatlands and alpine bogs can be thought of as acting as a sponge for the catchment. These systems are likely to be soaking up high rainfall events, reducing peak flows in rivers and streams which would otherwise lead to higher erosion rates and sediment transport. In period of low rainfall this rainfall is released slowly over many months. Feral horses could, by damaging these habitats, affect peak flows from the catchment and water quality in the rivers and streams in the KNP. This can increase the transmission of silt and the likelihood that suspended solids are deposited downstream affecting these aquatic environments. During drought conditions, water flows are reduced as the holding capacity of the catchments is lost.

These impacts were noted in the ACT Government recent *Namadgi National Park Feral Horse Management Plan* which highlights the significance of the Australian Alps as a source of water, for the Murray-Darling Rivers. It also notes that damage to alpine bogs and riparian zones by feral horses "is degrading water quality and increasing variability in rates of water flow from mountain catchments".[55]

A change in water quality has implications for a number of threatened and endangered species which call the streams and rivers of KNP home, such as the Stocky Galaxias. This species is listed as critically endangered, with the only known population located in headwaters of the Tantangara Creek catchment in KNP. Stocky Galaxias spawning relies on rocky substrates and clean spaces between stones, the availability of which is significantly reduced by sedimentation, which can smother and kill fish eggs.[56]

A decline in water quality, caused by feral horses, also has implications for those who make use of the Park for fishing (see section 2.1 above) and potentially for other downstream users who rely on the functioning of these eco-systems to protect the quality and flow of the water sources they rely on. The founding legislation required the Snowy Mountains Authority to protect the catchments of the Snowy Hydro scheme [57]

53 By way of example, Robertson et al (2019) found that on average, about 28 metres of the 50 m of streambed studied had a moderate to high sediment load in horse-present sites. In contrast, no horse-free sites had a moderate-high sediment load on the streambed. (source: Robertson, G., Brown. D, Yuen. K and Tongway. D. (2019) An assessment of feral horse impacts on treeless drainage lines in the Australian Alps, available at https://onlinelibrary.wiley.com/doi/10.1111/emr.12359)

54 Discussed in Sander van Tol (2016), Hydrology and scaling relationships of Snow Mountain Rivers, University of Wollongong, available at https://ro.uow.edu.au/theses/4947/, p.22.

55 ACT Government, Namadgi National Park Feral Horse Management Plan, September 2020 <accessible at https://www.environment.act.gov.au/__data/assets/pdf_file/0007/1624930/namadgi-national-park-feral-horse-management-plan-2020.pdf>

56 Allan, H. & Lintermans, Associate Professor M. (2020), Fish: Impacts of Feral Horses – Stocky Galaxias: The threat from feral horses to a critically endangered fish, Kosciuszko Conference Abstracts

57 See Schedule 1, Snowy Mountains Hydro-electric Power Act 1949, now repealed, which provided safeguards to the catchments where Snowy Hydro-Electric Authority operated.

3.1.3 Impact on heritage values within the Park

Another important 'intangible' park value relates to the Aboriginal heritage sites distributed across KNP. The park is a place of great cultural significance for the Australian Alps First Peoples and it is undisputed that the Australian Alps constitute a cultural landscape and host a range of cultural heritage items including physical items, sacred and/or spiritual landscapes, vegetation and past sites, and intangible culture.[58] Despite this, tracing the link between feral horses and heritage values within KNP is difficult and to our knowledge, there is no study that examines the issue for KNP specifically. However, it would appear Aboriginal heritage sites in KNP are being impacted. We note that there is anecdotal evidence that cultural sites within the Park have be affected by horses (see Box 3) and that Victorian sites of equivalent cultural significance have also been damaged by feral horse trampling.[59]

We note that some members of the community may assign strong cultural and social values to the wild horse population. This is due to:

- Historical and cultural values associated with the High-Country pastoralism and the 'Alps experience' that contributes to national identity.
- A strong aesthetic appreciation of the "Australian brumby" across the Australian community and the High Country, and the social values associated nation-building mythology in Australia (such as the *Man from Snowy River* legend).

We acknowledge there is likely to be some economic value associated with the existence of feral horses, with some visitors having the expectation of seeing feral horses in the landscape. However, in contrast, many visitors are also likely to expect to see a pristine and native landscape[60] as described in Box 3 above.

In addition, it would not appear that the heritage values associate with having a wild feral horse population would necessarily be lost with the substantive removal of feral horses from KNP. Consistent with this view, the Federal Court recently ruled that the removal of feral horses from the Alpine National Park in Victoria will not compromise heritage values.[61] A factor of this decision is that heritage values are placed on the presence of feral horses in the park, rather than the quantity of horses.

58 Australian Alps National Parks, Australian Alps Aboriginal Cultural and Spiritual Values, available at https://theaustralianalps.files.wordpress.com/2015/09/alps-aboriginal-cultural-and-spiritual-summary.pdf.

59 Victoria State Government (2017), Protection of the Alpine National Park: Feral Horse Strategic Action Plan 2018-2021.

60 Office of Environment and Heritage (2016), Draft Wild Horse Management Plan Kosciuszko National Park, available at: https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Pests-and-weeds/Kosciuszko-wild-horses/kosciuszko-national-park-draft-wild-horse-management-plan-160271.pdf

61 The Guardian (2020), Victoria to resume culling brumbies in alpine national parks after court ruling, available at https://www.theguardian.com/environment/2020/may/08/victoria-resume-culling-feral-horses-brumbies-alpine-national-parks-court-ruling.

3.2 The value of improved environmental and heritage outcomes in the Park

Given the likely significant detrimental impact of feral horses on habitats, water quality, ecosystems and species within the park, reducing feral horses to sustainable levels is likely to drive improved environmental outcomes in KNP. Unlike recreational impacts (see section 2) the value of any improvement in environmental outcomes need not only be derived from the communities use of the park. Rather the community is typically willing to pay to protect or preserve key environmental assets regardless of whether, or not, they *use* it. These are termed non-use values (see Box 1).

