Submission No 136

INQUIRY INTO PROPOSED AERIAL SHOOTING OF BRUMBIES IN KOSCIUSZKO NATIONAL PARK

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Inquiry into the proposed aerial shooting of brumbies in Kosciuszko National Park

by the Animal Welfare Committee in the NSW Legislative Council

Submission from Don Fletcher PhD, PSM
4 October 2023

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Contents

INTRODUCTION

Thank you for the opportunity to comment on the terms of reference for your inquiry into the proposed aerial shooting of brumbies in Kosciuszko National Park (KNP).

I have commented on each of the terms of reference stated on your web page, after first explaining the units, abbreviations, terms and scientific units that I have used.

My ecological and animal welfare qualifications and experience are summarised in Appendix 1.

Abbreviations

AANP	Australian Alps National Parks. A group of eight national parks and four other reserves managed co-operatively under an agreement between the governments of New South Wales (NSW), Victoria (Vic) and the Australian Capital Territory (ACT). The Alpine National Park (Vic) is one of the eight national parks, whose name has potential to be confused with the AANP.
AALC	Australian Alps Liaison Committee. Coordinates the management of the AANP
ACT	Australian Capital Territory
CI	Confidence Interval
h	hour
ha	hectare
HLTDS	Helicopter Line Transect Distance Sampling. A method of estimating abundance of wildlife
HMR	Helicopter Mark Resight. A method of estimating abundance of wildlife
km	kilometre
KNP	Kosciuszko National Park. The largest of the AANP, which contains the highest elevation parts of the AANP and holds well over two thirds of the wild horse population (Cairns 2019).
MRDS	Mark Resight Distance Sampling. A superior method of estimating abundance of wildlife
NHMRC	National Health and Medical Research Council
NPWS	National Parks and Wildlife Service (NSW)
NSW	New South Wales
PGR	population growth rate
RAAF	Royal Australian Air Force
SE	Standard Error
TOR	Term of Reference for this inquiry
Vic	Victoria
WHHI	Wild Horse Helicopter Index. Helicopter counts of all horses seen in a defined area. Also see Terminology.

Units

I have used International System Units (SI Units), so, e.g., km^2 means square kilometre and km^{-2} means per square kilometre. For example 100 horses km^{-2} means 100 horses per square kilometre = 1 horse ha^{-1}.

Terminology

Absolute abundance refers to the total number of animals of a species in an area, either as a density (number/unit area, e.g. wild horses km^{-2}), or as a population estimate (Caughley 1977; Krebs 2001). Estimates of absolute abundance are more expensive to obtain than indexes of abundance because both the seen and unseen components of the population need to be counted.

An **index of abundance**, also known as relative abundance, is a number obtained by a repeatable wildlife survey, which increases and decreases in proportion to population size (Caughley 1977; Krebs 2001). An example could be the number of rabbits seen in the beam of a 100 Watt spotlight from the tray of a vehicle driven at 5 km h^{-1} along a particular stretch of road starting 1 h after sunset on still moonless nights, if it is repeated over time. This would be an index of rabbit abundance. Not all rabbits along the road are seen, due to some being underground, or hidden in shadows and behind obstacles etc. However if the index is proportional to the unknown true population size, it provides all that is needed for most management purposes (Caughley 1977, Krebs 2001).

The animals involved most directly are variously referred to as **'brumbies', 'feral horses', and 'wild horses'** (*Equus caballus*). The term 'feral horses' is the most correct of the three terms according to Berman *et al*. (2023) but is regarded by brumby advocates as biased against the retention of horses. The term 'brumbies' is widely regarded as biased in favour of the protection of horses irrespective of their conservation impact. Therefore in this document I have used the least loaded term 'wild horses'.

Rather than referring to 'aerial shooting' I prefer '**helicopter shooting**' which is more descriptive of what is involved. 'Aerial shooting' has greater potential to be confused with either the use of fixed wing aircraft or with the shooting from aircraft of animals in the air, as used e.g. in New Zealand to control black swans.

I use the **central value of abundance estimates** in preference to the recent trend among people commenting on wild horse abundance to state only the 95% confidence bounds. It is statistically more likely that the true estimate is closer to the centre of the confidence interval than to its extremes. For example, I state the latest count as 18,814 (or ~19,000) in preference to stating it as '14,501 to 23,535'. Of course the best statement is to include both, i.e. 18,814 (95% CI: 14,501-23,535) or 18,814 (SE: 16,613-21,222)

'**Wildlife'** refers to both native and introduced species living in a non-captive state. 'Wildlife' is sometimes used to include introduced (i.e. non-indigenous) species, and sometimes to exclude them, but I am using the term in its broader sense, similar to the National Parks and Wildlife Act 1974 (NSW).

