

Assessing the humaneness of wild horse management methods

Kosciuszko National Park Wild Horse Management Plan

A report on the outcomes of a humaneness assessment panel assembled on behalf of the Independent Technical Reference Group (ITRG)

Contents

Introduction	2
Humaneness assessment model.....	2
Assumption of 'best practice'	4
Methods for control of wild horses	4
Capture methods	4
Post-capture methods and outcomes	5
Other methods	7
Outcomes of the assessments	11
References.....	13
Appendix 1 - wild horse humaneness assessment panel members	15
Appendix 2 - humaneness assessment panel worksheets	18

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Introduction

Development of a wild horse management strategy is a complex process. Consideration of any method to control or remove wild horses from KNP necessarily needs to take into account many different factors, including efficacy, cost, practicality, operator safety, target-specificity, environmental impact, as well as its impact on the welfare of the affected horses, also termed *humaneness*. For some stakeholders, the humaneness of a control method is the single most important aspect of managing wild horses. For many years, a major stumbling block in the consideration of animal welfare in wildlife management was the lack of a reliable and practical method of assessing it. In 2007, with the support of the Department of Agriculture, Fisheries and Forestry under the Australian Animal Welfare Strategy (AAWS), a project was funded to develop a process for assessing the relative humaneness of pest animal control methods. Under the management of a steering group formed from members of the AAWS Wild Animals Working Group, the NSW Government's Vertebrate Pest Research Unit was commissioned to develop a suitable model for humaneness assessment. The model was first published in 2008, with a second edition in 2011 (Sharp and Saunders 2011). The model has now been used to assess numerous pest animal control methods for a range of species in Australia (Hart et al., 2013; McLeod et al. (in prep); Sharp & Saunders 2008, 2011), New Zealand (Fisher et al. 2010) and the United Kingdom (Baker et al. submitted).

Humaneness assessment model

All assessments were carried out using the 2011 edition of the *Model for assessing the relative humaneness of pest animal control methods* (Sharp and Saunders 2011). The model provides a practical, general means of assessment that can be applied to any control method. The goal of humaneness assessment is to evaluate the impact of a control method on individual animals and to use this assessment to determine which methods are more or less humane compared to other methods.

The assessment of overall welfare impact is based on five domains:

1. Thirst/hunger/malnutrition
2. Environmental challenge
3. Injury/disease/functional impairment
4. Behavioural/interactive restriction
5. Anxiety/fear/pain/distress

The model was not designed to provide an absolute measure of humaneness but allows a judgement to be made about the impact of a specific control method on the target animal. When the model is applied to a range of different methods, these can be compared and a decision can be made on the choice of method that is informed by an understanding of the relative humaneness of each method being considered.

The model uses a two-part assessment process for each method:

- Part A examines the impact of a control method on overall welfare and the duration of this impact;
- Part B applies to lethal methods only and examines the effects of the killing method on welfare by evaluating the intensity of suffering and duration of suffering caused by the technique.

Both Part A and Part B are used to assess the overall humaneness of lethal control methods. For non-lethal methods, only Part A is used to examine the impacts on an animal's welfare.

With Part A, the impact in each of the five domains is assigned a grade (ranging from no impact to mild, moderate, severe, or extreme impact), and from this an overall impact grade and duration of impact are determined. With Part B the level of suffering is graded and the duration of suffering determined. Impact scores are assigned using a pre-determined scoring matrix (Boxes 1 and 2).

Where there are multiple stages in a process, the model can be used to assess the impact of each stage the animals go through from the application of the first method to a specific end-point.

There is often a paucity of published peer-reviewed literature on the application of control methods for wildlife and pest animal management. A lack of objective data means that there is always some reliance on subjective

data such as advice from experienced practitioners and comparisons with other similar species. It is important that those performing the assessment must have an understanding of the biology and behaviour of the target species as well as knowledge and experience of practical aspects of the control method being assessed. The composition of the panel should ensure that there is a wide range of relevant experience and knowledge that can be drawn on during the assessment process.

Panel members for this assessment had expertise in horse behaviour, horse ecology, animal welfare, animal ethics, humane wildlife capture and killing methods, equine medicine and horse performance, conservation, wildlife and pest animal management. The panel was made up of nine members in total, including three members of the Independent Technical Reference Group, a member of staff from NSW National Parks and Wildlife Service and five independent members appointed for their specific expertise. Biographies of all panel members are provided in Appendix 1.

Box 1 Scoring matrix for Part A: overall welfare impact (Sharp and Saunders 2011)

Overall impact on welfare	Duration of impact				
	Immediate to seconds	Minutes	Hours	Days	Weeks
EXTREME	5	6	7	8	8
SEVERE	4	5	6	7	8
MODERATE	3	4	5	6	7
MILD	2	3	4	5	6
NO IMPACT	1	1	1	1	1

Box 2 Scoring matrix for Part B: assessment of mode of death (Sharp and Saunders 2011)

Level of suffering*	Time to insensibility (minus any lag time)				
	Immediate to seconds	Minutes	Hours	Days	Weeks
EXTREME	E	F	G	H	H
SEVERE	D	E	F	G	H
MODERATE	C	D	E	F	G
MILD	B	C	D	E	F
NO IMPACT	A	A	A	A	A

Assumption of 'best practice'

When assessing the impact of a control method in each of the domains a key assumption is that the method is being carried out according to 'best practice' as set out in any relevant code of practice or standard operating procedure. This is to ensure that the evaluation is of the intrinsic humaneness of a method rather than technical inadequacies or limitations associated with its application. Best practice application also assumes that those carrying out the technique are sufficiently skilled, competent and experienced to be able to consistently and effectively achieve best practice outcomes.

Methods for control of wild horses

A range of different potential methods exist for the control or removal of wild horse populations, including non-lethal methods such as exclusion fencing, fertility control or removal of horses for domestication, and lethal methods such as *in situ* shooting or removal for slaughter in an abattoir or knackery. At present, the only method employed in the Park is passive trapping followed by removal of horses for either domestication or slaughter. The outcome for the majority (70%) of horses removed via trapping is slaughter in an export abattoir or knackery, with only 30% of horses being 'adopted' for domestication.

In determining the scope of this humaneness assessment, the panel considered all potential methods listed in Table 1 of the 2008 KNP Management Plan. Assessments were then conducted based on the availability of documented standards or standard operating procedures (SOPs) for these methods and the available scientific literature and experience in the application and outcomes of these methods. Assessments were conducted for each method and outcome where sufficient information existed to be able to define best practice application of the method.

Some control methods are single-stage methods and thus only required one assessment, while others, such as removal of horses for slaughter or domestication, are multi-stage processes. In the case of multi-stage processes separate assessments were made for each different stage.

The panel examined 11 different control methods or stages in the management of wild horses. Three of these could not be assessed, or were only partially assessed, due to lack of a standard operating procedure or its equivalent (Figure 1).

Capture methods

Passive trapping

The use of trap yards or 'passive trapping' has been the main management method for wild horses in alpine Australia over the past decade (NSW National Parks and Wildlife Service 2008; Axford and Brown 2013). Trap yards are constructed in strategic areas that are frequented by wild horses and are accessible by vehicle. In areas where water is scarce, traps are situated at water points; where water is abundant, attractants such as molasses or mineral (salt) licks are used. Trapping is avoided during foaling periods or when females are heavily pregnant. Once trapped, horses can be humanely killed *in situ* or loaded onto vehicles for transport off-site.

Trapping was assessed assuming compliance with SOP HORoo4 Trapping of feral horses (Sharp 2011d) from when the horse enters the trap until the gate is opened for removal.

Mustering

Helicopter mustering for wild horses involves the construction of large funnel-shaped traps leading to an enclosed yard (corral) in flat, central areas and the mustering of local wild horses towards the structure with the use of manoeuvrable helicopters. This technique has been used extensively in the flat, arid states of the western USA (e.g. Nevada; Ashley and Holcolmbe 2001). Helicopter mustering has also been used over smaller areas in forested alpine habitat in New Zealand (Linklater and Cameron 2002). Once captured in the yard, wild horses can be removed via road transport or humanely killed *in situ*, as with the use of passive trap yards.

For areas with suitable terrain, this method allows the capture of large numbers of wild horses in a short time frame with few staff. Logistic restraints of the technique include the requirement for building large and/or multiple funnel traps, safe terrain for helicopter flight and open terrain permitting visualisation of mustered animals. In some flat open areas, purpose-built yards have been constructed to include hydraulic squeeze chutes for restraint and handling of captured horses (Gray et al. 2010).

It has been suggested that the stress induced by helicopter pursuit is likely to be comparable to that associated with aerial shooting (Tracey and Fleming 2007), with the important differences that helicopter mustering involves pursuit of longer duration but lower intensity (the helicopter is not as close to the animals and animals are not forced to gallop; Ashley and Holcolmbe 2001). The incidental mortality rate for wild horses subjected to helicopter mustering is unknown, but it is likely that a minority of animals suffer exertion injuries such as myopathy, or traumatic falls, as with other wildlife species (e.g. Tracey and Fleming 2007).

Linklater and Cameron (2002) suggest that regular helicopter muster events may encourage escape behaviour in surviving wild horses and impede the efficacy of future aerial muster, culling or census operations. Tracey and Fleming (2007) found an absence of long-term behavioural effects but considerable short-term behavioural changes in feral goats subjected to regular helicopter mustering.

Mustering was assessed assuming compliance with the SOP HOR003 *Mustering of feral horses* (Sharp 2011b) and with the assumption that mustering would only be carried out within a small area (i.e. within approximately 2km) where horses are not pushed outside of their home range. The assessment of mustering applies from the beginning of contact with the horses, through to when they are contained in yards until the gate is opened for removal.

Roping

Roping or 'brumby running' refers to the practice of pursuing and physically capturing individual wild horses by a rider on horse-back using physical restraint with catching ropes. One or two horses in a social group will be targeted and separated out from the rest of the social group. After the initial agitation of capture has subsided, captured horses are then lead to the nearest vehicle access point where they can be loaded onto a vehicle and transported off-site for subsequent domestication or slaughter. This method has been widely practiced historically but has declined in popularity and acceptance in modern wildlife management.

Wildlife capture techniques that involve extended pursuit phases are often associated with poor animal welfare outcomes. This is particularly true of ungulate herbivores (e.g. Bateson and Bradshaw 1997) and especially in hot climates (e.g. Berger et al. 2010). Capture myopathy and hyperthermia are two stressful and often fatal physiological conditions associated with extended pursuit. Specifically, horses subjected to severe exertion can be affected by the syndrome of exertional rhabdomyolysis or 'tying up' (Valberg et al. 1999). There have been no published animal welfare assessments for the roping of wild horses.

While roping is still used to some extent in alpine areas of Victoria (Parks Victoria 2013), it has not been considered appropriate in NSW (NSW National Parks and Wildlife Service 2008). There are current operating guidelines for feral horse capture by roping for the adjoining alpine areas of Victoria (Parks Victoria 2013) that specifies several conditions, including that horses are not to be chased to exhaustion, not roped in hot weather (>30°C), not tethered for longer than 24 hours, and that working dogs are not to be used for chasing horses, however, muzzled dogs may be used under permit for locating or flushing horses. In the absence of a specific SOP, these guidelines were used as the basis for the assessment. The assessment applies from the start of the pursuit to when the captured horse is released from being tied up.

Post-capture methods and outcomes

The panel considered three potential outcomes for captured horses: on-site humane killing, removal for domestication or removal for slaughter (Figure 1). Methods involving the removal of live horses off-site necessarily also require loading and transport and this was assessed separately for short and long journeys.

On-site humane killing

On-site humane killing of captured horses has been proposed as a means of avoiding the adverse welfare impacts of transporting horses deemed unsuitable for domestication to an external site for or slaughter. However, currently there is no detailed standard operating procedure (SOP) specifically for the humane killing of groups of wild horses in yards. The SOPs for mustering and trapping do include a section on shooting of horses in yards (Sharp 2011c,d), however the wording describes a situation where individual horses within a group need to be euthanased because they are injured, unfit or otherwise unsuitable for transport, rather than one where the intention is that multiple captured horses will routinely be killed. The panel did not consider the available instructions sufficiently detailed or relevant to perform a humaneness assessment for Part A (the welfare impact of preparing or separating horses for humane killing) so the assessment was limited to Part B only (the welfare impact of the killing method itself) using an appropriate firearm (as described in the trapping SOP).

If on-site humane killing of captured horses is to be properly considered as an option, then a detailed SOP must first be developed. It should contain information on available techniques (e.g. shooting, chemical restraint, captive bolt devices) as well as use of partitions and visual barriers, sound suppressors for firearms and methods for minimising handling of horses, order of killing for different ages and classes of horses and possible effects on horses that are within sight or sound of these procedures.

Loading and transport

Where wild horses are captured and not killed on site they require transport by horse float or livestock carrier from the capture site to their next destination. Loading and transport were assessed assuming compliance with the *Australian Animal Welfare Standards and Guidelines – Land Transport of Livestock* which are regulated minimum standards in all jurisdictions except Western Australia. Two journey lengths were assessed: a 'short journey' where horses are off feed and water for up to 4 hours; and a 'long journey' where horses are off feed and water for up to 24 hours. The assessment applies from when the horses are loaded for transportation to when they are offloaded at their destination. Where multiple transport journeys are undertaken, the impact of loading and transport should be considered for each journey.

Current practice in KNP is that most horses captured through passive trapping are transported to a holding area where they may remain for some days or weeks before they are selected for domestication or are loaded and transported to an abattoir or knackery. Thus captured horses will generally experience two or more transport journeys before they reach their destination. While best practice indicates that the duration and number of journeys should be minimised, it should also be acknowledged that captured wild horses require time to adjust to confinement, drinking from water troughs and a changed diet and thus may require spelling for longer periods before and between transport than domesticated horses. The journey from the trapping yards to the holding areas should be considered as a 'short journey' in terms of this assessment.

In Australia there are two export abattoirs that accept horses for slaughter: one is located in Caboolture, Queensland and the other in Peterborough, South Australia. The continuous journey time from KNP is at least 16 hours to Caboolture and 15 hours to Peterborough, which means horses may be off feed and water for over 24 hours as well as dealing with the impact of loading, unloading, confinement and transport. A separate assessment was conducted for 'long journeys'. The journey from the holding area to either of these abattoirs should be considered as a 'long journey' in terms of this assessment.

Domestication

Currently a proportion of wild horses captured through passive trapping in KNP (historically around 30%) are transported from the park to a holding area and subsequently transferred to private owners for subsequent domestication (also termed *breaking in*, *gentling* or *foundation training*). The intention is that these horses will eventually be ridden. Given the variety of methods used to train horses for human use and the different welfare impacts these methods have on horses, the panel did not consider it possible to accurately assess the impact of the domestication process itself. It should be noted that domestication is a contentious practice for completely wild animals, especially in a highly social species such as wild horses (Holcomb et al. 2012, and once horses are acquired by private owners the success or failure of domestication and the final outcomes for these horses are

unknown. If domestication of captured horses is to continue, then it is recommended that individuals and groups taking these horses provide details of their domestication practices and information on the outcome and fate of these horses to allow the welfare impact of domestication to be assessed.

Lairage and slaughter

Where horses captured through passive trapping are not selected for domestication, either because they are deemed unsuitable or because there is insufficient demand for them, current practice in the KNP is to transport them to an abattoir or knackery. An abattoir is a facility licensed to slaughter animals for human consumption, and a knackery is a facility licensed to slaughter animals for animal (pet) food only. These two types of facilities were examined separately as they have different regulatory and auditing regimes.

Knackeries are required to comply with the requirements of the *Standard for the Hygienic Production of Pet Meat* (PISC 2009). This requires that animals are slaughtered in a way that minimises the risk of injury, pain and suffering to them and causes them the least practicable disturbance, however there are no specific standards or published SOPs for the slaughter of horses at knackeries.

All abattoirs in Australia are required to comply with the *Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption* (FRSC 2007). This standard also requires that animals are slaughtered in a way that minimises the risk of injury, pain and suffering to them and causes them the least practicable disturbance. In addition to this the Australian Meat Industry Council has developed *Industry Animal Welfare Standards for Livestock Processing Establishments* (AMIC 2009) which require participating abattoirs to have in place standard operating procedures for the management of livestock to prevent and/or mitigate possible risks to animal welfare. All export abattoirs are required to comply with the AMIC standard and the audit requirements under it.

For the purpose of this assessment it was assumed that slaughter was at an audited export abattoir in compliance with the AMIC standards. The two export abattoirs in Australia that accept horses for slaughter both have yards and infrastructure designed for holding, slaughtering and processing horses. The assessment applies from after unloading to the end of holding in yards (lairage) then from leaving the yards up to the point of death (slaughter).

Other methods

Ground shooting

Ground shooting is a tool that has been opportunistically used for reducing the abundance of wild horse populations at a local level. The technique is best suited to accessible and relatively flat areas and allows the shooting of very small numbers of horses at a time. The likelihood of removing an entire social group of wild horses is low with ground shooting due to the rapid escape behaviour of the species in response to loud disturbance (Linklater and Cameron 2002), so the impacts of disrupting the social group were included in the assessment.