The findings of the *Straight Talk* engagement process (see Box 4) suggest the community is likely to place a high value on the preservation of KNP habitats and environments. It found strong community support for the protection of flora, fauna and ecosystems and the management and removal of feral pests to protect these values.

Box 4: Protecting flora, fauna and ecosystems with KNP - outcomes of engagement

NSW National Parks and Wildlife Service (NPWS) commissioned a community engagement process to provide insight into the values, issues and interests of the general community regarding the management of feral horses in KNP. This engagement involved focus groups, an initial online (panel) survey and a 'town hall meeting' involving randomly selected, representative participants. The online (panel) survey found that:

- There is a strong understanding that the purpose of national parks is to protect and conserve native plants and animals (identified by 71% of respondents) and to protect natural and unique landscapes (identified by 59% of respondents). For 39% of respondents national parks protect and conserve cultural heritage and historic sites.
- Only 10% of respondents thought feral horses in KNP should be protected at all costs, compared to 49% who thought native flora and fauna in the park should be protected at all costs. A total of 41% of respondents were neutral, with 27% of those selecting 5 from the 0 to 10 scale, which suggests the need to balance the interests of both wild horses and native flora and fauna.

These findings were supported by the outcomes of the town hall, which found the majority of community participants supported or strongly supported the protection of flora and fauna and agreed that wild horses in KNP should be controlled in order to do so. In fact, the majority of respondents supported the removal of feral horses from the park and one-third supported their complete removal.

Source: Straight Talk. Community Engagement Report, Wild Horse Management Plan Review, 18 March 2015

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 horse numbers on environmental outcomes).

As discussed in more detail in Section 5.3, information on the willingness to pay of the community for changes in environmental and heritage outcomes arising from management of feral horses in general (let alone specific analysis for KNP) is limited.[62]

That said, there are a larger number of studies that we are aware of that estimate the community's willingness to pay for improvements in water quality and riparian environments. The estimates from these studies vary and are context dependent, however, they suggest households may be willing to pay between $3-7 per year for a 1% improvement in vegetation health along a waterway.[63] Assuming all NSW households[64] are prepared to pay this amount then this would equate to a value of, on average, **between $10m and $28m per year**, over the period. Given the evidence of the damage done by feral horses to riparian environments in the Park this seems to be a conservative estimate. As such, it seems reasonable to assume that a reduction in feral horse numbers in KNP would at least result in a 1% improvement in vegetation health along the waterways in KNP.

However, it should also be noted that these estimates are based on 'benefit transfer' and are applied absent of any precise knowledge of:

- the magnitude of the incremental impact of feral horse (relative to all other threats) on habitats within KNP and
- whether all NSW households would be willing to pay

On this basis they should be treated with caution. That said, this analysis in conservative and does suggest that the community is likely to place a significant value on the environmental benefits associated with reducing feral horse to sustainable levels.

As discussed in more detail in Section 5.3, there is likely to be benefit in undertaking further, targeted analysis around the scale and magnitude of the impact of feral horses on environmental habitats within the park. For example, new satellite surveying techniques may be able to assist future researchers to understand the scale of the impacts like erosion and vegetation destruction in specific locations and how this might be changing over time.

62 For example, Parks Victoria has previously identified existence value as a relevant component of their overall economic valuation of parks but did not have sufficient data to quantify this value (source: URS Sustainable Development (2005), Socio-Economic Assessment of Cattle Grazing in the Alpine National Park Final Report, prepared for Department of Sustainability and Environment on behalf of the Alpine Grazing Taskforce).

63 Based on data contained in the INFEWS model – This suggests a 1% increase in the percentage of healthy riverside vegetation and wetlands is likely be valued by a household at between $3-7. For example, a study related to the Clarence River (current level is 40% in health condition) found a value of $3.18 (2018) one off per household; A study related to the Murrumbidgee River (current level is 10% in health condition) found a value of $2.25 one off per household; A study related to the Moorabool River (current level is 25% in health condition) found a value of $7.43 one off per household, Finally a study of household willingness to pay per year for 10 years for a 1% increase in healthy vegetation along the River Murray found values for NSW of $3.54 and South Australia of $4.77.

64 Based on the forecast figure from the ABS 2016 Census of 3.0 million households in NSW in 2019 (ABS (2019), Household and Family Projections, Australia, available at < https://www.abs.gov.au/statistics/people/population/household-and-family-projections-australia/latest-release#data-download>.

4 The broader economic impacts of feral horses

4.1 Other economic impacts of feral horses

Anecdotal evidence suggests feral horses in KNP are associated with a range of broader, economic impacts, including:

- **Costs associated with replacing and/or repairing park infrastructure -** There is anecdotal evidence relating to the impact of feral horses on park infrastructure. For example, a paper by the *Department of Primary Industries and Energy* describes how feral horses have damaged fences, water troughs and pipes.[65] In addition, *Victoria's Feral Horse Strategic Action Plan* highlights an image of a horse-chewed camping sign.[66] This will likely increase NSW Parks and Wildlife's ongoing costs for repairing damaged infrastructure.
- **Costs to adjoining land users –** As discussed in Box 5 there is a range of anecdotal evidence that suggests feral horses in KNP are impose costs on adjoining land users when they leave the park, including by:
  - Damaging private infrastructure such as fences outside of the park;
  - Competing with farmed cattle for pasture and water, disrupting cattle musters, mating with domestic mares, and spreading diseases to domestic animals. For example, a paper on Feral Horses and Donkeys by the *Department of Sustainability, Environment, Water, Population and Communities* describes feral horses as a negative impact on the productivity of farming land, eating pasture grasses, destroying fences and causing cattle to scatter during musters.[67]
  - Requiring action to be taken to reduce horse numbers that enter their land.
- **Cost of road accidents -** The presence of feral horses in the park have resulted in a number of crashes and accidents on highways running through KNP. Recent observational data suggests there are around 13 feral-horse related crashes near KNP, annually.[68]