'Animal welfare' requires the minimisation of animal suffering caused directly or indirectly by humans. Animal welfare laws restrict their definition of 'animal' to vertebrates and usually also cephalopods and larger species of crustaceans.

RESPONSES TO THE TERMS OF REFERENCE

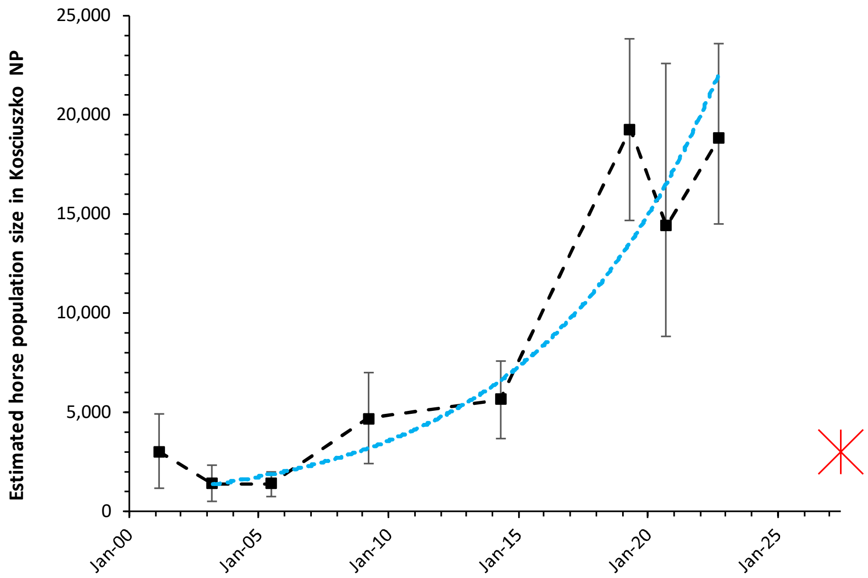
(a) the methodology used to survey and estimate the brumby population in Kosciuszko National Park

Scientists have made five estimates of the absolute abundance of wild horse populations in the AANP, three in KNP and one in a part of KNP. The first estimate was made in 1989 (Dyring 1990) in southern KNP. The other eight estimates since 2001 all used the same method, Helicopter Line Transect Distance Sampling (HLTDS) (Figure 1) and all included KNP. The reports of each HLTDS survey are listed in Appendix 2, which shows where the reports may be found, and how the estimates for KNP were calculated from the five AANP surveys.

These eight estimates are the only scientifically acceptable estimates of the number of horses in KNP, for reasons given below. Also they can be regarded as an appropriate basis for horse population management in KNP, again for reasons given below. Also see the comment below about the need for additional surveys and more than one type of survey at later stages.

The eight HLTDS surveys over the past 22 years have been conducted by a number of different scientists from independent universities and the National Parks and Wildlife Service (NPWS). Until recently, most of the counts were funded by the Australian Alps Liaison Committee (AALC) which is the committee for coordination of the AANP. Some of the more recent counts (including in 2014, 2020 and 2022) are of KNP alone and were funded by NSW.

Figure 1: The eight estimates of the wild horse population in KNP since 2001 (squares) were accompanied by wide 95% confidence intervals (error bars). Overall there has been a consistent trend of 15% annual increase since the 2003 bushfire (dashed blue curve), except around the time of the 2020 bushfire. The red star marks the commencement of the legal requirement for there to be only 3,000 horses from 30/6/27.



Collectively the set of eight horse counts has provided a highly plausible result because they consistently show an average annual increase of 15% except when the horse population was reduced by the bushfires of 2003 and 2020 (Figure 1).

Scepticism about the population estimates

The controversy over management of wild horses in the AANP shares features with most other wildlife management controversies. In particular, it is almost always the case with wildlife controversies that scientists' population estimates are disputed. Most or all of those who dispute the counts have no qualifications or experience in the estimation of wildlife abundance and have undertaken no serious study of this topic. There are similarities to a large number of other disagreements that involve scientists on one side, e.g. ones concerning climate change, the biodiversity crisis, GMOs, vaccination, evolution, astrology, chemtrails, flat earth, homeopathy, crystal healing, divining rods, auras, chakras, qi, and reik.