The standard operating procedure for ground shooting, SOP HOR001 *Ground shooting of feral horses* (Sharp 2011a) stipulates acceptable firearms and shooting conditions including the use of centrefire rifles with telescopic sights and the requirement that shooting is performed in the daytime, targeting stationary animals. Ground shooting of a species with a well-developed flight response, such as wild horses, often involves shooting over long distances, reducing precision. Wounding rates are often high for long-distance shooting (Hampton et al. in preparation). It is suspected that wounding rates for ground shooting are higher than for aerial shooting, given the greater difficulty associated with visualising and approaching wounded animals for a ground-based shooter (Sharp 2011), however, there have been no published wounding rates for the ground shooting of wild horses. While welfare assessment templates exist for the ground shooting of wildlife (Lewis et al. 1997), there have not been rigorous studies into outcomes for wild horses.

Ground shooting was assessed assuming compliance with SOP HOR001 using Part A and Part B of the model. Two assessments for Part B were made to distinguish between head shots and chest shots as the point of aim. The duration of impact for ground shooting takes into account the effect on surviving members of a social

group when one horse in a group is shot.

Aerial shooting

Aerial (helicopter) shooting is regarded as an effective tool for reducing the abundance of wild horse populations at landscape scales, but is currently seldom used because of concerns over public perceptions.

While aerial shooting has not been practiced for wild horse control in NSW, Victoria or the ACT for over a decade, it remains the preferred control method for extensive populations in Queensland, WA and the NT (Edwards et al. 2004). The technique involves a qualified shooter using a high-calibre semi-automatic rifle and deliberate repeat shooting ('overkill') from a small, manoeuvrable helicopter. The technique is guided by a standard operating procedure in Australia (Sharp 2011). Aerial shooting is an inherently imprecise technique due to the shooting of a moving target from a moving platform (Hampton et al. 2014).

Aerial shooting relies on helicopter pursuit and requires that at least two shots are fired at each animal targeted. The first quantitative study of animal welfare parameters in helicopter shooting was recently published for feral camels (*Camelus dromedarius*; Hampton et al. 2014). The study of Hampton et al. (in preparation) applied this assessment template to two wild horse aerial shooting programs in central Australia. The study sites were flat, open pastoral leases with little high-canopied vegetation. While shooting techniques are very similar for both camels and horses, the observed instantaneous death rate for horses in these studies was lower than that for camels, indicating that under the observed conditions it was more likely that camels would be killed outright by the first shot fired than horses. Possible explanations for this are differences in aim points (head versus thorax), anatomy, escape behaviour and terrain. The incidence of animals being shot but not killed (i.e. wounded) has been reported for both camels and horses at around 1% (English 2000; Hampton et al. 2014; Hampton et al. in preparation).

Investigation of the role of explanatory variables revealed that shooter characteristics (i.e. their skill and experience) was the most important determinant of animal welfare outcomes, followed by the nature of local vegetation (Hampton et al. 2014). While aerial shooting is widely used in undulating or thickly vegetated areas for other species such as goats or pigs (e.g. Forsyth et al. 2013), very little animal welfare data is currently available regarding aerial shooting outcomes in such areas. If aerial shooting were considered as a control option for wild horses then the terrain in which the horses were located and the skill and experience of shooters and helicopter pilots would be central to achieving good animal welfare outcomes.

Aerial shooting was assessed assuming compliance with SOP HOR002 *Aerial shooting of feral horses* (Sharp 2011b) as a single-stage method using Part A and Part B of the model. Under this SOP all horse must be shot at least twice. Two assessments were made to reflect two different scenarios in terms of the length of pursuit and whether the target animal was effectively head shot or not by the first shot: scenario 1 (best case) is where horses are chased for <1 minute, are rendered insensible with the first shot and do not recover consciousness prior to death; scenario 2 is where horses are chased for >5 minutes, are not effectively rendered insensible with the first shot and are shot again resulting in death.

Fertility control

Rather than reducing populations of overabundant wildlife by killing animals, fertility control aims to reduce population growth rates by reducing fecundity, and thereby potentially reducing population size in the longer term. This can be challenging for long-lived species with low fecundity, such as wild horses (Dawson and Hone 2012), but much research has been performed for this species, especially in the USA (Killian et al. 2008), with some promising results in terms of effectiveness in achieving reproductive control over a number of years. Turner et al. 2007; Gray et al. 2010). However, population size reduction using contraception involves a delayed response of around 8 years (Kirkpatrick & Turner 2008) as no horses are immediately removed, and is dependent on the proportion of mares that are treated.

While some fertility manipulation approaches have used surgical techniques or hormone supplementation, many modern approaches use a technique known as immunocontraception. This refers to inducing immunity to naturally occurring reproductive proteins in an animals' body. Antibodies are then produced that neutralise the reproductive protein, making it ineffective and thereby disrupting fertility. These may be tissue proteins such as the zona pellucida (ZP) in a female egg or a circulating hormone such as gonadotrophin-releasing hormone

(GnRH). Two recently developed commercial products that have been identified as being potentially suitable for wild horses are Gonacon® and Spayvac® (Killian et al. 2008; Gray et al. 2010).

1. GnRH vaccine

The GnRH vaccine prevents reproduction through endocrine suppression and has been shown to be effective in many wildlife species (Powers et al. 2014). GnRH vaccines have been used in male animals but this would likely not be considered in wild horses due to interference with androgenic behaviours in stallions. All approaches manipulating GnRH levels have the capacity to alter natural behaviours in both sexes but these effects are currently poorly understood.

2. ZP vaccine

Immunocontraception using a zona pellucida vaccine is used to target only mares and affects reproduction by preventing fertilisation. There are no known effects on circulating hormone levels, and hence no endocrine suppression. The main animal welfare concern raised with this technique is the potential for foals to be born 'out of season' (Kirkpatrick and Turner 2003) and that some mares treated multiple times become infertile (Kirkpatrick et al. 1992).

Both vaccines offer comparable efficacy (3 years infertility) and ease of administration (one-dose darting every 3 years). The important difference to note from an animal welfare perspective is that GnRH has the potential to alter reproductive cycling patterns and associated behaviours by interference with reproductive hormone levels (endocrine suppression) while the zona pellucida vaccine allows mares to continue to cycle without becoming pregnant.

The animal welfare impact of fertility control methods were assessed from the point where an individual horse is injected through to the full impact of treatment, using Part A of the model. However it should be noted that fertility control with an injectable vaccine is actually a two-stage process that includes the way in which the injection is delivered as well as the impact of the injection itself. Fertility control requires another technique to facilitate injection of vaccines, such as passive trapping or mustering, followed by darting in yards or restraint for hand-injection, or aerial or ground pursuit to deliver the vaccine by darting. A full assessment of the cumulative animal welfare impact of fertility control should include the impact of the method of delivering the treatment and take into account the required frequency of repeated treatment and potential impact on non-target animals (i.e. stallions), once an agreed methodology has been decided on.

Fencing

Fencing refers to the construction of fences that wild horses cannot cross to protect areas of designated high-value vegetation or habitat. This is effectively the use of exclosures, as used in ecological experiments on the impacts of herbivory (e.g. Kay and Bartos 2000; Linklater et al. 2000). As a management tool, this technique is only appropriate for removing wild horse access to very small selected areas. This approach is very unlikely to alter the size of the wild horse population, or ameliorate impacts other than those relating to herbivory and trampling.

The main areas of potential animal welfare impact relate to the capacity for fences to exclude wild horses from diminishing water resources in dry seasons (Hacker and Freudenberger 1997). This can constitute a considerable risk in hot, arid areas when animals are abruptly denied access to an isolated water source and could contribute to the risk of animals perishing. If fencing is only considered for small areas of high-value vegetation, the only likely animal welfare costs will be the relatively low risks of entanglement and electrocution (if electric fences are considered; Boone and Hobbs 2004). Disruption of social organisation and movement patterns would also be possible if an extensive fencing project was considered. The use of wild horse exclosure plots in forested alpine habitat in New Zealand has not been associated with any obvious animal welfare impacts (Linklater et al. 2000).

Fencing was assessed as a non-lethal single-stage method using Part A of the model only.

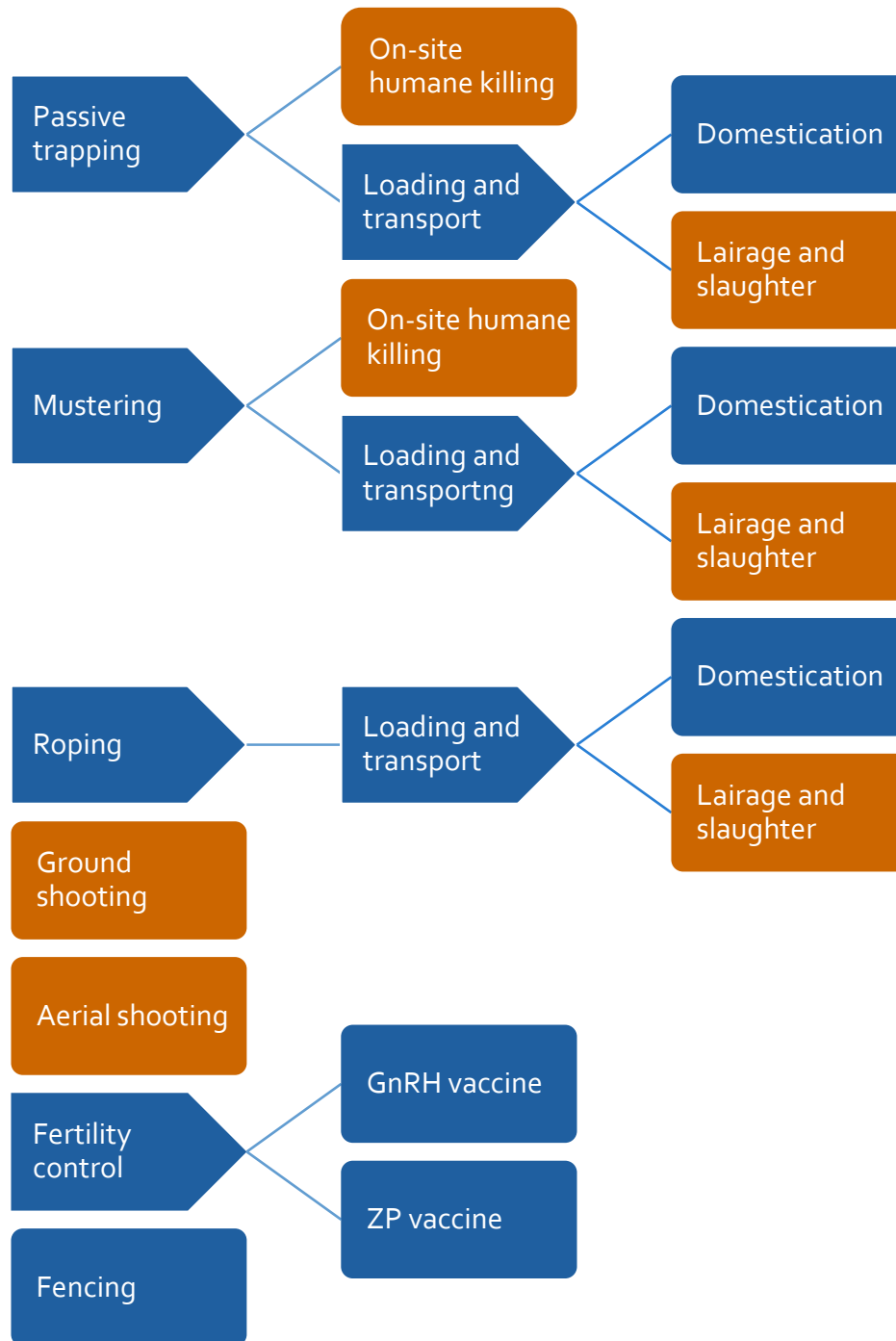


Figure 1 Single and multi-stage wild horse control methods and their outcomes: orange boxes indicate lethal outcomes; blue boxes indicate non-lethal outcomes

Outcomes of the assessments

Each assessment is based on a number of specific assumptions including that the method is carried out in accordance with best practice through compliance with a standard operating procedure. It is important to note these assumptions when considering the relative humaneness for any given method as any deviation from them will alter the outcome of the method. Some methods, such as those that include the risk of free-running animals becoming injured without being able to be followed-up, have the potential to result in significant adverse impacts if best practice is not followed. The notes, assumptions and summary of evidence for scoring the assessment against each domain, as well as any comments in relation to the overall humaneness score are provided in individual HAP Worksheets which accompany this report (Appendix 2). A summary of the assessment scores are shown in Table 1.

All potential methods for the control of wild horses were found to have some adverse impact on horse welfare. Choosing appropriate methods should therefore require careful consideration of how to mitigate those impacts. The severity and duration of impact both affect the final score, thus a long-lasting method with a mild impact can result in the same score as a faster-acting method with a severe impact.

When considering the overall impact of a multistage process, all stages must be considered as the cumulative effects of each procedure will compound the overall welfare impact. Where initial methods have similar scores, the adverse impact of those methods involving multiple stages will be greater than those with only one stage. Thus in seeking the most humane outcome, it is important to minimise the number of stages involved wherever possible, for example by minimising the number of times horses are subjected to loading and transport.

Further research and the development of standard operating procedures are required for those methods where there was insufficient information to conduct an assessment (these were: domestication practices; on-site humane killing; and delivery of fertility control).

In the case of aerial shooting, a number of specific conditions (over and above those set out in the relevant SOP) were identified that were considered more likely to result in a best-case scenario welfare outcome for shot animals. These were:

- Using highly experienced and skilled shooters and pilots.
- Ensuring that the point of aim for the first shot is always the cranium: if the first shot cannot be accurately placed then a shot is not fired.
- Shooting occurs only in open areas with minimal high-canopied vegetation (tree cover or woodland).
- Shooting in flat terrain rather than steep or undulating areas as this will result in fewer injuries and allow for easier sighting of wounded animals.
- Shooting in cooler temperatures to minimise heat stress in pursued animals.
- Small groups of horses (<10) are targeted at a time: congregations of social groups in larger mobs is avoided.

Given the importance of ensuring best practice in improving the relative humaneness of control methods, consideration should be given to instigating an auditing or inspection process to measure compliance.

Table 1 Assessment scores and key assumptions for each control method and stage. Please refer to the individual HAP Worksheets details of assumptions and evidence used in the assessment for each of these methods.

	PART A			PART B		
METHOD	Impact	Duration	Score	Impact	Duration	Score
Passive trapping	Moderate	Hours	5			
Mustering (small groups)	Moderate	Hours	5			
Mustering (large groups)	Moderate	Days	6			
Roping (brumby running)	Severe	Hours	6			
On-site humane killing	Not assessed			None	Very rapid	A
Loading and transport (short journeys)	Moderate	Hours	5			
Loading and transport (long journeys)	Severe	Days	7			
Domestication	Not assessed					
Lairage/holding*	Mild	Days	5			
Slaughter*	Moderate	Minutes	4	None	Very rapid	A
Ground shooting (head shot)	Mild	Days	5	None	Very rapid	A
Ground shooting (chest shot)	Mild	Days	5	Moderate	Minutes	D
Aerial shooting (scenario 1)	Moderate	Minutes	4	None	Very rapid	A
Aerial shooting (scenario 2)	Severe	Minutes	5	Severe/ Extreme	Very rapid/ Minutes	D
Fertility control delivery	Not assessed					
GnRH vaccine	Mild	Weeks	6			
PZP vaccine	Mild	Weeks	6			
Fencing	Mild	Days	5			