65 W.R. Dobbie, M.L. Braysher, D.McK. Berman (1993), Managing Vertebrate Pests: Feral horses, https://www.researchgate.net/profile/David_Berman6/publication/293517610_Managing_Vertebrate_Pests_Feral_horses/links/5f48a78e458515a88b7aa4b1/Managing-Vertebrate-Pests-Feral-horses.pdf

66 Parks Victoria (2018), Protection of the Alpine National Park Feral Horse Strategic Plan 2018-2021, https://s3.ap-southeast-2.amazonaws.com/hdp.au.prod.app.vic-engage.files/8815/2757/7404/Alpine-NP-Feral-Horse-SAP-2018-21.pdf

67 Department of Sustainability, Environment, Water, Population and Communities (2004), Feral Horse (Equus Caballus) and Feral Donkey (Equus Asinus), http://www.environment.gov.au/system/files/resources/b32a088c-cd31-4b24-8a7c-70e1880508b5/files/feral-horse.pdf

68 Private correspondence from the Invasive Species Council (2020).

Box 5: The impact of feral horses on adjacent landholders – anecdotal evidence

Discussions with adjacent landholders have highlighted the significant impacts that feral horses can have on surrounding property.

For example, an adjacent landholder indicated that feral horses from KNP are an increasing nuisance and while there have been attempts to mitigate the damage they cause through installing fences, *"they are very good at walking through fences".*

He estimated the cost of replacing fences to be $10-$12 per metre, in addition to labour costs (estimated at $1000/day), the combination of which, can be more expensive than building a new fence.

However, the impact of feral horses on adjacent landholders is not just a financial impact, with some feral horses incurring significant injuries as a result of walking through fences. An adjacent landholder reported that he has to shoot 3 feral horses a year as the horse had been seriously injured.

He also noted problems with wild stallions that have been kicked out of herds coming to their properties looking to attract females from domestic herds.

Observational reports from landholders further reinforce the notion that bushfires and drought have had little or no impact on the quantity of horses.

Source: Consultation with Ted Rowley (an adjacent landholder)

4.2 The value associated with fewer car crashes

Controlling feral horses in KNP to ecologically sustainable levels going forward is likely to be associated with lower economic costs for the community.

One such impact that can be valued is the likely reduction in the number of feral-horse related crashes on highways near KNP. Or more particularly the avoided costs associated with these incidents and crashes. Observational data suggests there are around 13 feral horse-related crashes in highways running through KNP, annually.[69]

To estimate the value of reducing crashes in the future by virtue of removing horses, we drew on the Transport for NSW (TfNSW) standard estimates of the cost of crashes,[70] and applied this to a forecast of future rates of feral horse related accidents in the absence of any horse management interventions.

This forecast was developed by adjusting the current rate of feral-horse related crash data for the likely growth in KNP feral horse population and increased highway utilisation (as a result of future population growth).

69 Private correspondence from the Invasive Species Council (2020).

70 On an annual basis, TfNSW publishes economic parameters used by them to estimate the benefits of initiatives across the NSW Transport cluster. These economic parameters includes their estimates on the economic cost of accidents across NSW (TfNSW (2020), TfNSW Economic Parameter Values, viewed 30th October 2020, available at https://www.transport.nsw.gov.au/system/files/media/documents/2020/200527%20-%20TfNSW%20Economic%20Parameter%20Values%20v2.0.pdf.)

These estimates include both the broad human cost (e.g. injuries) and the financial cost of crashes. Namely:

- Costs associated with repair the damaged vehicle.
- 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.

Our analysis indicates that reducing feral horses in KNP to ecologically sustainable levels could on **average, lead to a benefit of $2m per year, associated with fewer crashes** on highways within the Park. This assumes that by reducing feral horses to this level all future crashes involving horses are avoided. This value of avoided crashes increases over time assuming population and feral horse growth.

Given the lack of information on the impact of feral horses on other costs within and outside the park, we have not been able to robustly value the other broader economic impacts described above. As discussed in more detail in Section 5.3, there is likely to be benefit of further research around the impact of feral horses on these costs to understand the full cost of feral horses in KNP.

5 The benefits of managing feral horses will exceed the costs

This section provides a summary of the findings of our analysis and outlines a range of potential steps that could help address identified data gaps.

5.1 The benefits of more substantive and sustainable feral horse management could be significant

Feral horse numbers in KNP have been growing at a staggering rate of over 16%pa over the past 6 years, with numbers estimated to be around 14,000 today.[71] Assuming no management action is taken we have estimated that by 2040, there will be around 35,000 feral horse in the Park.

While the issue of feral horse management within KNP has been highly contentious (with significant debate around the appropriate management approach and level of feral horses in the park), what isn't contentious is that the Park's unique ecosystems (such as alpine heaths, bogs and fens) are at particularly severe risk from the horses. Feral horses damage native habitats through both grazing and trampling, which threatens native species that rely on these habitats, damaging water quality and accelerating erosion.

Our analysis has sought to identify and, where appropriate, value the social, environmental and economic benefits associated with managing feral horses in KNP at sustainable levels. Our findings highlight the need for decisive action to manage the feral horse population in KNP.