It is not uncommon for alternative counts to be undertaken in the hope of 'proving' the official counts to be wrong. Then the disparity between the scientific results and the alternative counts-is often striking. For example, in one case I was able to take a photo showing more animals than the entire population according to the alternative count. In another case, researchers ear tagged more female animals in a few weeks than the entire population according to the alternative count. In a third example, ten alternative counts of kangaroos were considered sufficiently reliable by their instigators that they submitted them as evidence in a court case which they had initiated to stop a culling program. Clearly they thought their estimates were plausible. Across the ten reserves, the disparity between the alternative and official count totals was more than 7-fold (Table 1). In this case no science was needed to begin to see flaws in the alternative counts. For example there was a lookout in one of the reserves where, every afternoon it was possible to see many more kangaroos than the total alternative count. And after the court case, more kangaroos were culled in two of the reserves, Callum Brae and Goorooyarroo, than the alternative count of the entire population in each reserve, nine times as many in one case, even though the culling retained a residual density of 1 kangaroo ha^{-1}. Also the total number of kangaroos culled in all reserves was greater than the alternative count even though culling occurred in only four areas of the ten counted.

Table 1: Evidence presented in court by opposing sides: Alternative Counts of eastern grey kangaroos, Official counts using recognised scientific methods and Number culled, on ten ACT sites.

Site Name	Alternative counts (Litigant)	Official counts (Defendant)	No. Culled
Callum Brae	**66**	288	**94**
Crace	54	140	0
Farrer Ridge	70	530	0
Goorooyarroo	**80**	1145	**725**
Kama	49	200	27
Mt Majura	80	594	0
Mt Painter	85	432	0
Mulligans Flat	84	330	78
Pinnacle	114	677	0
Wanniassa Hills	110	1685	0
TOTAL	**792**	**6021**	**924**

Alternative counts of wild horses in KNP conform to the same pattern, having produced figures 9 to 26 times less than the official counts. How can such a gulf of disagreement arise?

The disagreement arises for many reasons of which two seem particularly important (but also see the comments about 'hidden motivations' under TOR (i)). One reason is an inability or unwillingness on the part of the count sceptics to imagine there could be more animals than they can see. In reality the unseen component of populations is ubiquitous and is often large. The text relating to Figure 4 explains the statistical evidence that even kangaroos standing upright in open grassy communities are not all seen by even experienced observers in good sighting conditions, beyond 30m from the transect line. Yet it may be extraordinarily difficult to persuade some people that they are seeing only a fraction of the animals present. The second important factor is the extent of understanding of sampling. Ecologists sample populations of plants and animals routinely. It is rare for an ecologist to be able to see or directly count every individual fungus in the forest, every hydatid tapeworm inside a fox population, every African love grass plant on a roadside, or every wildebeest in the Serengeti, etc. Sampling design is thus a central element of all ecological surveys. It takes training and supervised practice to design sampling methods that can be used in the field but they are part of everyday practice for most ecologists. However, sampling is not necessarily such an accepted practice with all non-ecologists.

In some wildlife controversies, a person emerges who is sympathetic to the cause of the count sceptics and appears to them to have high-level qualifications. In the case of wild horses in KNP, Mrs Claire Galea is an example. I refer to her report *'Independent biostatistical report on the Brumby population in the Kosciuszko National Park'* in a separate section headed '*Criticism by Claire Galea of the 2014, 2019 and 2022 HLTDS counts*'.

Synopsis of the HLTDS method

HLTDS was the method used for all eight surveys. In the name 'Helicopter Line Transect Distance Sampling', the words 'line transect' refer to the straight lines along which the horses are observed. These transects are parallel east-west lines, except in two cases over the 22 years where a different direction was used in small steep areas, due to the safety profile of the helicopter available at the time. Within a survey block, the lines are equidistant (e.g. Figure 2) so this design is referred to as a 'systematic' layout. Each set of transects has a randomly chosen starting point, hence the design is sometimes referred to as 'systematic random' (*e.g.* Cairns 2022).

'Distance Sampling' refers to the analytic method used for statistical analysis of the data, typically using the program '*Distance*' or an equivalent package in statistical program R. (There are other ecological methods based on transect lines which are not distance sampling and there are other examples of distance sampling which are not from lines or which are not done from helicopters).