References

- Ashley, M. C., and Holcombe, D. W. (2001). Effect of stress induced by gathers and removals on reproductive success of feral horses. *Wildlife Society Bulletin* **29**, 248–254.
- AMIC (2009) National animal welfare standards for livestock processing establishments. Second edition. Australian Meat Industry Council, Sydney. Available: <http://www.amic.org.au>
- Animal Health Australia (2012). Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock. Canberra, ACT: Commonwealth of Australia.
- Axford, J. and Brown, D. (2013). Wild horse management and control methods. Parks Victoria, Melbourne, Victoria, Australia.
- Bateson, P., and Bradshaw, E. L. (1997). Physiological effects of hunting red deer (*Cervus elaphus*). *Proceedings of the Royal Society of London. Series B: Biological Sciences* **264**, 1707–1714.
- Baker, S.E., Sharp, T.M. and Macdonald, D.W. (submitted). Assessing Animal Welfare Impacts in the Management of European Rabbits (*Oryctolagus cuniculus*), European Moles (*Talpa europaea*) and Carrion Crows (*Corvus corone*). PLOS ONE.
- Berger, J., Murray, K. M., Buuveibaatar, B., Dunbar, M. R., and Lkhagvasuren, B. (2010). Capture of ungulates in Central Asia using drive nets: advantages and pitfalls illustrated by the endangered Mongolian saiga *Saiga tatarica mongolica*. *Oryx* **44**, 512–515.
- Carrion, V., Donlan, C. J., Campbell, K., Lavoie, C., and Cruz, F. (2007). Feral donkey (*Equus asinus*) eradications in the Galápagos. *Biodiversity and Conservation* **16**, 437–445.
- English, A. W. (2000). Report on the cull of feral horses in Guy Fawkes River National Park in October 2000. University of Sydney, Sydney, New South Wales, Australia.
- Fisher, P. Beausoleil, N.J., Warburton, B., Mellor, D.J., Campion, M., and Booth, L. (2010). How humane are our pest control tools (09-11326). Technical Paper No: 2011/01. Wellington NZ: MAF Biosecurity. Retrieved from <https://www.mpi.govt.nz/document-vault/4009>
- Forsyth, D. M., D. S. Ramsey, C. J. Veltman, R. B. Allen, W. J. Allen, R. J. Barker, C. L. Jacobson, S. J. Nicol, S. J. Richardson, and C. R. Todd. (2013). When deer must die: large uncertainty surrounds changes in deer abundance achieved by helicopter- and ground-based hunting in New Zealand forests. *Wildlife Research* **40**: 447–458.
- FRSC (2007). Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products. Food Regulation Standing Committee, Technical Report No.3, AS4696:2007
- Gray, M. E., Thain, D. S., Cameron, E. Z., and Miller, L. A. (2010). Multi-year fertility reduction in free-roaming feral horses with single-injection immunocontraceptive formulations. *Wildlife Research* **37**, 475–481.
- Hart, Q., Jones, B., Hampton, J. and Gee, P. (2013). Ensuring acceptable animal welfare standards under the Australian Feral Camel Management Project. Australian Feral Camel Management Project (AFCMP). Retrieved from: <http://www.feralcamels.com.au/resource/AnimalWelfareCaseStudy.pdf>
- Hampton, J. O., Cowled, B. D., Perry, A. L., Miller, C. J., Jones, B., and Hart, Q. (2014). Quantitative analysis of animal-welfare outcomes in helicopter shooting: a case study with feral dromedary camels (*Camelus dromedarius*). *Wildlife Research* **41**: 127–135.
- Hampton, J. O., Edwards, G. E., Cowled, B. D., Forsyth, D. M., Perry, A. L., Miller, C. J., Adams, P. J., Hyndman, T. H., and Collins, T. C. (In preparation). Assessment of Animal Welfare for Helicopter Shooting of Wild Horses.
- Hampton, J. O., Forsyth, D. M., McKenzie, D. I., and Stuart, I. G. (2015) In press). A simple quantitative method for assessing animal welfare outcomes in terrestrial wildlife shooting: the European rabbit as a case study. *Animal Welfare* **24**, 305–315.
- Holcomb, K. E., Stull, C. L., and Kass, P. H. (2012). Characteristics of relinquishing and adoptive owners of horses associated with US nonprofit equine rescue organizations. *Journal of Applied Animal Welfare Science* **15**, 21–31.
- Killian, G., Thain, D., Diehl, N. K., Rhyen, J., & Miller, L. (2008). Four-year contraception rates of mares treated with single-injection porcine zona pellucida and GnRH vaccines and intrauterine devices. *Wildlife Research*, **35**(6), 531–539.
- Kirkpatrick, J. F., and Turner, A. (2008). Achieving population goals in a long-lived wildlife species (*Equus caballus*) with contraception. *Wildlife Research* **35**, 513–519.
- Lewis, A. R., Pinchin, A. M., and Kestin, S. C. (1997). Welfare implications of the night shooting of wild impala (*Aepyceros melampus*). *Animal Welfare* **6**, 123–131.

- Linklater, W. L., and Cameron, E. Z. (2002). Escape behaviour of feral horses during a helicopter count. *Wildlife Research* **29**, 221–224.
- McLeod, S.R., Lukins, B. and Sharp, T.M. (in prep.) Propane-oxygen blasting of rabbit warrens: an assessment of the animal welfare impacts.
- NSW National Parks and Wildlife Service. (2008). Kosciuszko National Park wild horse management plan. NSW National Parks and Wildlife Service, Sydney, Australia.
- Parks Victoria. (2013). Operating guidelines for feral horse capture by roping. Parks Victoria, Melbourne, Victoria, Australia.
- PISC (2009) .Standard for the Hygienic Production of Pet Meat: Primary Industries Standing Committee, Technical Report 88.
- Sharp, T. & Saunders, G. (2008). A model for assessing the relative humaneness of pest animal control methods. Canberra ACT: Australian Government Department of Agriculture, Fisheries and Forestry.
- Sharp, T. & Saunders, G. (2011). A model for assessing the relative humaneness of pest animal control methods (2nd ed.). Canberra ACT: Australian Government Department of Agriculture, Fisheries and Forestry.
- Sharp, T. (2011a). Standard operating procedure HOR001: Ground shooting of feral horses. Invasive Animals CRC, Canberra, Australian Capital Territory, Australia.
- Sharp, T. (2011b). Standard operating procedure HOR002: Aerial shooting of feral horses. Invasive Animals CRC, Canberra, Australian Capital Territory, Australia.
- Sharp, T. (2011b). Standard operating procedure HOR003: Mustering of feral horses. Invasive Animals CRC, Canberra, Australian Capital Territory, Australia.
- Sharp, T. (2011d). Standard operating procedure HOR004: Trapping of feral horses. Invasive Animals CRC, Canberra, Australian Capital Territory, Australia.
- Tracey, J. P., and Fleming, P. J. (2007). Behavioural responses of feral goats (*Capra hircus*) to helicopters. *Applied Animal Behaviour Science* **108**, 114–128.
- Turner, J.W., Liu, I.K.M., Flanagan, D.R., Rutberg, A.T., Kirkpatrick, J.F. 2007. Immunocontraception in wild horses: One inoculation provides two years of infertility. *Journal of Wildlife Management* **71**: 662-667.
- Valberg, S. J., Mickelson, J. R., Gallant, E. M., Macleay, J. M., Lentz, L., and Corte, F. (1999). Exertional rhabdomyolysis in quarter horses and thoroughbreds: one syndrome, multiple aetiologies. *Equine Veterinary Journal* **31**, 533–53.

Appendix 1 - wild horse humaneness assessment panel members

Dr Andrew Braid	Andrew Braid graduated from the University of Melbourne's Faculty of Veterinary Science in 1969 and initially worked in the beef cattle industry in Victoria, far North Queensland and the Northern Territory before moving to general practice as the principal of the Kiama Veterinary Hospital in Kiama, NSW. From 1993 to 2011 Andrew worked part-time with CSIRO's Division of Wildlife and Ecology (now Sustainable Ecosystems) as the Executive Officer of the Division's Animal Ethics Committee and to provide veterinary advice in the care and use of feral animals in research undertaken by the CRC for Biological Control of Vertebrate Pest Populations. In 2009 Andrew was invited to join the initial Humaneness Assessment Panel project, and since then has been involved in several additional HAP projects. In 2014 he was appointed as an independent external reviewer of the ANU's use of animals in research. He is currently a member of the ACT Animal Welfare Advisory Committee and the Therapeutic Goods Administration AEC.
Professor Elissa Cameron <i>Member of the Independent Technical Reference Group</i>	Elissa Cameron works on the ecology, behaviour and conservation of mammals. She is Professor of Wildlife Ecology in the School of Biological Sciences at the University of Tasmania. Her main interests focus around the different strategies adopted by males and females, the impacts that these have on behaviour, ecology and social structure, and implications for management. She received her PhD from New Zealand's Massey University researching maternal behaviour in the Kaimanawa wild horses in New Zealand. Professor Cameron's research work has included work at the Mammal Research Institute at the University of Pretoria in South Africa, working with large mammals. She has also conducted research on Nevada's mule deer elk and wild horse populations in the US.
Professor Andrew Fisher <i>Chair, Wild Horse Humaneness Assessment Panel</i>	Andrew Fisher is the Chair of Cattle and Sheep Production Medicine with the Faculty of Veterinary and Agricultural Sciences at the University of Melbourne. He has significant experience in the area of animal welfare, with a particular focus on production animal management and transport. Research interests include welfare aspects of flexible feeding systems of dairy cows. Andrew graduated from the Faculty of Veterinary Science in 1989 and after a period of working in Colac, Victoria, moved to the UK, later completing a PhD at the Faculty of Veterinary Medicine at the University College, Dublin. He then moved to New Zealand where he carried out animal health and welfare research with dairy, cattle and sheep. Prior to taking up his current role, he was the leader of the Animal Welfare Group at CSIRO, which he joined in 2002. In his role, Andrew is working to provide sustainable improvements in animal management and welfare for the benefit of both the farming industries and the community. Andrew's teaching responsibilities focus mainly on dairy and beef cattle and sheep, in particular looking at husbandry, health, production and welfare with involvement in veterinary public health.
Rob Gibbs	Rob Gibbs is the Senior Project Officer for Kosciuszko National Park. Rob has worked for the NSW National Parks and Wildlife Service (NPWS) for over 24 years in a range of positions including field officer, ranger, area manager and project officer. After gaining a Bachelor of Applied Science Degree in Park Management from Charles Sturt University in 1994 Rob has been

	involved in both the planning aspects of conservation land management and the implementation of day to day operational park management including vertebrate pest, weed, fire, visitor, cultural heritage and wildlife management programs in a range of environments and locations from coastal to alpine areas. Rob has been involved in the Kosciuszko National Park Wild Horse Management Program since 2008 which has trapped and removed over 2600 wild horses from the Park and is currently working on the Wild Horse Management Plan review process. Rob has over 11 years working experience within Kosciuszko National Park and over 30 years of walking, driving, riding, cross country skiing, paddling, skidooing and flying over much of the 690,000 ha conservation reserve for both work and pleasure, with many more areas of the park still yet to be explored.
Dr Jordan Hampton	Jordan Hampton is a private consultant with Ecotone Wildlife Veterinary Services. Jordan graduated as a veterinarian from Murdoch University in 2005 and worked in mixed (large animal) veterinary practice for the next three years. Since 2009, Jordan has been working with wildlife management and research projects in Australia, focusing particularly on feral herbivore species. Jordan's focus includes the development and validation of humane capture and killing methods for wildlife species. Specific projects have included developing euthanasia methods for stranded whales, developing darting methods for feral horses and donkeys, and assessing the animal welfare impacts of aerial shooting for feral horses and camels. Jordan provides training courses for wildlife management staff, and has published several methods papers detailing improved wildlife management techniques. He has previously participated in a humaneness assessment panel for feral camel control methods.
Dr Bidda Jones <i>Member of the Independent Technical Reference Group</i>	Bidda Jones is the Chief Scientist with RSPCA Australia, based in Canberra. She graduated with honours in zoology from the University of Sheffield in 1988 and undertook her PhD at the University of London in 1993 studying the vocal behaviour of common marmosets. Her work to improve animal welfare began during her PhD and on its completion she was appointed as the first Scientific Officer to specialise in primate welfare for the UK RSPCA. Since moving to Australia in 1996, Bidda has worked for RSPCA Australia providing science-based advice and information on a wide range of animal welfare policy issues to government, industry and the public. She has represented the RSPCA on multiple national committees providing advice on animal welfare across a wide spectrum of issues. She has been an Honorary Associate with the Faculty of Veterinary Science at the University of Sydney since 2000. Bidda has been actively working to improve the humaneness of vertebrate pest management in Australia since 2003, starting with the development of a national strategy and discussion paper and leading to the development and implementation of the humaneness model. She has participated in humaneness assessment panels across all the key vertebrate pest animal species and control methods.
Professor Paul McGreevy	Paul McGreevy is a riding instructor, veterinarian and ethologist. He is Professor of Animal Behaviour and Animal Welfare Science at the University of Sydney's Faculty of Veterinary Science. The author of over 170 peer-reviewed scientific publications and six books, Paul has received numerous Australian and international awards for his research and teaching innovations. His PhD was in the behaviour of stabled horses but it was a

	chapter co-written with Dr Andrew McLean in his Equine Behavior textbook that coined the term "Equitation Science". Paul is especially proud of his term as Hon. President of the International Society for Equitation Science (ISES); a period that delivered the Eight Principles of Ethical Training, the ISES Ethics Committee, the first Consensus Workshop on Research Methods, the Position Statement on Restrictive Nosebands and the ISES Taper Gauge.
Professor Reuben Rose <i>Member of the Independent Technical Reference Group</i>	Reuben Rose is an internationally recognised authority in equine medicine and horse performance problems. He was the Director of the Equine Performance Laboratory and later Dean of the Faculty of Veterinary Science at the University of Sydney veterinary school. Professor Rose has been a Visiting Professor at Washington State University and was the Appleton Professor of Equine Medicine and Surgery at the University of Florida. He was awarded a Fellowship of the Royal College of Veterinary Surgeons and a Doctorate of Veterinary Science for his contributions to research in the field of equine exercise physiology. He has received a number of academic awards including the Gilruth Prize, the highest award of the Australian Veterinary Association.
Trudy Sharp	Trudy Sharp is an independent animal welfare science consultant with over 12 years' experience in the area of wild animal welfare. She is a PhD student with the School of Biological, Earth and Environmental Sciences at the University of New South Wales and has recently submitted her thesis. Her research examined animal welfare issues associated with the commercial harvesting of kangaroos with a focus on the impacts on dependent young. Trudy worked as a project officer within the Vertebrate Pest Research Unit of NSW Department of Primary Industries from 2003 until 2013 where she managed numerous projects and developed strategies to minimise the animal welfare impact of pest animal management programs. During this time she published over 75 standard operating procedures and codes of practice for the humane control of a wide range of pest animal species and also developed a model to assess the relative humaneness of pest animal control methods. The model has been adopted in Australia, New Zealand and the United Kingdom to systematically examine the welfare impacts of a wide range of pest animal management tools. Trudy's qualifications include a BSc (Hons) (Psychology) from the University of New England. She also has qualifications in medical laboratory science and has previously conducted diagnostic and research procedures in veterinary microbiology for over a decade.

Appendix 2 - humaneness assessment panel worksheets

HAPo1	Passive trapping
HAPo2	Mustering
HAPo3	Roping or brumby running
HAPo4	On-site humane killing
HAPo5	Loading and transport over short journeys
HAPo6	Loading and transport over long journeys
HAPo7	Lairage and slaughter
HAPo8	Ground shooting
HAPo9	Aerial shooting
HAP10	Fertility control with GnRH vaccine
HAP11	Fertility control with PZP vaccine
HAP12	Fencing

Control method: Passive trapping of wild horses

Important note: Removal of horses for humane killing, slaughter or domestication is a multi-stage process. Separate assessments have been made for each potential stage including passive trapping; mustering; on-site humane killing; loading and transport; and lairage and slaughter. The impact of on-site humane killing should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.

Assumptions:

- Best practice is followed in accordance with the standard operating procedure HOR004 Trapping of feral horses (http://www.pestsmart.org.au/wp-content/uploads/2013/08/HOR004_trapping.pdf)
- Trapping is avoided during foaling periods or when females are heavily pregnant
- This assessment applies from when the horse enters the trap until when the trap gate is opened for removal/loading for transport or until immediately before they are humanely killed on-site within the trap.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

↓

Overall impact
Moderate

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:

5

Summary of evidence:

Domain 1	Water is not available in the traps, so horses can potentially go for 24 hours without drinking. Also, there is no food, although sometimes molasses is used as a lure within the trap. It is usual for horses to enter traps around dusk and they will be in the trap overnight until it is checked and the animals processed. If they enter during the day there may be more exertion occurring in higher temperatures and so there will be a greater requirement for water.
Domain 2	Trap sites are mostly located where there is shade and shelter, however this is not always possible. In winter, capture at night is a problem as cool air can pool in low areas (i.e. hollows, valleys) causing a drop in temperature. If the horses are wet (i.e. from rain or from sweating due to exertion) this will exacerbate the cold conditions. If horses are from the same band, they could potentially huddle together to keep warm. In summer, temperatures around 30°C and above are likely to be an environmental challenge for trapped horses. In ponies, thermal stress has been observed with ambient temperatures above 30°C (with 21°C considered thermoneutral) [1]. In KNP horses are acclimatised to cold temperatures. Shade should limit the impacts of heat stress [2]. The impact in this domain has been rated as mild, although on occasion it could be as high as moderate.
Domain 3	Injuries can occur from horses trying to escape the trap or from aggression directed at them from other trapped horses. Over a four-month period there have been 3 deaths out of 675 horses trapped using this method in Kosciusko National Park (KNP) (R. Gibbs, personal communication, April 24, 2015). Since 2002, around 2900 horses have been trapped in KNP and deaths related to trapping injuries are less than 1%, with the majority of these related to impact with the trap fence (R. Gibbs, personal communication, April 24, 2015). Better trap designs (e.g. a figure of eight arrangement) will result in less aggression among horses since they are better for maintaining family groups.
Domain 4	Behaviour can vary widely when wild horses are held within a trap. Some individuals or groups can be calm while others can become very agitated. Impacts in this domain will be more severe when bonded groups (e.g. bands or mother-foal pairs) get separated and this cannot be reversed (e.g. when a foal remains outside of the trap).
Domain 5	Trapped horses can become very anxious and fearful when operators arrive to process them. They move around the trap and try to escape. The presence of humans and restriction of the flight response due to confinement in the trap, in addition to any disruption to social structure will have a moderate level of impact in this domain. However, on occasion the impact could be severe for some individuals.

PART B: Not performed – non-lethal method

Comments:
Non-target animals such as kangaroos and deer (e.g. fallow, red, sambar) can be non-target captures in wild horse traps. Injuries and death can occur with these animals, especially in deer with large antlers.