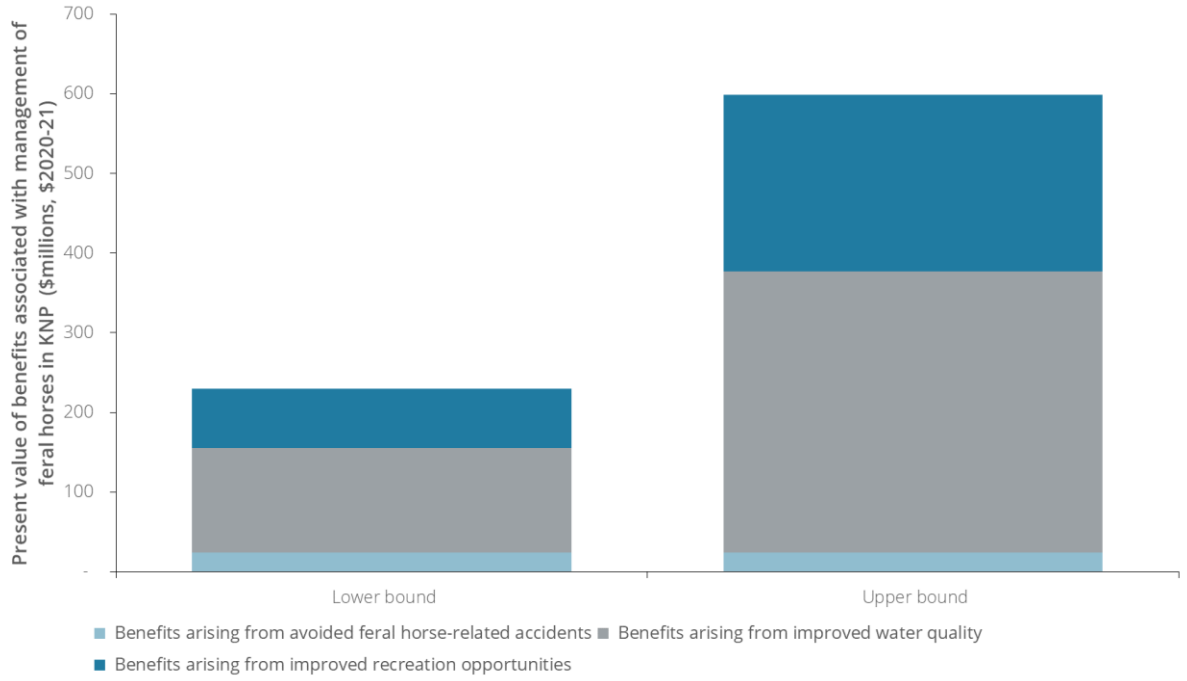
In particular, as shown in **Figure 5** acting to control feral horses to achieve ecologically sustainable numbers could lead to a total benefit to society over the next 30 years of between **$230m and $599m** (in PV terms). This is made up of:

- **Use benefits of between $74m and $222m** in PV terms**.** This is based on the assumption that use of the park each year for camping, hiking, fishing and mountain biking will be dampened by 1% due to the impact of feral horses. This results in an annual benefit of $7m and $20m per year (undiscounted, on average over the period).
- **Non-use benefits from improved water quality and riparian health of between $131m and $353m** in PV terms. This assumes sustainably low horse numbers in the Park results in a 1% increase in healthy vegetation along the waterway**,** which results in an annual benefit, based on peoples willingness to pay for this improvement, of between $10m and $28m per year (undiscounted, on average over the period).

[71] A survey conducted in 2014 estimated that there were 6,000 feral horse in Kosciuszko National Park and 14,380 in 2020, reflecting a 16% per year growth rate (NSW Office of Environment & Heritage (2016), Final report of the Independent Technical Reference Group; NSW Department of Planning, Industry and Environment (2021), Tracking the wild horse population, viewed 13 January 2021, https://www.environment.nsw.gov.au/topics/animals-and-plants/pest-animals-and-weeds/pest-animals/wild-horses/kosciuszko-national-park-wild-horse-management/tracking-the-wild-horse-population).

- **Avoided cost of crashes of $24m** in PV terms. This assumes all future horse related crashes on highways within the Park can be avoided which results in an average benefit of around $2m per year (undiscounted).

Figure 5: Economic, social and environmental benefits associated with feral horse management KNP over the period to 2049 ($millions, $2020-21)



Source: Frontier Economics

Given the relationship between water quality and fishing opportunities, there is the potential for double counting between the value of benefits arising from improved water quality and the value of recreation and use benefits. However, we consider the risk to be relatively low as the benefit from improved water quality primarily represents a non-use value and we have consistently adopted a relatively conservative approach to estimating the benefits in this report.

Importantly, 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 benefits associated with the management of feral horses in KNP, including:

- Avoided maintenance / replacement expenditure within KNP, including costs associated with protecting species and restoring areas of high conservation from horse impacts (i.e, costs associated with exclusion fences, erosion control and replanting) and the costs of repairing horse damaged park infrastructure such as signs, fence and trails within the park.
- Avoided costs incurred by adjacent landholders, for example, as a result of replacing damaged fences.
- Increased carbon sequestration as a result of reduced damage to vegetation within the park. The carbon-carrying capacity of soils and vegetation in KNP may be impacted by feral horse trampling and vegetation loss.
- Reduced impact on aboriginal cultural values.

- Any improvement in flows and water quality for downstream users.

5.2 The costs of acting quickly and decisively to remove feral horses will be lower than the benefits

More substantive management of feral horses in KNP will not be costless and will include both:

- the cost of any management action itself (e.g. increased trapping, removal and rehoming costs, and costs of culling activities); and
- the broader social costs associate with their removal, including the lost amenity and non-use value given reduced feral horse numbers (e.g. the 'feel good factor' from the existence of feral horses). In particular, it's important to note that in some cases, management of feral horses can involve competing cultural values. Although, as discussed above, the community values protection of native plants and animals in KNP, some segments of the community may assign strong heritage value to feral horses due to their role in early alpine life when the area was first inhabited by Europeans.

However, we note that while there are costs associated with reducing feral horse numbers to sustainable levels, these seem highly unlikely to outweigh the benefits.

A recent study estimated feral horse management costs are likely to range from $87 to $4,955 per horse ($2020-21) depending on the density of horses and the control method used.[72] The lower figure assumes aerial culling of horse at high densities while the lower figure assumes trapping at lower densities.

These unit costs suggest that acting to immediately remove the entire feral horse population currently residing in KNP would cost between $1m and $71m, depending on the management approach adopted. [73] This is significantly lower than the potential value of the economic, social and environmental benefits associated with managing feral horses in the park which we have estimated to be in the order of $230m and $599m (in PV terms).

The marginal cost of removing a horse can be expected to increase as the management method that can be used, terrain and density changes. If the marginal benefit of removing feral horses is constant, then there is likely to be an optimal feral horse population number that should be maintained. With the data available it is not possible to estimate this. However, we note that the longer the delay in acting, the larger the population of feral horses and the greater the cost of inaction.