The Distance Sampling method (Thomas *et al.* 2010 and https://distancesampling.org/whatisds.html#online-bibliography) is one of the most widely used methods in the world for estimating abundance of wildlife populations. Its mathematical and statistical foundation is comprehensively explained in two books, particularly Buckland *et al.* (2001), and a second book covering more advanced applications (Buckland *et al.* 2004). The results have been evaluated against known populations on numerous occasions and found to be accurate (e.g. Hone 1988; Hounsome *et al.* 2005; Glass *et al.* 2015). Thousands of published, peer-reviewed scientific papers exemplify its use. More than 1,400 are listed in the bibliography at https://distancesampling.org/dbib.html. Populations of a wide range of species have been counted using Distance Sampling, including insects, crabs, fish, reptiles, antelopes, deer, kangaroos, feral pigs, fruit bats, primates, polar bears, whales, dolphins and mice, as well as inanimate objects such as birds' nests, mammal burrows and carcasses (Buckland *et al.* 2001 p11). There is no reason to doubt the Distance Sampling method itself.

Figure 2: A systematic random sampling design: east-west helicopter transects at 2 km spacing in the Northern Kosciuszko survey block, whose location is shown in Figure 3. Total transect length in this block is 665 km. Orange triangles are tops of hills. Copied from Cairns (2022 Fig 2).