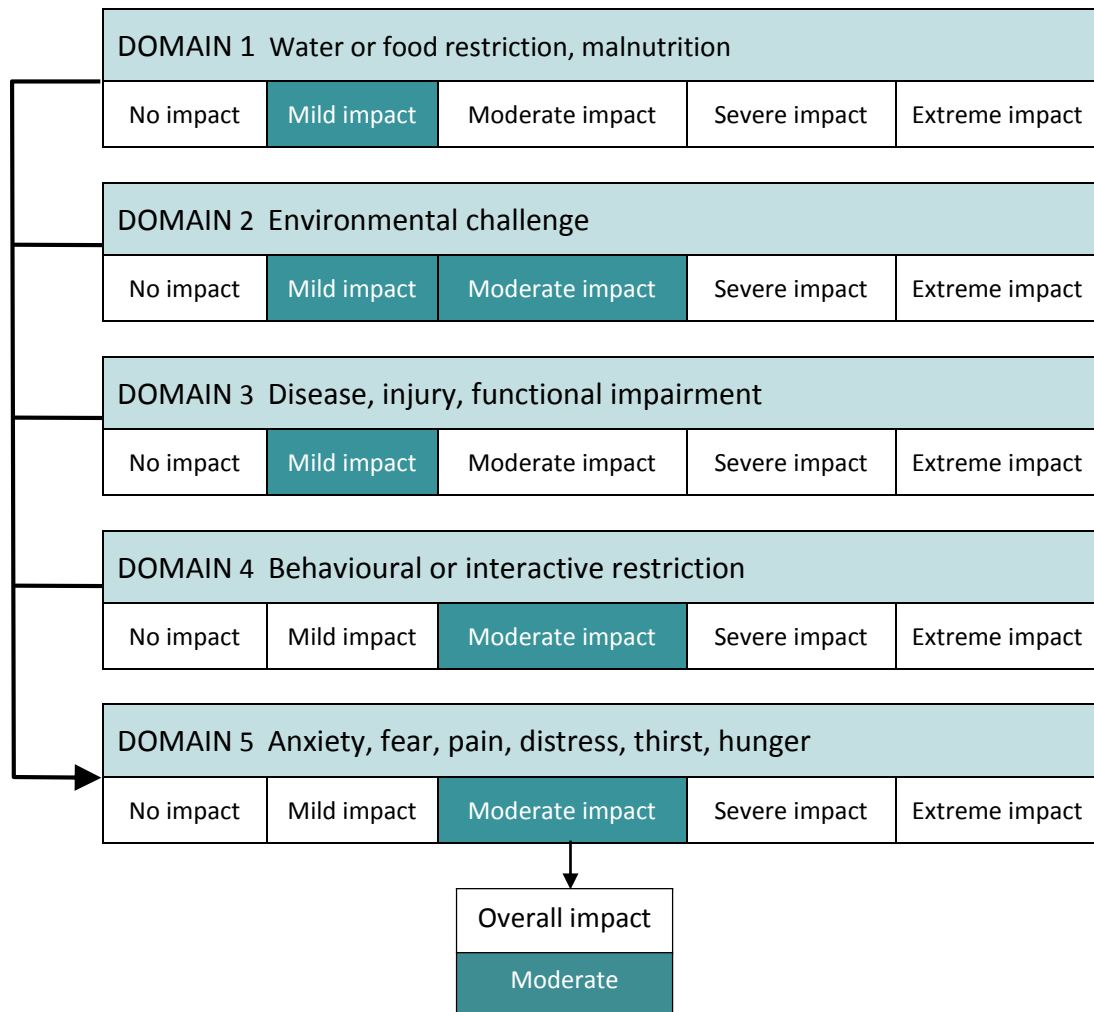
Bibliography

1. Weeks, C. A., McGreevy, P., & Waran, N. K. (2012). Welfare issues related to transport and handling of both trained and unhandled horses and ponies. *Equine Veterinary Education*, 24(8), 423–430. doi:10.1111/j.2042-3292.2011.00293.x
2. Holcomb, K. E., Tucker, C. B., & Stull, C. L. (2014). Preference of domestic horses for shade in a hot, sunny environment. *Journal of Animal Science*, 92(4), 1708–1717. doi:10.2527/jas.2013-7386

Control method: Mustering of wild horses

Important note:	Removal of horses for humane killing, slaughter or domestication is a multi-stage process. Separate assessments have been made for each potential stage including passive trapping; mustering; on-site humane killing; loading and transport; and lairage and slaughter. The impact of on-site humane killing should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.
Assumptions:	• Best practice is followed in accordance with the standard operating procedure HOR003 Mustering of feral horses http://www.pestsmart.org.au/wp-content/uploads/2013/08/HOR003_mustering.pdf • It is assumed that mustering is completed within daylight hours and that feed and water is provided on completion of mustering according to the standard operating procedure. • This assessment applies to mustering of horses within a small area (i.e. maximum distance of approximately 2km) where they are not pushed outside of their home range. • A skilled operator, who holds an appropriate firearm license, is always readily available with a suitable calibre firearm to euthanase any injured animals. • Multiple bands would be mustered with an accumulation of one to four bands typical. • This assessment applies from the beginning of contact with the horses, through to when they are contained in yards until the gate is opened to move horses onto the next stage. • Aerial and ground mustering are often used in combination so they are considered together here.

PART A: assessment of overall welfare impact



DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours (Smaller groups of horses)	Days (Larger groups of horses)	Weeks

SCORE FOR PART A:	Smaller groups of horses – 5 Larger groups of horses – 6										
Summary of evidence: <table border="0"> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 1</td> <td>There is a short period of food and water deprivation during the mustering process.</td> </tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 2</td> <td>Horses will be subjected to a period of exertion as they are being mustered. The impacts will be greater when they are moved over longer distances.</td> </tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 3</td> <td>Injuries can occur during mustering and these can be catastrophic (e.g. broken leg) especially if the terrain is rough (e.g. over creek crossings etc.). However, based on observations of mustering in New Zealand, severe traumatic injuries are rare (at a rate of less than 1%) (E. Cameron, personal communication, April 24, 2015). Injuries such as bites can also occur during aggressive encounters with other horses while being held in the yards.</td> </tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 4</td> <td>With mustering, bands (or groups) of horses are likely to get mixed together, which is antagonistic to a species that continually tries to maintain band integrity. This will result in aggression, especially among the stallions, in an attempt to maintain established social groups. The impact on behaviour will therefore be moderate but can be severe for stallions.</td> </tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 5</td> <td>When pursued by a helicopter, groups of horses will break from cover and aggregate together and this flight behaviour becomes contagious [1]. Mustering appears to cause confusion among the horses rather than panic however, at higher densities horses are likely to get more anxious and the likelihood of harassment and aggression will be higher.</td> </tr> </table>		Domain 1	There is a short period of food and water deprivation during the mustering process.	Domain 2	Horses will be subjected to a period of exertion as they are being mustered. The impacts will be greater when they are moved over longer distances.	Domain 3	Injuries can occur during mustering and these can be catastrophic (e.g. broken leg) especially if the terrain is rough (e.g. over creek crossings etc.). However, based on observations of mustering in New Zealand, severe traumatic injuries are rare (at a rate of less than 1%) (E. Cameron, personal communication, April 24, 2015). Injuries such as bites can also occur during aggressive encounters with other horses while being held in the yards.	Domain 4	With mustering, bands (or groups) of horses are likely to get mixed together, which is antagonistic to a species that continually tries to maintain band integrity. This will result in aggression, especially among the stallions, in an attempt to maintain established social groups. The impact on behaviour will therefore be moderate but can be severe for stallions.	Domain 5	When pursued by a helicopter, groups of horses will break from cover and aggregate together and this flight behaviour becomes contagious [1]. Mustering appears to cause confusion among the horses rather than panic however, at higher densities horses are likely to get more anxious and the likelihood of harassment and aggression will be higher.
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Domain 5	When pursued by a helicopter, groups of horses will break from cover and aggregate together and this flight behaviour becomes contagious [1]. Mustering appears to cause confusion among the horses rather than panic however, at higher densities horses are likely to get more anxious and the likelihood of harassment and aggression will be higher.										

PART B: Not performed – non-lethal method

Comments:
There should be sufficient holding yards to avoid mixing different groups of stock. The welfare impact on mustered horses will be less if horses are sorted into appropriate groups when they are in the yards. Managing horses in mixed groups (in terms of age and size) results in fewer agonistic interactions and less injuries [2]. Maintaining existing band structure is important for minimising stress, anxiety, harassment and aggression, thus horses should be closely observed prior to sorting and only related or familiar groups put together in the same yard. Minimising the duration that horses are exposed to the multiple stressors of mustering will also reduce the overall welfare impact [3].

Bibliography

1. Linklater, W. L., & Cameron, E. Z. (2002). Escape behaviour of feral horses during a helicopter count. *Wildlife Research*, 29(2), 221–224.
2. Giles, S. L., Nicol, C. J., Harris, P. A., & Rands, S. A. (2015). Dominance rank is associated with body condition in outdoor-living domestic horses (*Equus caballus*). *Applied Animal Behaviour Science*, 166, 71–79. doi:10.1016/j.applanim.2015.02.019
3. Ashley, M. C., & Holcombe, D. W. (2001). Effect of stress induced by gathers and removals on reproductive success of feral horses. *Wildlife Society Bulletin*, 29(1), 248–254.

Control method: Roping of wild horses (or brumby running)

Important note:	Roping of wild horses for domestication is a multi-stage process. Separate assessments have been made for each stage including roping and loading and transport. The impact of roping should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.
Assumptions:	• There is no national model standard operating procedure (SOP) for this method; therefore it was assessed using the Parks Victoria Roping SOP [1]. • Roping (also called brumby running) is a capture method conducted from horseback, usually with two or more riders. It involves pursuing a target wild horse, bringing it under control using a neck rope, tying it to a tree to allow it to settle and then leading it to a yard or vehicle from where it is removed from the area. • Horses are not roped when temperatures exceed 30°C. • Muzzled dogs are sometimes used assist in the location of wild horses but are not used for catching or loading the wild horses. • Horses can potentially be left tied to a tree for a period of 24 hours, however there is no restriction on the duration of pursuit [1]. • This assessment applies from the start of the pursuit to the point at which the captured horse is released from being tied up.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

↓

Overall impact
Severe

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:

6

Summary of evidence:

Domain 1	Captured horses can potentially be without food and water for a period of 24 hours. They will have been pursued for minutes to hours and will not have access to water for many hours afterwards whilst tied up, thus they are likely to become dehydrated. The impact will be more severe the longer the exertion during the chase and the longer the period of water deprivation.
Domain 2	In hot weather, horses could experience heat stress (hyperthermia) due to exertion and being tied up for a period up to 24 hours. Horses could also suffer from hypothermia if tied up for long periods in cold temperatures.
Domain 3	Prolonged or excessive exertion and stress could also result in capture myopathy (exertional rhabdomyolysis)[2]. Neck ropes can cause serious injuries and damage to the neck and problems with breathing when used to capture and running horses. The pursued horses will already be breathing heavily due to exertion; applying a neck rope will exacerbate this to the point where the animal could experience 'air hunger' [3]. Pursuing horses for a long distance over rough terrain has the potential to result in severe (i.e. cuts and lacerations) and sometime catastrophic injuries (i.e. broken legs, impalement).
Domain 4	Horses could be tied up for a period of 24 hours and during this time they cannot perform the natural behaviours they are motivated to perform and are prevented from interacting with conspecifics. Younger horses or those in a debilitated state are potentially vulnerable to attack (or distress from the presence of) predators (i.e. wild dogs). Removal of a single horse could disrupt the social system of the remaining horses dramatically (depending on the age and sex of the horse), and may disrupt the band. This procedure can also lead to abandonment of foals. Foals are likely to be left behind in prolonged chases, and not just the foal of the removed horses. Foals that have been separated by a disturbance event only rarely reunite with their mothers, and usually starve to death. Foals orphaned before 120 days of age do not survive independently, and are not adopted by other mares, and often treated with aggression by other mares [4].
Domain 5	As individual horses are generally captured using this method, it is likely that they will experience considerable fear, anxiety and distress not just due to excessive pursuit and being tied up for a prolonged period, but also at being separated from their normal band.

PART B: Not performed – non-lethal method

Comments:

Wildlife capture techniques that involve extended pursuit phases are often associated with poor animal welfare outcomes. For example, red deer (*Cervus elaphus*) subjected to prolonged pursuit with hounds show damage to red blood cells, depletion of carbohydrate resources for powering muscles, disruption of muscle tissue, elevated secretion of beta-endorphin and high concentrations of cortisol, typically associated with extreme physiological and psychological stress [5].

Bibliography

1. Parks Victoria. (2013). *Operating guidelines for feral horse capture by roping. Alpine Brumby Management Association (ABMA)*. Melbourne, Victoria: Parks Victoria.
2. Valberg, S. J., Mickelson, J. R., Gallant, E. M., MacLeay, J. M., Lentz, L., & de la Corte, F. (1999). Exertional rhabdomyolysis in quarter horses and thoroughbreds: one syndrome, multiple aetiologies. *Equine Veterinary Journal. Supplement*, (30), 533–538.
3. Beausoleil, N., & Mellor, D. (2015). Introducing breathlessness as a significant animal welfare issue. *New Zealand Veterinary Journal*, 63(1), 44–51. doi:10.1080/00480169.2014.940410
4. Cameron, E. Z., Linklater, W. L., Stafford, K. J., & Minot, E. O. (1999). A case of co-operative nursing and offspring care by mother and daughter feral horses. *Journal of Zoology*, 249(4), 486–489. doi:10.1111/j.1469-7998.1999.tb01221.x
5. Bateson, P., & Bradshaw, E. L. (1997). Physiological effects of hunting red deer (*Cervus elaphus*). *Proceedings of the Royal Society B: Biological Sciences*, 264(1389), 1707–1714.

Control method: On-site humane killing of captured wild horses

- | | |
|-------------------------|---|
| Important notes: | <ul style="list-style-type: none">• Removal of horses for humane killing, slaughter or domestication is a multi-stage process. Separate assessments have been made for each potential stage including passive trapping; mustering; on-site humane killing; loading and transport; and lairage and slaughter. The impact of on-site humane killing should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.• Currently there is no detailed standard operating procedure (SOP) specifically for the humane killing of wild horses in yards. The SOPs for mustering and trapping have a section on shooting of horses in yards however the committee did not consider these instructions sufficiently detailed to perform a humaneness assessment for Part A for this method• A detailed SOP on the humane killing of horses in yards is required. It should contain information on different techniques available for use in yards (e.g. shooting, chemical restraint, captive bolt devices) as well as use of partitions and visual barriers, sound suppressors for firearms and methods for minimising handling of horses, order of humane killing for different ages and classes of horses and possible effects on horses that are within sight or sound of the procedures. |
| Assumptions: | <ul style="list-style-type: none">• The humane killing method assessed here in Part B is a shot to the head using a firearm and ammunition adequate for shooting horses at short range (i.e. within 5m). |

PART A: Not assessed – insufficient information available

PART B: assessment of mode of death

Time to insensibility (minus any lag time)				
Very rapid	Minutes	Hours	Days	Weeks
Level of suffering (after application of the method that causes death but before insensibility)				
No suffering	Mild suffering	Moderate suffering	Severe suffering	Extreme suffering

SCORE FOR PART B:	A
Summary of evidence:	
Duration	With head shots, a properly placed shot will result in immediate insensibility [1-3].
Suffering	When animals are rendered insensible immediately with a well-placed head shot that causes adequate destruction of brain tissue there should be no suffering [1].

Bibliography

1. AVMA Panel on Euthanasia. (2013). *AVMA Guidelines for the Euthanasia of Animals: 2013 Edition (Version 2013.0.1)*. American Veterinary Medical Association. Retrieved from <https://www.avma.org/KB/Policies/Pages/Euthanasia-Guidelines.aspx>
2. Gregory, N. (2004). *Physiology and behaviour of animal suffering*. Oxford, UK: Blackwell.
3. Longair, J. (Al), Finley, G. G., Laniel, M.-A., MacKay, C., Mould, K., Olfert, E. D., Preston, A. (1991). Guidelines for euthanasia of domestic animals by firearms. *Canadian Veterinary Journal*, 32(12), 724–726.

Control method: Loading and transport of wild horses over short journeys

Important note: Removal of horses for humane killing, slaughter or domestication is a multi-stage process. Separate assessments have been made for each potential stage including passive trapping; mustering; on-site humane killing; loading and transport; and lairage and slaughter. The impact of on-site humane killing should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.