In this report we have identified, and where possible,[74] valued the economic, social and environmental impacts on society of reducing feral horses to an ecologically sustainably low level

[72] Based on a recent study that estimated feral horse management costs are likely to range from $87 to $4,955 per horse ($2020-21) depending on the density of horses and the control method used. The lower figure assumes aerial culling of horse at high densities while the higher figure assumes trapping at a density of one horse per 0.2 km^2 (source: Beeton, N. & Johnson, C. (2019), Modelling horse management in the Australian Alps, *Special Issue: Feral horses in the Australian Alps*, 20(1), pp. 57-62.)

[73] These figures are based on the assumption on the removal of 14,380 horses in KNP.

[74] As discussed in Section 5, there is limited scientific and economic data available on the specific impacts of alternative feral horse management approaches in KNP. Our analysis makes reasonable, conservative assumptions where required in a data poor environment, and we have articulated caveats to the analysis as

(i.e. at a level at which they are likely to have limited impact on the environmental and cultural values of the Park). At this level, there will still be feral horses in the park and the cultural values of these horses will still exist, albeit the total horse population will be significantly lower than at present. This scenario will be relative to a scenario where feral horse numbers either remain at their present numbers of continue to grow dramatically (as described in section 1.1).

It should be noted, this report does not investigate or recommend an appropriate method of managing feral horses. Instead, it provides an economic perspective on the costs and benefits of feral horse management, regardless of how this is achieved. Box 6 below provides a summary of the outcomes of community engagement in relation to how feral horses should be managed in KNP.

We note that both the extent and approach to feral horse management will determine the level of benefits society receives, because different management strategies will have different impacts on the feral horse population at different costs. However, it is likely that a strategy that quickly and significantly reduces horse numbers will deliver greater benefits than a slower and tentative response, while at the same time requiring lower costs to achieve.

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.

Box 6: Managing feral horses in KNP - outcomes of engagement

The effective management of feral horses is highly contentious and there is a long history of stakeholders actively seeking to have their perspective pursued and supported by government. A town hall engagement meeting on the Wild Horse Management Plan for KNP studied community representatives on their views on management strategies.

Findings of the engagement indicated that trapping and removal of horses was not largely supported if the horses were transported to an abattoir, however, there was greater support if horses were euthanised on site (due to less stress on the animal). Community participants were spread across the whole spectrum of 'completely unacceptable' to 'completely acceptable' on this management method.

Fertility control was more polarising with only 25% of participants finding it 'completely acceptable', the same number which found it 'completely unacceptable', and a range of 50% spread evenly in between. While the trapping and administering of the fertility control was found to be humane, the time and costs involved were prohibitive and the method needs to be re-administered after some years.

Views on aerial or ground mustering were also polarising with 48% finding it acceptable or completely acceptable, and 33% finding it unacceptable or completely unacceptable. The negative responses were due to the stress caused to the horses and other species.

While aerial shooting was largely deemed appropriate (by 62% of participants) there was concern about carcasses being left on site. While a number of community responses were emotionally against it, there was support on the logic of this technique.

Trapping and euthanasia on site were the most strongly supported option with 69% of the community participants finding it acceptable or completely acceptable. This was deemed an effective method of control and preferable to trapping and transporting to an abattoir. However, there was notes of concern about leaving the carcasses on site and the stress caused to the horses for witnessing the killing experience.

Fencing was not a supported method by 70% of respondents due to its visual impact, cost and effectiveness. However, it was noted that this method may be useful in small specific areas. Feral horses running or roping was found to be unacceptable or completely unacceptable by 63% of participants.

Despite the differing responses to management methods, 70% of the respondents agreed that effectiveness was the most important consideration for population control methods, and cost was identified as the least important consideration by 63% of the respondents.

Source: Straight Talk. Community Engagement Report, Wild Horse Management Plan Review, 18 March 2015

5.3 Further primary scientific and economic research will assist our understanding of the economic impacts of feral horses

Although our analysis has sought to value, as much as is practicable, the benefits associated with managing feral horses in KNP, the extent to which we have been able to do so has been restricted by some data gaps. These include:

- Insufficient baseline scientific research and data around the magnitude of change in key social and environmental outcomes and how this relates to growing feral horse populations within the park (including the impact of alternative management strategies on these outcomes). This includes limited information around:
  - The proportion of, or extent to which, habitats and streams within KNP have been degraded as a result of large numbers of feral horses, and the extent to which these habitats may improve as a result of lower numbers of feral horses;
  - The extent to which recreational use of KNP is affected by the growing presence of feral horses.
- Limited primary economic data around the community's willingness to pay for changes in key social and environmental outcomes.
- Lack of information on other impacts such as the impact of feral horses on the Park maintenance and replacement costs, and the costs incurred by private land holders outside the park.

Understanding the quantum of changes in outcomes and the appropriate price is helpful to robustly value the economic, social and environmental benefits of managing feral horses within the park.

That said, while our results are inherently uncertain and there are gaps in the available research and primary data, it is difficult to conceive how this uncertainty would change the fundamental finding that great action to control horse numbers is warranted.

A Valuing the impact of feral horses on the use and enjoyment of the park

Economics has a range of approaches available to convert environmental or social impacts into consistent dollar value terms. While original scientific and economic research on the specific project is preferred (as it is more likely to produce more precise estimates), this is typically expensive and time consuming.

Given the timeframe available for this analysis, we have relied on benefit transfer[75] and drawn estimates from existing studies (e.g. existing travel cost or stated preference studies) to estimate the value of improved recreation opportunities in KNP. We note that the overall robustness of this approach is subject to availability and robustness of existing source studies.

This appendix provides more detail around the range of approaches to estimate the economic value of recreation which could be drawn upon as part of benefit transfer.

Approaches to economic valuation

Economics has a range of methods to help understand, in dollar value terms, the impact of lost recreation opportunity or quality from ongoing unchecked feral horse population growth (that is, our do-nothing base case). These include:

- **The Travel Cost Method (TCM**) which has been widely used to estimate the value of parks. The basic concept underpinning the TCM is that the amount of time (which can be estimated using income as a proxy) and expenditure visitors incur to visit a park is a strong indicator of individual (and in aggregate, community) value of that recreation in the park. In its simplest form, the TCM uses data collected from park users about their place of residence and estimates of their costs of travelling to the park. Together this information reveals people's preferences for certain recreational experiences and their willingness to pay for that experience.
- **Stated preference techniques**, which rely on respondents revealing their preference and/or willingness to pay through a structured questionnaire. It can be used to estimate the value associated with moving from the 'status quo' situation to one in which a range of social and environmental features are improved. While the TCM method above is a preferable approach because it draws information from observed behaviour rather than a stated estimate of preferences, well-designed willingness to pay studies are still a robust method of estimating economic value where goods don't trade in markets and therefore have no observable market price.

As we have previously outlined, we are unaware of any primary scientific research that can identify and quantify the incremental impact of feral horse management approaches on key community values of KNP such as recreation. As a result, to our knowledge, we are unaware of any studies that measure the recreation value of KNP specifically.

Given available information in our view, adopting an existing TCM study as of the Australian Alps as the basis for a benefit transfer approach is the most appropriate method for valuing

[75] Which involves leveraging existing scientific and economic research, with adjustments made as needed

recreational outcomes (see Section 2.2). However, as discussed further in Section 5.3, the current debate over feral horse management, heightened by the devastating impacts of recent bushfires, only underscores the need and usefulness of tailored primary research in this area.

The sections below provide further detail on some key primary economic research approaches that can help uncover robust estimates of community values for different use and non-use features of KNP.

Travel cost method

There are two key stages to the travel cost method:

- The first is identifying visitor numbers and the distance they have travelled from their origin to their destination (the recreational site). This can be used to determine their costs in travelling from their origin to the site and back again. A functional relationship can be formed between visitation rates and travel costs.
- The second stage involves the assumption that individuals respond to changes in travel costs similar to how they react to changes in prices. This can be used to stimulate visitation responses to hypothetical changes in prices. This is a demand curve for the recreational use value of a site, from which consumer surplus can be estimated.

Given data and time constraints, this report leverages an existing TCM to estimate the cost of unmanaged feral horse on the community value of recreation in the park (i.e. benefit transfer). There may be a role for the development of an original TCM model to estimate a unique community value for each recreational experience with and without some defined impact of feral horses. However, this exercise can be very costly and time and data intensive.

Willingness to pay (including stated preference)

An alternative approach is to adopt a contingent valuation approach which estimates the community's willingness to pay for some non-market good or service (such as recreational benefits). Most commonly this involves surveying members of the community who state their preferences and/or willingness to pay.

It is possible to adopt existing willingness to pay estimates of particular activities and use benefit transfer techniques to apply these to use of KNP where the original WTP research is robust and the broad conditions outlined in Box 2 are sufficiently achieved. However, this relies on relevant and related existing studies (e.g. studies of mountain biking in other similar NSW locations). **Table 1** below outlines examples of willingness to pay studies that could be relevant for the KNP context.

Table 1: Examples of willingness to pay by activity

Activity	Summary of impact of feral horse management	Examples of existing data
Fishing	Removing feral horses from the park should increase angler's amenity by improving the habitats of fish species and water quality, resulting in healthier and potentially more abundant fish populations.	A willingness to pay study from Western Australia used benefit transfer to estimate the consumer surplus from recreational fishing. A North American Study was used and adjusted for time and currency differences, resulting in an expansive consumer surplus for recreational fishing, averaging to $178 per person per day. Higher estimates were prevalent for prized sport fish.[76]
Hiking and camping	Removing feral horses will improve hiker and camper safety and increase their enjoyment of the national values due to less horse damage and less introduced animal species.	A study which estimated the recreational use value of hiking and camping in the Bellenden Ker National Park in Queensland can be used to gauge an estimation of this value in Kosciuszko. This study found that the value of hiking and camping in this park was found to be $144.45 per visitor per year.[77]
Mountain biking	Removing feral horses will improve biker safety and increase their enjoyment of the natural values due to less horse damage and less introduced animal species.	There is a research gap in willingness to pay for mountain biking in national parks within Australia. Thus, there is scope for further research to allow a full understanding of the impact of feral horses on this recreational activity.

Source: McLeod & Linder (2018), Economic Dimension of Recreational Fishing in Western Australia, Research report for the Recreational Fishing Initiatives Fund, available at: https://recfishwest.org.au/wp-content/uploads/2019/03/Economic-Dimensions-of-Recreational-Fishing-in-Western-Australia-Report-2.pdf; Nillesen, E., Wesseler, J. & Cook, A (2005), Estimating the Recreational-Use Value for Hiking in Bellenden Ker National Park, Australia. Environmental Management 36, 311–316. https://doi.org/10.1007/s00267-003-0219-7

76 McLeod & Linder (2018), Economic Dimension of Recreational Fishing in Western Australia, Research report for the Recreational Fishing Initiatives Fund, available at: https://recfishwest.org.au/wp-content/uploads/2019/03/Economic-Dimensions-of-Recreational-Fishing-in-Western-Australia-Report-2.pdf

77 Nillesen, E., Wesseler, J. & Cook, A (2005), Estimating the Recreational-Use Value for Hiking in Bellenden Ker National Park, Australia. Environmental Management 36, 311–316. https://doi.org/10.1007/s00267-003-0219-7

B Valuing the impact of feral horses on the environment and heritage in KNP

As with recreational opportunities, contingent valuation surveys that ask respondents their willingness to pay for goods like a pristine park environment (i.e. without damage from feral horses) is a common approach to measuring community value.

Table 2 summarises a range of studies investigating the impact of feral horses on different habitat types.