Assumptions:

- Procedures are followed in accordance with the Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock [1]. (<http://www.animalwelfarestandards.net.au/land-transport/>).
- A skilled operator, who holds an appropriate firearm license, is always readily available with a suitable calibre firearm to euthanase any injured and non-commercial animals.
- Contingency plans are in place to care for animals in the case of a truck breakdown during transportation.
- The distances that horses can be transported will vary considerably. This assessment applies to a single journey lasting no longer than 4 hours.
- Horses are segregated into appropriate groups to reduce aggression and partitions or pens are used to separate unfamiliar groups when transported together. Note that the Australian Land Transport Standards state that all stallions should be segregated during transport, however the view of the assessment panel is that for wild (rather than domesticated) horses, in some instances, stallions should be kept with their familiar group.
- Transport vehicles should provide protection from wind chill when cold and direct sunlight when hot.
- This assessment applies from when the horses are loaded for transportation to when they are offloaded at their destination.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

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Overall impact
Moderate

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	5										
Summary of evidence: <table border="0"> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 1</td><td>The horses will have no access to food or water for a maximum of around 4 hours.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 2</td><td>Transport vehicles will protect from extremes of weather.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 3</td><td>Some horses could potentially become injured during loading and transport. Injuries can range from minor lacerations to more severe injuries. In rare cases, injuries can be catastrophic (e.g. horses can break legs) and horses can require euthanasia. Segregation of incompatible social groups will help to reduce the risk of injury caused by aggression.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 4</td><td>Behaviour is restricted as horses are required to enter races, yards, and transport vehicles. They cannot perform normal behaviours on the transport vehicles (e.g. feeding, moving, resting, grooming etc.) and will also be separated from conspecifics for brief periods during some stages (i.e. loading). During transport there is less scope for escape from other horses, thus aggressive interactions can be increased [2].</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 5</td><td>The multiple stressors associated with loading and transportation are likely to cause considerable fear, anxiety and distress in wild horses [3]. Horses are constrained and they may not be able to escape unfamiliar animals, resulting in aggression and injury. They will experience a moving platform for the first time and have to learn to maintain their balance sometimes whilst moving over very rough terrain. Initially the impact in this domain will be severe but as the horses adapt and take comfort from other animals in their social group, the impact could be reduced [2].</td></tr> </table>		Domain 1	The horses will have no access to food or water for a maximum of around 4 hours.	Domain 2	Transport vehicles will protect from extremes of weather.	Domain 3	Some horses could potentially become injured during loading and transport. Injuries can range from minor lacerations to more severe injuries. In rare cases, injuries can be catastrophic (e.g. horses can break legs) and horses can require euthanasia. Segregation of incompatible social groups will help to reduce the risk of injury caused by aggression.	Domain 4	Behaviour is restricted as horses are required to enter races, yards, and transport vehicles. They cannot perform normal behaviours on the transport vehicles (e.g. feeding, moving, resting, grooming etc.) and will also be separated from conspecifics for brief periods during some stages (i.e. loading). During transport there is less scope for escape from other horses, thus aggressive interactions can be increased [2].	Domain 5	The multiple stressors associated with loading and transportation are likely to cause considerable fear, anxiety and distress in wild horses [3]. Horses are constrained and they may not be able to escape unfamiliar animals, resulting in aggression and injury. They will experience a moving platform for the first time and have to learn to maintain their balance sometimes whilst moving over very rough terrain. Initially the impact in this domain will be severe but as the horses adapt and take comfort from other animals in their social group, the impact could be reduced [2].
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PART B: Not performed – non-lethal method

Comments:
The terrain covered and condition of roads is another factor that will influence the severity of impact for transportation. There will be less jarring and injuries from slips and falls when traveling on bitumen roads. Also, less energy is expended to maintain balance when roads are smoother [3].

Bibliography

1. Animal Health Australia. (2012). *Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock*. Canberra, ACT: Commonwealth of Australia.
2. Knowles, T., Brown, S., Pope, S., Nicol, C., Warriss, P., & Weeks, C. (2010). The response of untamed (unbroken) ponies to conditions of road transport. *Animal Welfare*, 19(1), 1–15.
3. Weeks, C. A., McGreevy, P., & Waran, N. K. (2012). Welfare issues related to transport and handling of both trained and unhandled horses and ponies. *Equine Veterinary Education*, 24(8), 423–430. doi:10.1111/j.2042-3292.2011.00293.x

Control method: Loading and transport of wild horses over long journeys

Important note: Removal of horses for humane killing, slaughter or domestication is a multi-stage process. Separate assessments have been made for each potential stage including passive trapping; mustering; on-site humane killing; loading and transport; and lairage and slaughter. The impact of on-site humane killing should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.

Assumptions:

- Procedures are followed in accordance with the Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock [1]. (<http://www.animalwelfarestandards.net.au/land-transport/>).
- A skilled operator, who holds an appropriate firearm license, is always readily available with a suitable calibre firearm to euthanase any injured and non-commercial animals.
- Contingency plans are in place to care for animals in the case of a truck breakdown during transportation.
- The distances that horses can be transported will vary considerably. This assessment applies to a single journey lasting up to 24 hours.
- Horses are segregated into appropriate groups to reduce aggression and partitions or pens are used to separate unfamiliar groups when transported together. Note that the Australian Land Transport Standards state that all stallions should be segregated during transport, however the view of the assessment panel is that for wild (rather than domesticated) horses, in some instances, stallions should be kept with their familiar group.
- Transport vehicles should provide protection from wind chill when cold and direct sunlight when hot.
- This assessment applies from when the horses are loaded for transportation to when they are offloaded at their destination.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

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Overall impact
Severe

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	7										
Summary of evidence: <table border="0"> <tr> <td data-bbox="240 338 541 510">Domain 1</td><td data-bbox="544 338 1353 510">Abattoirs licensed to process horses for slaughter are located in Peterborough, SA and Caboolture, QLD, therefore horses removed from KNP could be travelling for many hours (up to 15 to 16 hours or longer.) The horses could potentially have no access to food or water for up to 24 hours.</td></tr> <tr> <td data-bbox="240 515 541 622">Domain 2</td><td data-bbox="544 515 1353 622">Transport vehicles will protect from extremes of weather. However, transportation for many hours in very hot or cold conditions will result in some short-term heat or cold stress.</td></tr> <tr> <td data-bbox="240 627 541 835">Domain 3</td><td data-bbox="544 627 1353 835">Some horses could potentially become injured during loading and transport. Injuries can range from minor lacerations to more severe injuries. In rare cases, injuries can be catastrophic (e.g. horses can break legs) and horses could go down and need to be euthanased. Segregation of incompatible social groups will help to reduce the risk of injury caused by aggression.</td></tr> <tr> <td data-bbox="240 840 541 1048">Domain 4</td><td data-bbox="544 840 1353 1048">Behaviour is restricted as horses are required to enter races, yards, and transport vehicles. They cannot perform normal behaviours on the transport vehicles (e.g. feeding, moving, resting, grooming etc.) and will also be separated from conspecifics for brief periods during some stages (i.e. loading). During transport there is less scope for escape from other horses, thus aggressive interactions can be increased [2].</td></tr> <tr> <td data-bbox="240 1052 541 1361">Domain 5</td><td data-bbox="544 1052 1353 1361">The multiple stressors associated with loading and transportation are likely to cause considerable fear, anxiety and distress in wild horses [3]. Horses are confined for many hours and they may not be able to escape unfamiliar animals, resulting in aggression and injury. They will experience a moving platform for the first time and have to learn to maintain their balance sometimes whilst moving over very rough terrain [2]. Horses will adapt and take comfort from other animals in their social group, however due to the long period of travel, suffering and distress is likely to be severe.</td></tr> </table>		Domain 1	Abattoirs licensed to process horses for slaughter are located in Peterborough, SA and Caboolture, QLD, therefore horses removed from KNP could be travelling for many hours (up to 15 to 16 hours or longer.) The horses could potentially have no access to food or water for up to 24 hours.	Domain 2	Transport vehicles will protect from extremes of weather. However, transportation for many hours in very hot or cold conditions will result in some short-term heat or cold stress.	Domain 3	Some horses could potentially become injured during loading and transport. Injuries can range from minor lacerations to more severe injuries. In rare cases, injuries can be catastrophic (e.g. horses can break legs) and horses could go down and need to be euthanased. Segregation of incompatible social groups will help to reduce the risk of injury caused by aggression.	Domain 4	Behaviour is restricted as horses are required to enter races, yards, and transport vehicles. They cannot perform normal behaviours on the transport vehicles (e.g. feeding, moving, resting, grooming etc.) and will also be separated from conspecifics for brief periods during some stages (i.e. loading). During transport there is less scope for escape from other horses, thus aggressive interactions can be increased [2].	Domain 5	The multiple stressors associated with loading and transportation are likely to cause considerable fear, anxiety and distress in wild horses [3]. Horses are confined for many hours and they may not be able to escape unfamiliar animals, resulting in aggression and injury. They will experience a moving platform for the first time and have to learn to maintain their balance sometimes whilst moving over very rough terrain [2]. Horses will adapt and take comfort from other animals in their social group, however due to the long period of travel, suffering and distress is likely to be severe.
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PART B: Not performed – non-lethal method

Comments:
The terrain covered and condition of roads is another factor that will influence the severity of impact for transportation. There will be less jarring and injuries from slips and falls when traveling on bitumen roads. Also, less energy is expended to maintain balance when roads are smoother [3]

Bibliography

1. Animal Health Australia. (2012). *Australian Animal Welfare Standards and Guidelines — Land Transport of Livestock*. Canberra, ACT: Commonwealth of Australia.
2. Knowles, T., Brown, S., Pope, S., Nicol, C., Warriss, P., & Weeks, C. (2010). The response of untamed (unbroken) ponies to conditions of road transport. *Animal Welfare*, 19(1), 1–15.
3. Weeks, C. A., McGreevy, P., & Waran, N. K. (2012). Welfare issues related to transport and handling of both trained and unhandled horses and ponies. *Equine Veterinary Education*, 24(8), 423–430. doi:10.1111/j.2042-3292.2011.00293.x

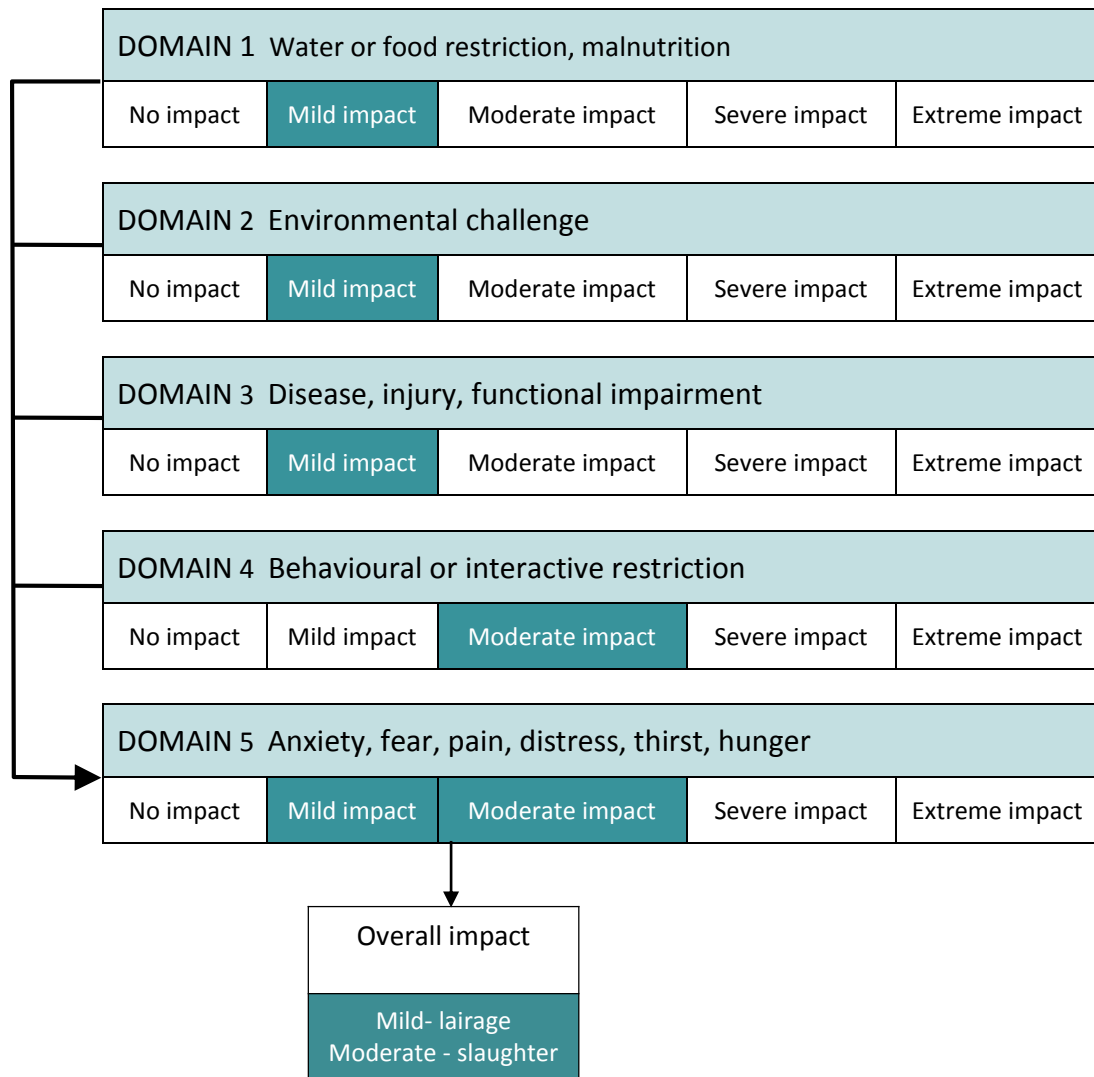
Control method: Lairage and slaughter of wild horses at abattoirs

Important note: Removal of horses for humane killing, slaughter or domestication is a multi-stage process. Separate assessments have been made for each potential stage including passive trapping; mustering; on-site humane killing; loading and transport; and lairage and slaughter. The impact of on-site humane killing should not be considered in isolation from other stages, as the cumulative effects of these procedures will compound the welfare impact.

Assumptions:

- There are no published standards specific to the abattoir slaughter of wild horses in Australia, therefore we assumed that best practice would be followed in accordance with the *National Animal Welfare Standards for Livestock Processing Establishments* published by AMIC. See: http://www.amic.org.au/content_common/pg-amics-animal-welfare-standards-for-processing-establishments.seo
- This assessment applies after unloading, from the holding of horses in yards at the abattoir (lairage) up to the point of death in the slaughter room.

PART A: assessment of overall welfare impact



DURATION OF IMPACT				
Immediate to seconds	Minutes (Slaughter)	Hours	Days (Lairage)	Weeks

SCORE FOR PART A:	Lairage: 5 Slaughter: 4										
Summary of evidence: <table border="0"> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 1</td><td>By the time horses have got to this stage (i.e. they have been trapped or mustered, yarded and transported) they will have experience of being confined, drinking out of troughs and accepting fodder, so if held for longer periods there should not be any problems with water and food intake. Horses can sometimes be held for a week or more in the yards before they are slaughtered. There may be a period of short-term deprivation of food and water just prior to slaughter if the abattoir requires a curfew.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 2</td><td>When being held in the yards prior to slaughter there may be times when the animals are exposed to hot conditions, however it is expected that abattoirs will have mitigation strategies in place to deal with temperature extremes.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 3</td><td>There is a small risk that animals could be injured during offloading and holding in the yards, however standards require that when these injuries are severe the animals are promptly euthanased to prevent further suffering.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 4</td><td>Horses are restrained in yards, so they will not be able to perform the full range of natural behaviours. However they will have been drafted into appropriate social groupings prior to loading and will be more familiar with being handled by humans than when first trapped or mustered.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 5</td><td> The welfare impact over the days to weeks during lairage was considered to be mild. It is preferable to keep horses in family groups during lairage, however if this is not possible, horses will bond with other horses as they become more familiar with them. They will settle down quickly and form new relationships the longer they are kept together. Moving from lairage to the slaughterhouse floor will be the most stressful period for horses during the slaughter process. Horses are likely to experience a moderate degree of fear, anxiety and distress for a period of minutes during this time. </td></tr> </table>		Domain 1	By the time horses have got to this stage (i.e. they have been trapped or mustered, yarded and transported) they will have experience of being confined, drinking out of troughs and accepting fodder, so if held for longer periods there should not be any problems with water and food intake. Horses can sometimes be held for a week or more in the yards before they are slaughtered. There may be a period of short-term deprivation of food and water just prior to slaughter if the abattoir requires a curfew.	Domain 2	When being held in the yards prior to slaughter there may be times when the animals are exposed to hot conditions, however it is expected that abattoirs will have mitigation strategies in place to deal with temperature extremes.	Domain 3	There is a small risk that animals could be injured during offloading and holding in the yards, however standards require that when these injuries are severe the animals are promptly euthanased to prevent further suffering.	Domain 4	Horses are restrained in yards, so they will not be able to perform the full range of natural behaviours. However they will have been drafted into appropriate social groupings prior to loading and will be more familiar with being handled by humans than when first trapped or mustered.	Domain 5	The welfare impact over the days to weeks during lairage was considered to be mild. It is preferable to keep horses in family groups during lairage, however if this is not possible, horses will bond with other horses as they become more familiar with them. They will settle down quickly and form new relationships the longer they are kept together. Moving from lairage to the slaughterhouse floor will be the most stressful period for horses during the slaughter process. Horses are likely to experience a moderate degree of fear, anxiety and distress for a period of minutes during this time.
Domain 1	By the time horses have got to this stage (i.e. they have been trapped or mustered, yarded and transported) they will have experience of being confined, drinking out of troughs and accepting fodder, so if held for longer periods there should not be any problems with water and food intake. Horses can sometimes be held for a week or more in the yards before they are slaughtered. There may be a period of short-term deprivation of food and water just prior to slaughter if the abattoir requires a curfew.										
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PART B: assessment of mode of death

Time to insensibility (minus any lag time)				
Very rapid	Minutes	Hours	Days	Weeks
Level of suffering (after application of the method that causes death but before insensibility)				
No suffering	Mild suffering	Moderate suffering	Severe suffering	Extreme suffering

SCORE FOR PART B:	A
Summary of evidence: Duration Horses are stunned with a penetrating captive bolt gun to render them insensible to pain prior to being bled out. The time to insensibility will be very rapid for the majority of animals. The minimal acceptable success rate for stunning devices used in abattoirs is 95% [2,3,4]. Suffering When animals are rendered insensible immediately with a well-placed captive bolt shot and they do not regain consciousness prior to death there should be no suffering.	

Comments:
It is preferable to manage horses in mixed groups (in terms of age and size) since this results in fewer agonistic interactions and less injuries [1].