Table 2: Environmental impacts of horses in different habitat types

Ecological feature	Types of impact	Environments	References *Australian references **Australian montane/ alpine/ sub-alpine references
		Negative impacts	
Soil	Increased compaction, resistance to penetration, erosion, soil loss	Sub-alpine Montane Arid/ semi-arid Coastal dunes	Dyring 1990[78]** Whinam et al. 1994[79]** Andreoni 1998[80]** Summer 1986[81] Beever & Herrick 2006[82] Beever et al. 2008[83] Davies et al. 2014[84]

78 Dyring, J (1990), 'The impact of feral horses (Equus caballus) on sub-alpine and montane environments', M App Sc thesis, University of Canberra, Canberra

79 Whinam, J, Cannell, EJ, Kirkpatrick, JB and Comfort, M (1994), 'Studies on the potential impact of recreational horse riding on some alpine environments of the central plateau, Tasmania', Journal of Environmental Management 40: 103–117

80 Andreoni, F (1998), Evaluating environmental consequences of feral horses in Guy Fawkes River National Park: a report to National Parks and Wildlife Service, NR 490 Project, University of New England, Armidale, NSW.

81 Summer, R (1986), 'Geomorphic impacts of horse traffic on team landforms', Journal of Soil and Water Conservation 41: 126–128.

82 Beever, EA and Herrick, JE (2006), 'Effects of feral horses in Great Basin landscapes on soils and ants: direct and indirect mechanisms', Journal of Arid Environments 66: 96–112.

83 Beever, EA, Taush, RJ and Thogmartin, WE (2008), 'Multi-scale responses of vegetation to removal of horse grazing from the Great Basin (USA) mountain ranges', Plant Ecology 196:163–184.

84 Davies, KW, Collins, G and Boyd, CS (2014), 'Effects of feral free-roaming horses on semi-arid rangeland ecosystems: an example from the sagebrush steppe', Ecosphere 5: 127.

			De Stoppelaire et al. 2004[85]
	Lower soil aggregate stability	Arid/ semi-arid	Davies et al. 2014
	Impacts on ecological functioning (particularly water availability) resulting from soil impacts	Arid / semi-arid	Davies et al. 2014
Water	Damage to waterways including bank collapse, pugging and channel widening	Overview Sub-alpine	Kauffmann & Krueger 1984[86] Dyring 1990**, 1991[87]** Hope et al. 2012[88]** Whinam et al. 1994[89]**
	Lower water quality including pollution and turbidity	Sub-alpine Arid / semi-arid	Rogers 1991[90] Berman & Jarman 1988[91]* Beever & Brussard 2000[92]
	Damage to peatlands including gullying, compaction, drainage, irreversible oxidation of peat profiles and	Sub-alpine, montane	Dyring 1990** Rogers 1991 Grover et al. 2005[93]** Grover & Baldock 2010[94]**

85 De Stoppelaire, GH, Gillespie, TW, Brock, JC and Tobin, GA (2004), 'Use of remote sensing techniques to determine the effects of grazing on vegetation cover and dune elevation at Assateague island national seashore: impact of horses', Environmental Management 34: 642–649.

86 Kauffmann, JB and Krueger, WC (1984), 'Livestock impacts on riparian ecosystems and streamside management implications: a review', Journal of Range Management 37: 430–438.

87 Dyring, J (1991), Management implications of the 1988–1990 study: the impact of feral horses on subalpine and montane environments in Australia, University of Canberra, Canberra.

88 Hope, GS, Nanson, R and Jones, P (2012), Peat-forming bogs and fens of the Snowy Mountains of NSW, NSW Office of Environment and Heritage Technical Report.

89 Whinam, J, Cannell, EJ, Kirkpatrick, JB and Comfort, M (1994), 'Studies on the potential impact of recreational horse riding on some alpine environments of the central plateau, Tasmania', Journal of Environmental Management 40: 103–117.

90 Rogers, GM (1991), 'Kaimanawa feral horses and their environmental impacts', New Zealand Journal of Ecology 15: 49–64.

91 Berman, MD and Jarman, PJ (1988), Feral horses in the Northern Territory, Vol. 4: Environmental impact of feral horses in central Australia, Conservation Commission of the Northern Territory, Darwin.

92 Beever, EA and Brussard, PF (2000), 'Examining ecological consequences of feral horse grazing using exclosures', Western North American Naturalist 60: 236–254.

93 Grover, SPP, McKenzie, BM, Baldock, JA and Papst, WA (2005), 'Chemical characterisation of bog peat and dried peat of the Australian Alps', Australian Journal of Soil Research 43: 963–971.

94 Grover, SPP and Baldock, JA (2010), 'Carbon decomposition processes in a peat from the Australian Alps', European Journal of Soil Science 61: 217–230.

	increased vulnerability to fire		
Trampling	Vegetation and networks of tracks	Sub-alpine Arid / semi-arid	Drying 1990** Beever & Brussard 2000
Manure	Large manure piles supress vegetation	Sub-alpine	Dyring 1990**
	Manure piles as 'invasion windows' for exotic plant species	Grasslands	Loydi & Zalba 2009[95] Campbell & Gibson 2001[96]
Plants	Reducing plant species richness	Arid / semi-arid	Berman & Jarman 1988*
	Changes to species composition and slow hydric successions	Sub-alpine Grassland	Dyring 1990** McDougall & Walsh 2007[97]** De Villalobos & Zalba 2010[98]
	Increasing weed species	Global review Sub-alpine	Ansong & Pickering 2013[99] Rogers 1991[100]
	Reducing plant and seed density	Arid and semiarid Montane	Davies et al. 2014 Loydi et al. 2012[101]
	Altered species composition	Grassland and peatland Steppe	McDougall 1989[102]**, 2007[103]** McDougall & Walsh 2007[104]**

95 Loydi, A and Zalba, SM (2009), 'Feral horses dung piles as potential invasion windows for alien plant species in natural grasslands', Plant Ecology 201: 471–480.

96 Campbell, JE and Gibson, DJ (2001), 'The effect of seeds of exotic species transported via horse dung on vegetation along trail corridors', Plant Ecology 157: 23–35.