Bibliography

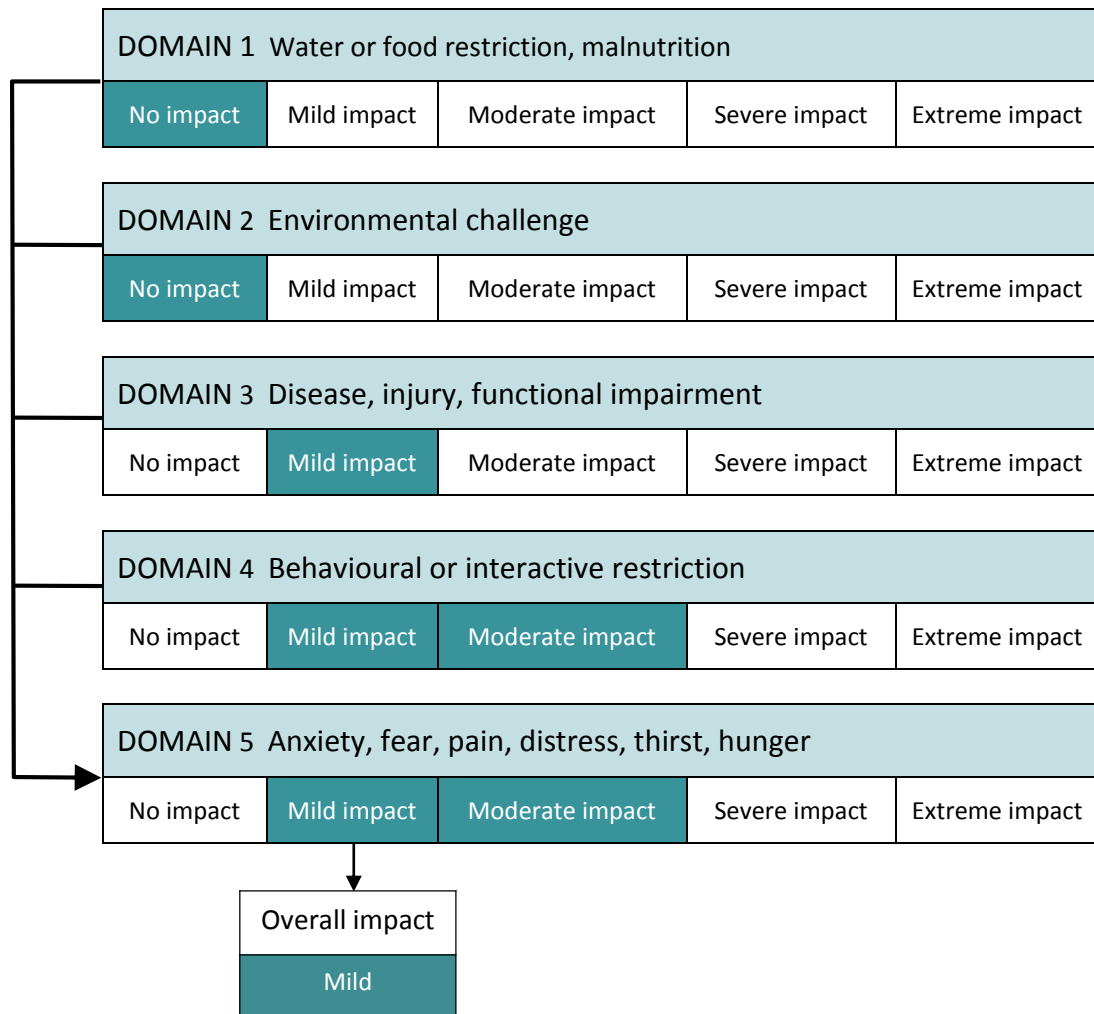
1. Giles, S. L., Nicol, C. J., Harris, P. A., & Rands, S. A. (2015). Dominance rank is associated with body condition in outdoor-living domestic horses (*Equus caballus*). *Applied Animal Behaviour Science*, 166, 71–79. doi:10.1016/j.applanim.2015.02.019
2. Grandin, T. (2005). *Recommended Animal Handling Guidelines and Audit Guide for Cattle, Pigs, and Sheep*. American Meat Institute Foundation. Retrieved from <http://www.grandin.com/RecAnimalHandlingGuidelines.html>
3. Gregory, N. G. (2007). *Animal Welfare and Meat Production*. Wallingford, Oxfordshire: CAB International.
4. Australian Meat Industry Council (2009) *National Animal Welfare Standards for Livestock Processing Establishments*. Retrieved from http://www.amic.org.au/content_common/pg-amic-animal-welfare-standards-for-processing-establishments.seo

Control method: Ground shooting of wild horses

Assumptions:

- Best practice is followed in accordance with the standard operating procedure HOR001 Ground shooting of feral horses
http://www.pestsmart.org.au/wp-content/uploads/2013/08/HOR001_ground_shooting.pdf
- The shooter is competent and will make accurate decisions about whether the shot can be successfully placed. Welfare outcomes are highly dependent on the skill of the shooter. If the shooter is not skilled then animal suffering is likely.
- Shooting of individuals should stop when the flight response of the herd limits further accurate shooting (except when a mare is shot that has a dependent foal. The shooter must wait until the foal returns so it can be shot).
- Older females are always shot first.
- The impacts were considered on the group of horses being targeted – the first animal to be shot and killed would be naïve but the negative impacts would increase with each subsequent animal.
- Note that horse shooting is a specialised operation. Ground shooting is only appropriate for very small groups or individual horses and is *not* suited to rapid population reduction of high-density populations.

PART A: assessment of overall welfare impact



DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	5										
Summary of evidence: <table border="0"> <tr> <td data-bbox="240 338 541 376">Domain 1</td><td data-bbox="541 338 1353 376">No impact in this domain.</td></tr> <tr> <td data-bbox="240 398 541 436">Domain 2</td><td data-bbox="541 398 1353 436">No impact in this domain.</td></tr> <tr> <td data-bbox="240 459 541 965">Domain 3</td><td data-bbox="541 459 1353 965"> Ground shooting has the advantage over aerial shooting of operators not shooting from a moving platform and the target animals being stationary rather than running, however there is still a higher risk of wounding with this method compared to aerial shooting. This is because animals are shot over a greater distance and following up wounded animals is more difficult because there is less opportunity to take follow-up shots quickly. Wounded animals are less visible and it is more difficult to set up the ideal orientation to the target zones when shooting from the ground. Furthermore, the operators are less likely to be highly trained and skilled compared with those conducting aerial shooting. Non-target horses can also be injured as large highly powerful ammunition is required to bring down a horse with a chest shot and there is a risk that a bullet could pass right through the target animal and hit another animal. </td></tr> <tr> <td data-bbox="240 976 541 1144">Domain 4</td><td data-bbox="541 976 1353 1144"> Female horses live in long-term social groups with unrelated members [1] therefore removing individuals or small numbers of horses will have long-term negative effects on the animals in that social group that remain [2]. There will be less impact if all horses in a social group are shot. </td></tr> <tr> <td data-bbox="240 1155 541 1404">Domain 5</td><td data-bbox="541 1155 1353 1404"> Horses are likely to experience a moderate degree of anxiety and distress during ground shooting due to the high risk of being wounded. If animals are injured and escape (i.e. they not euthanased) they could suffer a painful and protracted death. Also, individuals in a social group that are left behind have the potential to suffer, and this will be considerable in orphaned foals that still require maternal interaction (even though they may not still be suckling). </td></tr> </table>		Domain 1	No impact in this domain.	Domain 2	No impact in this domain.	Domain 3	Ground shooting has the advantage over aerial shooting of operators not shooting from a moving platform and the target animals being stationary rather than running, however there is still a higher risk of wounding with this method compared to aerial shooting. This is because animals are shot over a greater distance and following up wounded animals is more difficult because there is less opportunity to take follow-up shots quickly. Wounded animals are less visible and it is more difficult to set up the ideal orientation to the target zones when shooting from the ground. Furthermore, the operators are less likely to be highly trained and skilled compared with those conducting aerial shooting. Non-target horses can also be injured as large highly powerful ammunition is required to bring down a horse with a chest shot and there is a risk that a bullet could pass right through the target animal and hit another animal.	Domain 4	Female horses live in long-term social groups with unrelated members [1] therefore removing individuals or small numbers of horses will have long-term negative effects on the animals in that social group that remain [2]. There will be less impact if all horses in a social group are shot.	Domain 5	Horses are likely to experience a moderate degree of anxiety and distress during ground shooting due to the high risk of being wounded. If animals are injured and escape (i.e. they not euthanased) they could suffer a painful and protracted death. Also, individuals in a social group that are left behind have the potential to suffer, and this will be considerable in orphaned foals that still require maternal interaction (even though they may not still be suckling).
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PART B: assessment of mode of death – head shot

Time to insensibility (minus any lag time)				
Very rapid	Minutes	Hours	Days	Weeks
Level of suffering (after application of the method that causes death but before insensibility)				
No suffering	Mild suffering	Moderate suffering	Severe suffering	Extreme suffering

PART B: assessment of mode of death – chest shot

Time to insensibility (minus any lag time)				
rapid	Minutes	Hours	Days	Weeks
Level of suffering (after application of the method that causes death but before insensibility)				
suffering	Mild suffering	Moderate suffering	Severe suffering	Extreme suffering

SCORE FOR PART B:	Head shot - A Chest shot - D				
Summary of evidence: <table border="0"> <tr> <td data-bbox="240 353 539 920">Duration</td><td data-bbox="544 353 1353 920"> With head shots, a properly placed shot will result in immediate insensibility [2–4]. With chest shots, time to insensibility can range from seconds to a few minutes. The time to loss of consciousness and the time to death will depend on which tissues are damaged and, in particular, on the rate of blood loss and hence the rate of induction of cerebral hypoxaemia [5]. Loss of consciousness and death are likely to be quick when animals have been shot in the heart. With ground shooting, single shots to the chest are often used (as opposed to ‘double tap’ chest shots used during aerial shooting), therefore less damage could result and the duration of suffering could potentially be minutes. There is some evidence that a phenomenon called ‘hydrostatic shock’ (see below) may also contribute to rapid incapacitation and potentially rapid loss of consciousness with shots to the chest; however this effect seems to be variable and does not occur in all instances. </td></tr> <tr> <td data-bbox="240 927 539 1458">Suffering</td><td data-bbox="544 927 1353 1458"> When animals are rendered insensible immediately with a well-placed head shot that causes adequate destruction of brain tissue there should be no suffering [2]. Animals that are chest shot and still conscious are likely to have a short period of suffering, though the extent of suffering will vary depending on which tissues are damaged and the rate of blood loss. During haemorrhage there is likely to be tachypnoea and hyperventilation, which, when severe, would indicate that there is a sense of breathlessness before the loss of consciousness [5]. Severe haemorrhage in humans is also associated with anxiety and confusion [6]. If chest shot animals are rendered insensible by the mechanism of ‘hydrostatic shock’ and they do not regain consciousness prior to death they are unlikely to suffer. </td></tr> </table>		Duration	With head shots, a properly placed shot will result in immediate insensibility [2–4]. With chest shots, time to insensibility can range from seconds to a few minutes. The time to loss of consciousness and the time to death will depend on which tissues are damaged and, in particular, on the rate of blood loss and hence the rate of induction of cerebral hypoxaemia [5]. Loss of consciousness and death are likely to be quick when animals have been shot in the heart. With ground shooting, single shots to the chest are often used (as opposed to ‘double tap’ chest shots used during aerial shooting), therefore less damage could result and the duration of suffering could potentially be minutes. There is some evidence that a phenomenon called ‘hydrostatic shock’ (see below) may also contribute to rapid incapacitation and potentially rapid loss of consciousness with shots to the chest; however this effect seems to be variable and does not occur in all instances.	Suffering	When animals are rendered insensible immediately with a well-placed head shot that causes adequate destruction of brain tissue there should be no suffering [2]. Animals that are chest shot and still conscious are likely to have a short period of suffering, though the extent of suffering will vary depending on which tissues are damaged and the rate of blood loss. During haemorrhage there is likely to be tachypnoea and hyperventilation, which, when severe, would indicate that there is a sense of breathlessness before the loss of consciousness [5]. Severe haemorrhage in humans is also associated with anxiety and confusion [6]. If chest shot animals are rendered insensible by the mechanism of ‘hydrostatic shock’ and they do not regain consciousness prior to death they are unlikely to suffer.
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Comments:

Wounding rates with ground shooting

When animals are shot at, some will be killed outright, others will be missed and some will be wounded but not killed. Of the ones that are wounded, some will be killed by subsequent shots but some will escape. Therefore to determine welfare impact we are interested in the extent of injury or wounding associated with ground shooting and the likelihood of it happening.

There are no reported observations of wounding rates during ground shooting of wild horses however wounding rates could potentially be high. This is mostly due to shooting over long ranges, poor presentation of the animal to allow a good shot to the target zone and difficulty in following up animals that are injured with a first shot.

There have been a few studies of wounding rates associated with ground shooting in other species. For example:

Impala

A study of the night shooting of wild impala found that when the point of aim was the head, 93% of animals were killed instantaneously by the first shot [7]. Of the 6.3% of animals that were wounded and the timing of shots was recorded (n=31), the mean time between wounding and death was 30 seconds (maximum time 1 min 57s; minimum time 4.8s). Of a total of 990 shots fired, 74 (7.5%) missed animals completely and 57 (5.8%) resulted in animals being wounded (3 animals were wounded before dispatch). No animals escaped after wounding.

Deer

Estimates of wounding rates by deer stalkers have shown that 2% of deer escape wounded, 11% of deer required two or more shots to kill and 7% took 2-15 minutes to die [8].

In a study to examine the effects of wound site and blood collection method on biochemical measures obtained from red deer, 84% of 69 deer were killed with a single shot and no deer escaped wounded [9]. Eleven of the deer were shot twice (and one deer was shot 3 times), the first shot usually being in the chest. Of the deer killed with one shot, 38% of stags and 80% of hinds were shot in the head or neck. When deer had been shot in the chest, they often ran a short distance. An estimate was made of the time between the first shot and the deer falling to the ground. The median time was 60 seconds for the multiple shot animals and 0 seconds for the single-shot.

What would be considered to be an acceptable wounding rate for ground shooting?

As a guide, for captive bolt stunning in abattoirs, the level of acceptability is that 95% of animals must be rendered insensible with one shot. An excellent score is 99% [10].

It has been proposed that a review of deer culling by shooting is warranted when, in a cull of average size (between 80 and 120 deer), 14 to 16% of the carcasses contain more than one permanent wound tract (i.e. required more than one shot). [11]

For comparison with a method that is considered to be less humane than shooting – bow hunting of deer-between 12% and 48% of shot deer may be injured and escape [5].

Hydrostatic shock

With shooting, in addition to the damage caused by the penetrating projectile, there is scientific evidence that organs can also be damaged by the pressure wave that occurs when a projectile enters a viscous medium, a phenomenon known as 'hydrostatic shock' [12]. Experimental studies on pigs and dogs demonstrate that a significant ballistic pressure wave reaches the brain of animals shot in an extremity such as the thigh [13], [14], [15]. It is hypothesised that damage to the brain occurs when the pressure wave reaches the brain from the thoracic cavity via major blood vessels but could also occur via acceleration of the head or by passage of the wave via a cranial mechanism [16]. It is also thought that hydrostatic shock may produce incapacitation more quickly

than blood loss effects, however not all bullet impacts will produce a pressure wave strong enough to cause this rapid incapacitation [17].

Anecdotal reports by hunters maintain that some species are more susceptible to this shock effect than others; however no studies were found that confirmed this. However there is some speculation that, if one of the mechanisms that contribute to the effect of hydrostatic shock and subsequent damage to the brain is caused by acceleration of the head, it is possible that some animals may be more resistant to the incapacitating effects of shooting. Some animals that engage in head butting appear to be more resistant to concussion than humans and are thought to have a higher acceleration threshold which could make them more resistant to traumatic brain injury not only from externally imposed forces, accelerations and blunt force trauma but also from an internal ballistic pressure wave generated by a projectile [18] [19].

Bibliography

1. Cameron, E. Z., Setsaas, T. H., & Linklater, W. L. (2009). Social bonds between unrelated females increase reproductive success in feral horses. *Proceedings of the National Academy of Sciences of the United States of America*, 106(33), 13850–13853. doi:10.1073/pnas.0900639106
2. AVMA Panel on Euthanasia. (2013). *AVMA Guidelines for the Euthanasia of Animals: 2013 Edition (Version 2013.0.1)*. American Veterinary Medical Association. Retrieved from <https://www.avma.org/KB/Policies/Pages/Euthanasia-Guidelines.aspx>
3. Gregory, N. (2004). *Physiology and behaviour of animal suffering*. Oxford, UK: Blackwell.
4. Longair, J. (Al), Finley, G. G., Laniel, M.-A., MacKay, C., Mould, K., Olfert, E. D., ... Preston, A. (1991). Guidelines for euthanasia of domestic animals by firearms. *Canadian Veterinary Journal*, 32(12), 724–726.
5. Gregory, N. G. (2005). Bowhunting deer. *Animal Welfare*, 14(2), 111–116.
6. Zajtcuk, R. (1995). Anesthesia and Perioperative Care of the Combat Casualty. Chapter 4 - Hemorrhage, Shock and Fluid Resuscitation. Washington, DC: Office of The Surgeon General at TMM Publications, Borden Institute, Walter Reed Army Medical Center. Retrieved from http://www.bordeninstitute.army.mil/published_volumes/anesthesia/ANfm.pdf
7. Lewis, A. R., Pinchin, A. M., & Kestin, S. C. (1997). Welfare implications of the night shooting of wild impala (*Aepyceros Melampus*). *Animal Welfare*, 6, 123–131.
8. Bradshaw, E. L., & Bateson, P. (2000). Welfare Implications of culling Red Deer (*Cervus elaphus*). *Animal Welfare*, 9, 3–24.
9. Bateson, P., & Bradshaw, E. L. (2000). The effects of wound site and blood collection method on biochemical measures obtained from wild, free-ranging red deer *Cervus elaphus* shot by rifle. *Journal of Zoology*, 252(3), 285–292.
10. Grandin, T. (2007). Implementing effective animal welfare auditing programmes. In N. G. Gregory (Ed.), *Animal Welfare & Meat Production* (pp. 227–242). Cambridge: CABI.
11. Urquhart, K. A., & McKendrick, I. J. (2003). Survey of permanent wound tracts in the carcasses of culled wild red deer in Scotland. *Veterinary Record*, 152(16), 497–501.
12. Courtney, M., & Courtney, A. (2008). Scientific Evidence for Hydrostatic Shock. 0803.3051. Retrieved from <http://arxiv.org/abs/0803.3051>
13. Suneson, A., Hansson, H.-A., & Seeman, T. (1990). Pressure Wave Injuries to the Nervous System Caused by High-energy Missile Extremity Impact: Part I. Local and Distant Effects on the Peripheral Nervous System-A Light and Electron Microscopic Study on Pigs. *The Journal of Trauma*, 30(3), 281–294.
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15. Wang, Q., Wang, Z., Zhu, P., & Jiang, J. (2004). Alterations of Myelin Basic Protein and Ultrastructure in the Limbic System at the Early Stage of Trauma-Related Stress Disorder in Dogs. *The Journal of Trauma*, 56(3), 604–610.
16. Courtney, A., & Courtney, M. (2009). A thoracic mechanism of mild traumatic brain injury due to blast pressure waves. *Medical Hypotheses*, 72(1), 76–83. doi:10.1016/j.mehy.2008.08.015
17. Courtney, A., & Courtney, M. (2007). Links between traumatic brain injury and ballistic pressure waves originating in the thoracic cavity and extremities. *Brain Injury*, 21(7), 657–662. doi:10.1080/02699050701481571
18. Courtney, M., & Courtney, A. (2007). Sheep Collisions: the Good, the Bad, and the TBI. 0711.3804. Retrieved from <http://arxiv.org/abs/0711.3804>
19. Shaw, N. A. (2002). The neurophysiology of concussion. *Progress in Neurobiology*, 67(4), 281–344. doi:10.1016/S0301-0082(02)00018-7

Control method: Aerial shooting of wild horses

Assumptions:	• Best practice is followed in accordance with the standard operating procedure HOR002 Aerial shooting of feral horses http://www.pestsmart.org.au/wp-content/uploads/2013/08/HOR002_aerial_shooting.pdf • The SOP requires that all animals in a social group are targeted. • The shooter is competent and will make accurate decisions about whether the shot can be successfully placed. Welfare outcomes are highly dependent on the skill level of both the shooter and the pilot. If the shooter and helicopter pilot are not skilled then animal suffering is likely. • Best practice for aerial shooting requires that all animals are always shot at least twice (known as <i>double-tap</i>) to ensure death. Thus, unlike ground shooting (where only one effective shot is required) it is not practical to assess aerial shooting in terms of head shots and chest shots.
Scenarios	The assessment was divided into two scenarios to take into account circumstances where best practice alone does not result in the ideal outcome of immediate death. • Scenario 1 (best-case) requires the point of aim to be the cranium (i.e. a head shot as described in the SOP) and comprises an animal being chased for a short period of time (<1 minute), the first shot hitting the cranium and the animal immediately rendered insensible. The animal is then shot again in the thorax or cranium and is killed without ever regaining consciousness. • Scenario 2 comprises an animal being chased for an extended period of time (>5 minutes), being shot and not killed (wounded), regaining consciousness and then being shot again one or more times resulting in death. Information on conditions that would be more likely to result in scenario 1 (best case) are included in the SOP and the Comments section of this assessment. The scenario where an animal is chased and shot but not killed (wounded), no follow-up shots are applied and there is a protracted period until death (if death occurs), was not assessed as this would necessarily have a poorer outcome than the above scenarios.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact Scenario 1	Severe impact Scenario 2	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

↓

Overall impact
Moderate – Scenario 1 Severe – Scenario 2

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	Scenario 1: 4 Scenario 2: 5										
Summary of evidence: <table border="0"> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 1</td><td>No impact in this domain.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 2</td><td>No impact in this domain.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 3</td><td> There is the potential for horses to be severely injured whilst being pursued. They are running at high speed and so a fall could result in catastrophic injuries such as a broken leg. They could also run over the top of slower moving animals. This risk of injury is significantly reduced with shorter pursuit times (scenario 1- best case). Compared with ground shooting, the shooter is closer to the animals and therefore wounding rates (proportion of animals shot but not killed) will be lower with aerial shooting. Close proximity allows more energy transfer from shots, resulting in more damage to target organs, but there is a loss of precision when shooting from a moving platform at a moving target. However, the use of a mobile shooting platform allows greater opportunities to deliver follow-up shots if animals are wounded. There have been two wild horse studies to examine the animal welfare impact of aerial shooting [1, 2]. In one study, of the horses that were killed 58% were killed outright, while 42% were wounded but killed by subsequent shots [1]. In the other study, 1% of animals were wounded and not killed [2]. </td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 4</td><td>Aerial shooting forces horses to run a short distance, which restricts normal behaviour and interactions. However, the entire group is killed therefore there are no long-term effects on social groups.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 5</td><td> When pursued by a helicopter, groups of horses will break from cover and aggregate together and this flight behaviour becomes contagious [3]. When horses are closer to the helicopter have been observed to panic and run erratically and are thus they are likely to be experiencing a high degree of fear and distress (J. Hampton, personal communication, April 24, 2015). Chase time—defined as the period from an animal beginning to gallop in an attempt to escape the helicopter and the first shooting event—has been measured in an observational study of an aerial horse cull conducted in the Northern Territory. Of the 937 horses observed, chase time ranged from 2 to 654 seconds with an average time of 73 seconds. For 39% of animals (n=370), chase time was greater than 60 seconds [1]. </td></tr> </table>		Domain 1	No impact in this domain.	Domain 2	No impact in this domain.	Domain 3	There is the potential for horses to be severely injured whilst being pursued. They are running at high speed and so a fall could result in catastrophic injuries such as a broken leg. They could also run over the top of slower moving animals. This risk of injury is significantly reduced with shorter pursuit times (scenario 1- best case). Compared with ground shooting, the shooter is closer to the animals and therefore wounding rates (proportion of animals shot but not killed) will be lower with aerial shooting. Close proximity allows more energy transfer from shots, resulting in more damage to target organs, but there is a loss of precision when shooting from a moving platform at a moving target. However, the use of a mobile shooting platform allows greater opportunities to deliver follow-up shots if animals are wounded. There have been two wild horse studies to examine the animal welfare impact of aerial shooting [1, 2]. In one study, of the horses that were killed 58% were killed outright, while 42% were wounded but killed by subsequent shots [1]. In the other study, 1% of animals were wounded and not killed [2].	Domain 4	Aerial shooting forces horses to run a short distance, which restricts normal behaviour and interactions. However, the entire group is killed therefore there are no long-term effects on social groups.	Domain 5	When pursued by a helicopter, groups of horses will break from cover and aggregate together and this flight behaviour becomes contagious [3]. When horses are closer to the helicopter have been observed to panic and run erratically and are thus they are likely to be experiencing a high degree of fear and distress (J. Hampton, personal communication, April 24, 2015). Chase time—defined as the period from an animal beginning to gallop in an attempt to escape the helicopter and the first shooting event—has been measured in an observational study of an aerial horse cull conducted in the Northern Territory. Of the 937 horses observed, chase time ranged from 2 to 654 seconds with an average time of 73 seconds. For 39% of animals (n=370), chase time was greater than 60 seconds [1].
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PART B: assessment of mode of death – Scenario 1

Time to insensibility (minus any lag time)				
Very rapid	Minutes	Hours	Days	Weeks
Level of suffering (after application of the method that causes death but before insensibility)				
No suffering	Mild suffering	Moderate suffering	Severe suffering	Extreme suffering

PART B: assessment of mode of death – Scenario 2

Time to insensibility (minus any lag time)				
Very rapid	Minutes	Hours	Days	Weeks
Level of suffering (after application of the method that causes death but before insensibility)				
No suffering	Mild suffering	Moderate suffering	Severe suffering	Extreme suffering

SCORE FOR PART B:	Scenario 1: A Scenario 2: D-F
Summary of evidence:	
Duration	With Scenario 1 a properly placed head shot will result in immediate insensibility [4–6]. With Scenario 2, time to insensibility is likely to be seconds but could be minutes for some animals depending on where they are shot, which tissues are damaged and on the rate of blood loss and hence the rate of induction of cerebral hypoxaemia [7]. Loss of consciousness and death will be quick if an animal is shot in the heart. When ‘double tap’ chest shots are used in quick succession there will be more damage and the duration of suffering would be less. If the shots are not taken close together then duration would be longer. There is some evidence that a phenomenon called ‘hydrostatic shock’ (see below) may also contribute to rapid incapacitation and potentially rapid loss of consciousness with some shots (e.g. to the chest or abdomen) and the pressure transfer effect is greater in organs that contain the largest amount of fluid and are closer to the brain; however it seems to be variable and does not occur in all instances.
Suffering	In Scenario 1 (best case), with animals that are rendered insensible immediately with a well-placed head shot that causes adequate destruction of brain tissue, there will be suffering [4]. These animals are likely to be insensible before they hit the ground. In Scenario 2, animals are not rendered immediately insensible and will have an intense but short period of pain and suffering prior to death caused by the initial or subsequent projectiles. For most animals this suffering will be severe, but for some it will be extreme. It is possible that some animals will be conscious when they hit the ground. The extent of suffering for these animals will vary depending on which tissues are damaged by the projectile and the rate of blood loss and also the injuries caused when they hit the ground. During haemorrhage there is likely to be tachypnoea and hyperventilation, which, when severe, would indicate that there is a sense of breathlessness before the loss of consciousness [7]. Severe haemorrhage in humans is also associated with anxiety and confusion [8].

Comments:

Conditions more likely to result in Scenario 1 (best case) welfare outcome for shot animals

- Highly experienced and skilled shooter and pilot.
- Point of aim for the first shot is always the cranium: if the first shot cannot be accurately placed then a shot is not fired.
- Shooting occurs only in open areas with minimal high-canopied vegetation (tree cover or woodland). Shooting in flat terrain rather than steep or undulating areas will result in fewer injuries and allow for easier sighting of wounded animals.
- Shooting is performed in cooler temperatures to minimise heat stress in pursued animals.
- Small groups of horses (<10) are targeted at a time: congregations of social groups in larger mobs is avoided.

Wounding rates with aerial shooting

When animals are shot at, some will be killed outright, others will be missed and some will be wounded but not killed. Of the ones that are wounded, some will be killed by subsequent shots but some may escape. Therefore to determine welfare impact we are interested in the extent of injury or wounding associated with aerial shooting and the likelihood of it happening.

Horses

There are two studies that have examined the animal welfare impact on wild horses shot during aerial culling operations. In one study, post mortem examinations were conducted on a random sample of culled animals (n=452) and animal welfare outcomes were dichotomised into 'inferred instantaneous deaths' (74%) (no blood trails etc.) and 'inferred non-instantaneous deaths' (26%) (where there were obvious signs of suffering before death). A wounding rate of 1.1% was observed. Animals displayed a mean 2.5 ± 0.8 (mean $\pm$ standard deviation) bullet wound tracts with 54%, 51% and 43% of animals shot at least once in the cervical spine, thorax and cranium respectively [2]. Shooter identity (i.e. relating to skill and experience) was found to be the most important factor determining the humaneness of animal welfare outcomes.

In the other study, observers recorded the time elapsed during the killing (n=1165) and pursuit (n=937) of horses. In addition, a post-mortem examination was conducted on a sub-sample of animals (n=102) within five minutes of shooting. Time to death (TTD), was defined as the period from the first shooting event to the animal ceasing to move, with no further signs of life. TTD for all animals was calculated to be 8 ± 16 seconds (mean $\pm$ standard deviation; n=1165). IDR (instantaneous death rate; the proportion of animals for which TTD was zero) was estimated to be 0.58 (95% CI; 0.56-0.61), or as commonly expressed, 58%. Chase time, defined as the period elapsed between the animal beginning to gallop away from the helicopter and the first shooting event, was 73 ± 78 seconds (n=937). Post-mortem ground-based observations revealed 2.2 ± 0.6 bullet wound tracts in each animal and blood trails, evidence of mobility after first shooting, leading to 17% (n=17) of animals [1].

Camels

There have also been studies to assess the animal welfare outcomes of the aerial culling of camels [9]. Seven post-mortem studies (n = 715) and one ante-mortem study (n = 192) were undertaken during routine helicopter shooting programs of free-ranging camels. For the shooting of 192 camels, the mean 'time to death'—defined as the interval between the first shot being fired at an animal and the moment the animal falls and does not move— was 4 seconds. The time to death ranged from 0 to 180 seconds. The proportion of animals that were killed instantaneously (time to death of 0 seconds) was 83% and the time to death was greater than a minute for only 1% of animals. Post-mortem observations on the 715 camels revealed a wounding rate (proportion of animals shot but not killed) of 0.4% (3 animals). The number of bullet wound tracts ranged from one to eight, the mean was 2.4, with 87% of animals shot more than once. Although the SOP states that only head and chest shots should be used, 35% of camels in this study had been shot in the

cervical spine (neck shot). Seventy-five per cent had been shot at least once in the thorax (chest shot) and 63% in the cranium (head shot). Ninety eight per cent of animals had been shot at least once in the head, chest or neck. In this study shooter skill was found to have the largest impact on animal welfare outcomes.

Hydrostatic shock

With shooting, in addition to the damage caused by the penetrating projectile, there is scientific evidence that organs can also be damaged by the pressure wave that occurs when a projectile enters a viscous medium, a phenomenon known as 'hydrostatic shock' [10]. Experimental studies on pigs and dogs demonstrate that a significant ballistic pressure wave reaches the brain of animals shot in an extremity such as the thigh [11][12] [13]. It is hypothesised that damage to the brain occurs when the pressure wave reaches the brain from the thoracic cavity via major blood vessels but could also occur via acceleration of the head or by passage of the wave via a cranial mechanism [14]. It is also thought that hydrostatic shock may produce incapacitation more quickly than blood loss effects, however not all bullet impacts will produce a pressure wave strong enough to cause this rapid incapacitation [15].

Apparent instantaneous unconsciousness has been observed in beavers that were body-shot, and this was presumed to have been caused by pressure waves created as energy is transmitted from the impacting projectiles to adjacent tissues [16].

Anecdotal reports by hunters maintain that some species are more susceptible to this shock effect than others; however no studies were found that confirmed this. However there is some speculation that, if one of the mechanisms that contribute to the effect of hydrostatic shock and subsequent damage to the brain is caused by acceleration of the head, it is possible that some animals may be more resistant to the incapacitating effects of shooting. Some animals that engage in head butting appear to be more resistant to concussion than humans and are thought to have a higher acceleration threshold which could make them more resistant to traumatic brain injury not only from externally imposed forces, accelerations and blunt force trauma but also from an internal ballistic pressure wave generated by a projectile [17] [18].

Bibliography

1. Hampton, J. O. (2013). *Assessment of the Humaneness of Feral Horse Helicopter Shooting Operations in the Northern Territory: Tempe Downs, May 2013. A report for the Northern Territory Parks and Wildlife Commission (unpublished)*. Canberra, ACT: Ecotone Wildlife Veterinary Services.
2. Hampton, J. O., Cowled, B., Perry, A., & Miller, C. (2014). *Independent animal welfare assessment of wild horse (Equus caballus) helicopter shooting operations in northwestern Australia, October-November 2013. A report prepared for the Department of Aboriginal Affairs (DAA), Western Australia (unpublished)*. Canberra, ACT: Ecotone Wildlife Veterinary Services.
3. Linklater, W. L., & Cameron, E. Z. (2002). Escape behaviour of feral horses during a helicopter count. *Wildlife Research*, 29(2), 221–224.
4. AVMA Panel on Euthanasia. (2013). *AVMA Guidelines for the Euthanasia of Animals: 2013 Edition (Version 2013.0.1)*. American Veterinary Medical Association. Retrieved from <https://www.avma.org/KB/Policies/Pages/Euthanasia-Guidelines.aspx>
5. Gregory, N. (2004). *Physiology and behaviour of animal suffering*. Oxford, UK: Blackwell.
6. Longair, J. (Al), Finley, G. G., Laniel, M.-A., MacKay, C., Mould, K., Olfert, E. D., ... Preston, A. (1991). Guidelines for euthanasia of domestic animals by firearms. *Canadian Veterinary Journal*, 32(12), 724–726.
7. Gregory, N. G. (2005). Bowhunting deer. *Animal Welfare*, 14(2), 111–116.