97 McDougall, KL and Walsh, NG (2007), 'Treeless vegetation of the Australian Alps', Cunninghamia 10: 1–57.

98 de Villalobos, AE and Zalba, SM (2010), 'Continuous feral horse grazing and grazing exclusion in mountain pampean grasslands in Argentina', Acta Oecologica 36: 514–519.

99 Ansong, M and Pickering, C (2013), 'A global review of weeds that can germinate from horse dung', Ecological Management & Restoration 14: 216–223.

100 Rogers, GM (1991), 'Kaimanawa feral horses and their environmental impacts', New Zealand Journal of Ecology 15: 49–64.

101 Loydi, A, Zalba, SM and Distel, RA (2012), 'Viable seed banks under grazing and exclosure conditions in montane mesic grasslands in Argentina', Acta Oecologica 43: 8–15.

102 McDougall, KL (1989), The Effect of Excluding Cattle from a Mossbed on the Bogong High Plains, Victoria, Arthur Rylah Institute for Environmental Research, Technical Report Series no. 95, Victorian Department of Conservation, Forests and Lands, Melbourne, VIC.

103 McDougall, KL (2007), 'Grazing and fire in two subalpine peatlands', Australian Journal of Botany 55: 42–47.

104 McDougall, KL and Walsh, NG (2007), 'Treeless vegetation of the Australian Alps', Cunninghamia 10: 1–57.

			Van Staalduinen et al. 2007[105]
Wildlife	Impacts on other species of wildlife	Estuarine Grassland Arid / semi-arid Alpine herpetofauna	Levin et al. 2002[106] Zalba & Cozzani 2004[107] Matthews et al. 2001[108] Beever & Brussard 2004[109] Meredith et al. 2003[110] Clemann 2013[111]**
	Repression of peatland fauna including crayfish and rodents May assist other taxa (e.g. deer, marsupials) by increased access via horse trails	Sub-alpine	Whinam & Hope 2005[112]**
	Positive impacts		
Plants	Increased species diversity	Sub-alpine, montane, desert	Fahnestock & Detling 1999[113] Austrheim & Eriksson 2001[114]

105 Van Staalduinen, MA, During, H and Werger, MJA (2007), 'Impact of grazing regime on a Mongolian forest steppe', Applied Vegetation Science 10: 299–306.

106 Levin, PS, Ellis, J, Petrik, R and Hay, ME (2002), 'Indirect effects of feral horses on estuarine communities', Conservation Biology 16: 1364–1371.

107 Zalba, SM and Cozzani, NC (2004), 'The impact of feral horses on grassland bird communities in Argentina', Animal Conservation 7: 35–44.

108 Matthews, D, Bryan, R and Edwards, G (2001), 'Recovery of the blackfooted rock-wallaby following horse removal on Finke Gorge National Park, Northern Territory', p. 397 in Proceedings of the 12th Australasian Vertebrate Pest Conference.

109 Beever, EA and Brussard, PF (2004), 'Community- and landscape-level responses of reptiles and small mammals to feral-horse grazing in the Great Basin', Journal of Arid Environments 59: 271–297.

110 Meredith, C, Hudson, S, Robertson, P and Clemann, N (2003), Flora and Fauna Guarantee Action Statement: Alpine Water Skink Eulamprus kosciuskoi, Department of Sustainability and Environment, Victoria, www.depi.vic.gov.au/__data/assets/pdf_file/0017/247004/Alpine_Water_Skink_Eulamprus_kosciuskoi. pdf

111 Clemann, N (2013), Survey and monitoring of threatened Victorian alpine herpetofauna: results for the 2011–12 season, Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, report to State-wide Services, Department of Sustainability and Environment, Heidelberg, VIC.

112 Whinam, J and Hope, GS (2005), 'The peatlands of the Australasian region', pp. 397–434 in GM Steiner (ed.), Moore – von Sibirien bis Feuerland / Mires – from Siberia to Tierra del Fuego, Biologiezentrum der Oberoesterreichischen Landesmuseen Neue Serie 35, Linz.

113 Fahnestock, JT and Detling, JK (1999), 'The influence of herbivory on plant cover and species composition in the Pryor Mountain Wild Horse Range, USA', Plant Ecology 144: 145–157.

114 Austrheim, G and Eriksson, O (2001), 'Plant species diversity and grazing in the Scandinavian mountains – patterns and processes at different scales', Ecography 24: 683–695.

			Fahnestock & Detling 2002[115] Ostermann-Kelm et al. 2009 Stroh et al. 2012[116]
	Seed dispersal	Coastal dunes	Cosyns & Hoffmann 2005[117]
Fire	Reduction of fire severity	Forest, subalpine, montane, semiarid	Silvers 1993[118]* Davies et al. 2015[119]

Source: Frontier Economics interpretation of impacts identified in ITRG (2016), Final report of the Independent Technical Reference Group: Supplementary to the Kosciuszko National Park Wild Horse Management Plan, report by the Independent Technical Reference Group to the Office of Environment and Heritage NSW, Sydney

115 Fahnestock, JT and Detling, JK (2002), 'Bison–prairie dog–plant interactions in a North American mixed-grass prairie', Oecologia 132: 86–95.

116 Ostermann-Kelm, SD, Atwill, EA, Rubin, ES, Hendrickson, LE and Boyce, WM (2009), 'Impacts of feral horses on a desert environment', BMC Ecology 9: 22, http://bmcecol.biomedcentral.com/articles/10.1186/1472-6785-9-22, doi: 10.1186/1472-6785-9-22.

117 Cosyns, E and Hoffmann, M (2005), 'Horse dung germinable seed content in relation to plant species abundance, diet composition and seed characteristics', Basic & Applied Ecology 6: 11–24

118 Silvers, L (1993), 'The effects of grazing on fuel loads and vegetation in the Barmah Forest', Honours thesis, School of Environmental and Information Sciences, Charles Sturt University, Albury, NSW.

119 Davies, KW, Boyd, CS, Bates, JD and Hulet, A (2015), 'Dormant season grazing may decrease wildfire probability by increasing fuel moisture and reducing fuel amount and continuity', International Journal of Wildland Fire 24: 849–856.

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