8. Zajтчuk, R. (1995). Anesthesia and Perioperative Care of the Combat Casualty. Chapter 4 - Hemorrhage, Shock and Fluid Resuscitation. Washington, DC: Office of The Surgeon General at TMM Publications, Borden Institute, Walter Reed Army Medical Center. Retrieved from http://www.bordeninstitute.army.mil/published_volumes/anesthesia/ANfm.pdf
9. Hampton, J. O., Cowled, B. D., Perry, A. L., Miller, C. J., Jones, B., & Hart, Q. (2014). Quantitative analysis of animal-welfare outcomes in helicopter shooting: a case study with feral dromedary camels (*Camelus dromedarius*). *Wildlife Research*, 41(2), 127–135.
10. Courtney, M., & Courtney, A. (2008). Scientific Evidence for Hydrostatic Shock. 0803.3051. Retrieved from <http://arxiv.org/abs/0803.3051>
11. Suneson, A., Hansson, H.-A., & Seeman, T. (1990). Pressure Wave Injuries to the Nervous System Caused by High-energy Missile Extremity Impact: Part I. Local and Distant Effects on the Peripheral Nervous System-A Light and Electron Microscopic Study on Pigs. *The Journal of Trauma*, 30(3), 281–294.
12. Suneson, A., Hansson, H., & Seeman, T. (1990). Pressure Wave Injuries to the Nervous System Caused by High-energy Missile Extremity Impact: Part II. Distant Effects on the Central Nervous System-A Light and Electron Microscopic Study on Pigs. *The Journal of Trauma*, 30(3), 295–306.
13. Wang, Q., Wang, Z., Zhu, P., & Jiang, J. (2004). Alterations of Myelin Basic Protein and Ultrastructure in the Limbic System at the Early Stage of Trauma-Related Stress Disorder in Dogs. *The Journal of Trauma*, 56(3), 604–610.
14. Courtney, A., & Courtney, M. (2009). A thoracic mechanism of mild traumatic brain injury due to blast pressure waves. *Medical Hypotheses*, 72(1), 76–83. doi:10.1016/j.mehy.2008.08.015
15. Courtney, A., & Courtney, M. (2007). Links between traumatic brain injury and ballistic pressure waves originating in the thoracic cavity and extremities. *Brain Injury*, 21(7), 657–662. doi:10.1080/02699050701481571
16. Parker, H., Rosell, F., & Danielsen, J. (2006). Efficacy of Cartridge Type and Projectile Design in the Harvest of Beaver. *Wildlife Society Bulletin*, 34(1), 127–130. doi:10.2193/0091-7648(2006)34[127:EOCTAP]2.0.CO;2
17. Courtney, M., & Courtney, A. (2007). Sheep Collisions: the Good, the Bad, and the TBI. 0711.3804. Retrieved from <http://arxiv.org/abs/0711.3804>
18. Shaw, N. A. (2002). The neurophysiology of concussion. *Progress in Neurobiology*, 67(4), 281–344. doi:10.1016/S0301-0082(02)00018-7

Control method: Fertility control of wild horses with GnRH vaccine

Assumptions:

- There is no standard operating procedure for this method.
- The vaccine can be administered using a dart (e.g. shot from a helicopter) or by hand injection to a confined animal (e.g. trapped and mustered and held in a yard).
- Mares aged 5-10 years are the targets for the vaccine. Some females in each band should be left unvaccinated.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

↓

Overall impact
Mild

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	6										
Summary of evidence: <table border="0"> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 1</td><td>No impact in this domain</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 2</td><td>No impact in this domain.</td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 3</td><td> GnRH vaccine stimulates an immune response against gonadotrophin-releasing hormone. Antibodies bind to GnRH molecules causing suppression of LH and FSH secretion with subsequent inhibition of ovarian function [1]. There is some concern that the effects of GnRH are not limited to the reproductive tract and there could be side –effects in other body systems that also have GnRH receptors [1]. Immunocontraceptive vaccines could potentially result in immune suppression in future generations since treated females that do breed will have a lower immune response to the vaccine [2]. The vaccine could potentially cause granulomas at the injection site [3]. </td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 4</td><td> Studies of the effects of GnRH vaccines on behaviour of female wild horses are limited [4,5]. Ovarian suppression could affect behaviours (e.g. agonistic) that are important in maintaining the complex social structure of the herd. Treated mares may lose their status in the band and could become targets of aggression. According to Ransom et al. (2014)[5], studies of <i>captive</i> mares treated with GnRH vaccine (and also other ungulates) have demonstrated that although ovarian activity and ovulation are suppressed after immunisation, females continued to show evidence of oestrous behaviour at irregular intervals and duration, which may help to maintain band fidelity. A study on the short-term effects of GnRH vaccine has demonstrated that it has little effect on time-budget behaviours (e.g. feeding, resting, moving etc.) [5]. </td></tr> <tr> <td style="vertical-align: top; padding-right: 20px;">Domain 5</td><td>The treated mare could possibly experience some mild anxiety associated with a change in social status.</td></tr> </table>		Domain 1	No impact in this domain	Domain 2	No impact in this domain.	Domain 3	GnRH vaccine stimulates an immune response against gonadotrophin-releasing hormone. Antibodies bind to GnRH molecules causing suppression of LH and FSH secretion with subsequent inhibition of ovarian function [1]. There is some concern that the effects of GnRH are not limited to the reproductive tract and there could be side –effects in other body systems that also have GnRH receptors [1]. Immunocontraceptive vaccines could potentially result in immune suppression in future generations since treated females that do breed will have a lower immune response to the vaccine [2]. The vaccine could potentially cause granulomas at the injection site [3].	Domain 4	Studies of the effects of GnRH vaccines on behaviour of female wild horses are limited [4,5]. Ovarian suppression could affect behaviours (e.g. agonistic) that are important in maintaining the complex social structure of the herd. Treated mares may lose their status in the band and could become targets of aggression. According to Ransom et al. (2014)[5], studies of <i>captive</i> mares treated with GnRH vaccine (and also other ungulates) have demonstrated that although ovarian activity and ovulation are suppressed after immunisation, females continued to show evidence of oestrous behaviour at irregular intervals and duration, which may help to maintain band fidelity. A study on the short-term effects of GnRH vaccine has demonstrated that it has little effect on time-budget behaviours (e.g. feeding, resting, moving etc.) [5].	Domain 5	The treated mare could possibly experience some mild anxiety associated with a change in social status.
Domain 1	No impact in this domain										
Domain 2	No impact in this domain.										
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Domain 5	The treated mare could possibly experience some mild anxiety associated with a change in social status.										

PART B: Not performed – non-lethal method

Comments:
It is important to note that fertility control is not a useful tool for reducing population size, but can be effective for preventing population growth. Treating horses with fertility control will not have any effect on existing levels of impact by horses, but will potentially prevent escalation of impacts by limiting population growth. Reduction of population size must be achieved by another method. The most effective strategy for reducing the population growth rate involves a combination of removal and fertility control [6].

Bibliography

1. Kirkpatrick, J. F., Lyda, R. O., & Frank, K. M. (2011). Contraceptive Vaccines for Wildlife: A Review. *American Journal of Reproductive Immunology*, 66(1), 40–50. doi:10.1111/j.1600-0897.2011.01003.x
2. Gray, M. E., & Cameron, E. Z. (2010). Does contraceptive treatment in wildlife result in side effects? A review of quantitative and anecdotal evidence. *Reproduction (Cambridge, England)*, 139(1), 45–55. doi:10.1530/REP-08-0456
3. Massei, G., & Cowan, D. (2014). Fertility control to mitigate human–wildlife conflicts: a review. *Wildlife Research*, 41(1), 1–21.
4. Gray, M. E., Thain, D. S., Cameron, E. Z., & Miller, L. A. (2010). Multi-year fertility reduction in free-roaming feral horses with single-injection immunocontraceptive formulations. *Wildlife Research*, 37(6), 475–481.
5. Ransom, J. I., Powers, J. G., Garbe, H. M., Oehler Sr., M. W., Nett, T. M., & Baker, D. L. (2014). Behavior of feral horses in response to culling and GnRH immunocontraception. *Applied Animal Behaviour Science*, 157, 81–92. doi:10.1016/j.applanim.2014.05.002
6. Cameron, E. Z., Linklater, W. L., Minot, E. O., & Stafford, K. J. (2001). *Population Dynamics 1994-98, and Management of Kaimanawa Wild Horses*. New Zealand Department of Conservation - DOC Science Publishing. Retrieved from <http://www.doc.govt.nz/upload/documents/science-and-technical/sfc171.pdf>

Control method: Fertility control of wild horses with PZP vaccine

Assumptions:

- Currently there is no standard operating procedure for use of this method.
- Liquid formulations of the vaccine can be administered using a dart (e.g. shot from a helicopter) or by hand injection to a confined animal (e.g. trapped and mustered and held in a yard). However, pelleted PZP must be injected by hand because darts cannot provide adequate pressure to release pellets into the animal effectively. SpayVac® (liquid formulation) can be given by hand injection or dart.
- Mares aged 5-10 years are the targets for the vaccine and some females in each band are left unvaccinated.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

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Overall impact	
Mild	

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	6										
Summary of evidence: <table border="0"> <tr> <td data-bbox="240 338 539 383">Domain 1</td><td data-bbox="539 338 1353 383">No impact in this domain</td></tr> <tr> <td data-bbox="240 383 539 427">Domain 2</td><td data-bbox="539 383 1353 427">No impact in this domain</td></tr> <tr> <td data-bbox="240 427 539 831">Domain 3</td><td data-bbox="539 427 1353 831"> PZP vaccine stimulates an immune response to the zona pellucida, a glycoprotein layer located on the outer surface of the mammalian oocyte (egg). Fertility is inhibited by prevention of fertilisation of the oocyte by sperm (and there may also be interference with oocyte development). Mares treated with PZP vaccines have a greater incidence of uterine oedema [1]. Immunocontraceptive vaccines could potentially result in immune suppression in future generations since treated females that do breed will have a lower immune response to the vaccine [2]. </td></tr> <tr> <td data-bbox="240 831 539 1234">Domain 4</td><td data-bbox="539 831 1353 1234"> Reproductive behaviours are not affected since endocrine suppression does not occur and oestrus is not suppressed. Although females do not fall pregnant, they continue to cycle and receive attention from stallions. In one study, treated females received 55% more reproductive behaviours from stallions than did control mares [3]. PZP vaccine has little effect on time-budget behaviours (e.g. feeding, resting, moving etc.)[3]. Decreased band fidelity has also been reported among PZP-treated female horses most likely due to the frequent reproductive behaviour [4, 5. However other studies have found no difference between treated and untreated mares in band-changing [6]. </td></tr> <tr> <td data-bbox="240 1234 539 1413">Domain 5</td><td data-bbox="539 1234 1353 1413"> The treated mare could possibly experience distress related to the increase in attention and reproductive behaviour from stallions. The band structure in horses would usually protect mares from high levels of stallion aggression [7], so if band fidelity is decreased, treated females could become even more susceptible to stallion harassment. </td></tr> </table>		Domain 1	No impact in this domain	Domain 2	No impact in this domain	Domain 3	PZP vaccine stimulates an immune response to the zona pellucida, a glycoprotein layer located on the outer surface of the mammalian oocyte (egg). Fertility is inhibited by prevention of fertilisation of the oocyte by sperm (and there may also be interference with oocyte development). Mares treated with PZP vaccines have a greater incidence of uterine oedema [1]. Immunocontraceptive vaccines could potentially result in immune suppression in future generations since treated females that do breed will have a lower immune response to the vaccine [2].	Domain 4	Reproductive behaviours are not affected since endocrine suppression does not occur and oestrus is not suppressed. Although females do not fall pregnant, they continue to cycle and receive attention from stallions. In one study, treated females received 55% more reproductive behaviours from stallions than did control mares [3]. PZP vaccine has little effect on time-budget behaviours (e.g. feeding, resting, moving etc.)[3]. Decreased band fidelity has also been reported among PZP-treated female horses most likely due to the frequent reproductive behaviour [4, 5. However other studies have found no difference between treated and untreated mares in band-changing [6].	Domain 5	The treated mare could possibly experience distress related to the increase in attention and reproductive behaviour from stallions. The band structure in horses would usually protect mares from high levels of stallion aggression [7], so if band fidelity is decreased, treated females could become even more susceptible to stallion harassment.
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PART B: Not performed – non-lethal method

Comments:

PZP vaccines cause females to have an extended breeding season, which in turn requires males to defend females longer. This could have a considerable impact on the well-being and body condition of stallions.

Debilitating long-term effects have not been observed in any species of wildlife treated with PZP. In the case of wild horses, long-term effects (15–20 years) of treatment include a significant improvement in body condition, significantly increased longevity and decreased mortality. These positive long-term effects are thought to be due to the decrease in physiological costs of pregnancy and lactation rather than a direct physiological effect of treatment [8].

It is important to note that fertility control is not a useful tool for reducing population size, but can be effective for preventing population growth. Treating horses with fertility control will not have any effect on existing levels of impact by horses, but will potentially prevent escalation of impacts by limiting population growth. Reduction of population size must be achieved by another method.

The most effective strategy for reducing the population growth rate involves a combination of removal and fertility control [9].

Bibliography

1. Killian, G., Thain, D., Diehl, N. K., Rhyan, J., & Miller, L. (2008). Four-year contraception rates of mares treated with single-injection porcine zona pellucida and GnRH vaccines and intrauterine devices. *Wildlife Research*, 35(6), 531–539.
2. Gray, M. E., & Cameron, E. Z. (2010). Does contraceptive treatment in wildlife result in side effects? A review of quantitative and anecdotal evidence. *Reproduction (Cambridge, England)*, 139(1), 45–55. doi:10.1530/REP-08-0456
3. Ransom, J. I., Cade, B. S., & Hobbs, N. T. (2010). Influences of immunocontraception on time budgets, social behavior, and body condition in feral horses. *Applied Animal Behaviour Science*, 124(1–2), 51–60. doi:10.1016/j.applanim.2010.01.015
4. Madosky, J. M., Rubenstein, D. I., Howard, J. J., & Stuska, S. (2010). The effects of immunocontraception on harem fidelity in a feral horse (*Equus caballus*) population. *Applied Animal Behaviour Science*, 128(1–4), 50–56. doi:10.1016/j.applanim.2010.09.013
5. Nuñez, C. M. V., Adelman, J. S., Mason, C., & Rubenstein, D. I. (2009). Immunocontraception decreases group fidelity in a feral horse population during the non-breeding season. *Applied Animal Behaviour Science*, 117(1–2), 74–83. doi:10.1016/j.applanim.2008.12.001
6. National Research Council. (2013). *Using Science to Improve the BLM Wild Horse and Burro Program: A Way Forward*. Washington, DC.: The National Academies Press. Retrieved from <http://www.nap.edu/catalog/13511/using-science-to-improve-the-blm-wild-horse-and-burro-program>
7. Cameron, E. Z., Setsaas, T. H., & Linklater, W. L. (2009). Social bonds between unrelated females increase reproductive success in feral horses. *Proceedings of the National Academy of Sciences of the United States of America*, 106(33), 13850–13853. doi:10.1073/pnas.0900639106
8. Kirkpatrick, J. F., Rowan, A., Lamberski, N., Wallace, R., Frank, K., & Lyda, R. (2009). The practical side of immunocontraception: zona proteins and wildlife. *Journal of Reproductive Immunology*, 83(1–2), 151–157. doi:10.1016/j.jri.2009.06.257
9. Cameron, E. Z., Linklater, W. L., Minot, E. O., & Stafford, K. J. (2001). *Population Dynamics 1994–98, and Management of Kaimanawa Wild Horses*. New Zealand Department of Conservation - DOC Science Publishing. Retrieved from <http://www.doc.govt.nz/upload/documents/science-and-technical/sfc171.pdf>

Control method: Fencing to exclude wild horses

Assumptions:

- Currently there is no standard operating procedure for the use of this method.
- Fencing is used on a small scale to strategically exclude horses from specific areas (i.e. sensitive areas, usually with threatened or endangered species or communities) and is not used to specifically prevent access to food or water.
- Standard cattle fencing with straight plain wire (not barbed) is used. This type of fencing has the least impact on non-target animals as many species of native fauna can go through it.

PART A: assessment of overall welfare impact

DOMAIN 1 Water or food restriction, malnutrition					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 2 Environmental challenge					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 3 Disease, injury, functional impairment					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 4 Behavioural or interactive restriction					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	
DOMAIN 5 Anxiety, fear, pain, distress, thirst, hunger					
No impact	Mild impact	Moderate impact	Severe impact	Extreme impact	

↓

Overall impact
Mild

DURATION OF IMPACT				
Immediate to seconds	Minutes	Hours	Days	Weeks

SCORE FOR PART A:	5
Summary of evidence:	
Domain 1	There could potentially be some restriction of horses from preferred grazing or watering sites, but once they have adjusted to the fence they will find new areas.
Domain 2	No impact in this domain.
Domain 3	Horses will put pressure on the fences if resources they desire are on the other side. This could result in some minor injuries. They may also be injured more seriously if they run into the fence if they become spooked (e.g. during a thunderstorm) and have forgotten that the fence is there.
Domain 4	Fencing will restrict or change some behaviour patterns that the horses are accustomed to performing. It may also break up groups of horses that previously associated together. These impacts will lessen once they become acclimated to the fence.
Domain 5	No impact this domain.

PART B: Not performed – non-lethal method

Comments:
The welfare impacts of fencing to exclude wild horses are likely to be minimised if alternative sources of food and water are located in accessible areas where the horses are known to frequent and they adapt to these new sources quickly.