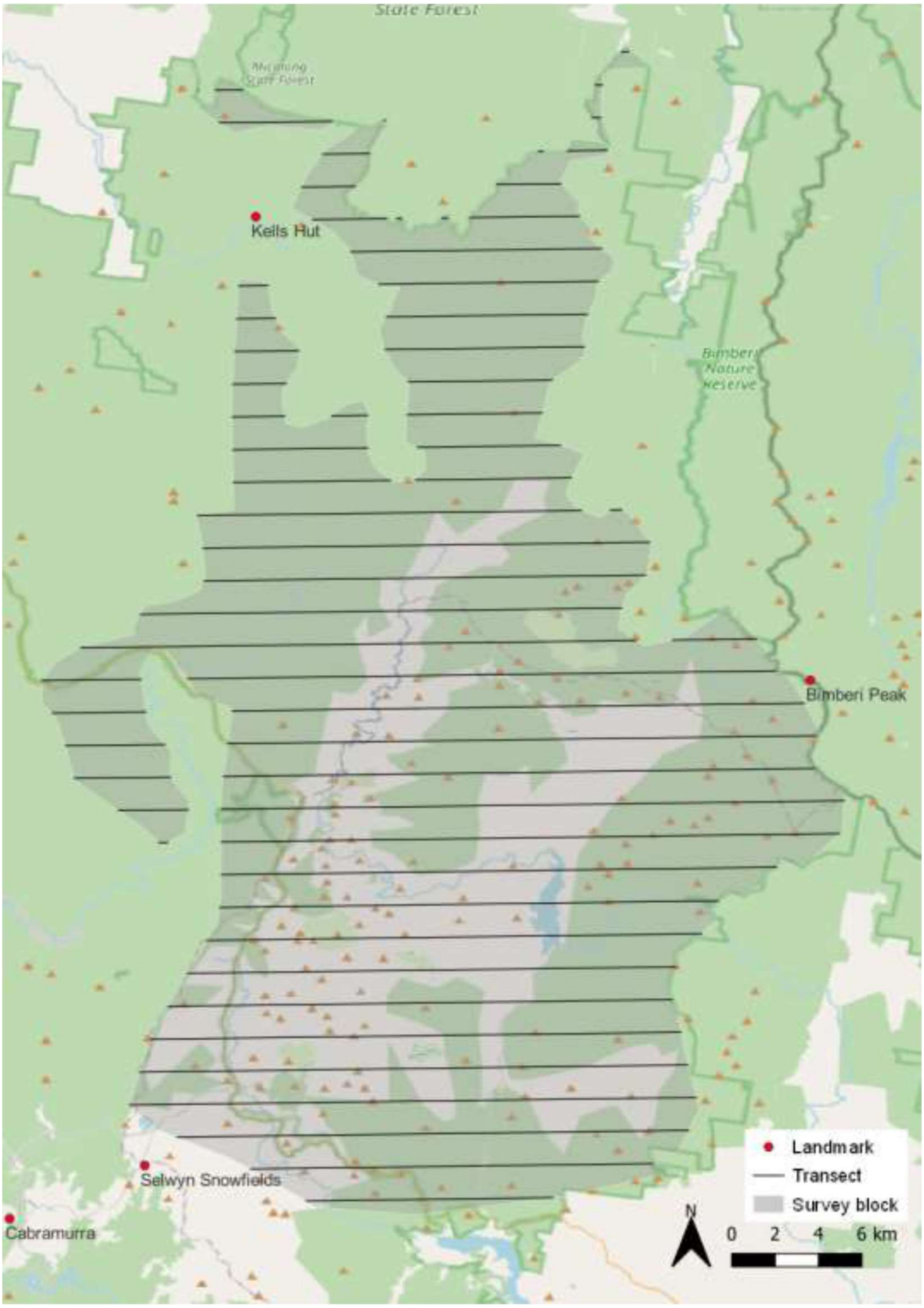
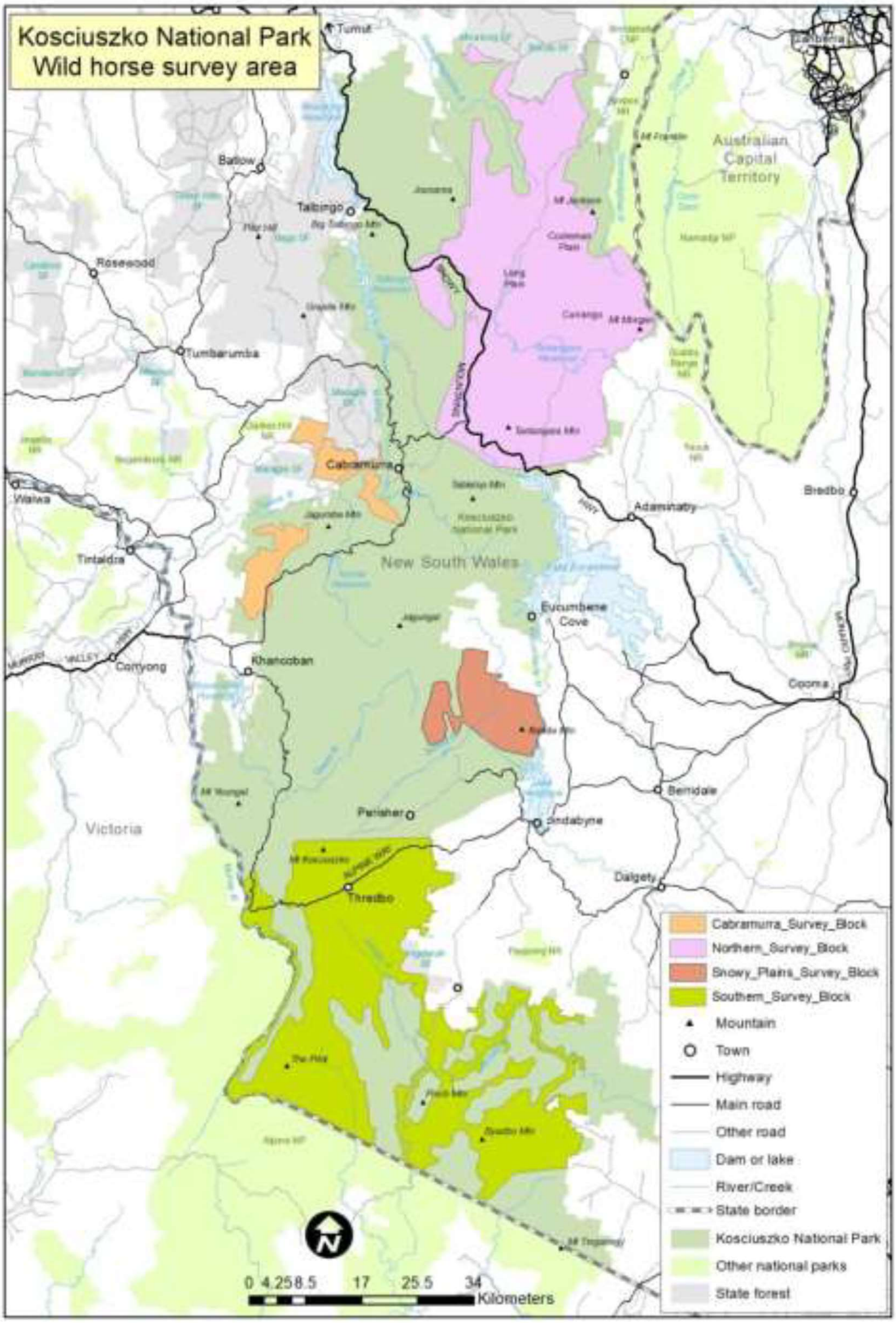


Figure 3: The four wild horse survey blocks in KNP (coloured) with the legend in the lower right corner. The Northern Kosciuszko block is coloured pink. The four blocks total 2,745 sq km in area (i.e. 274, 500 ha), i.e. 1.5 times the area of Sydney (but not as easy to walk or ride across). Copied from Cairns (2022 Fig 1

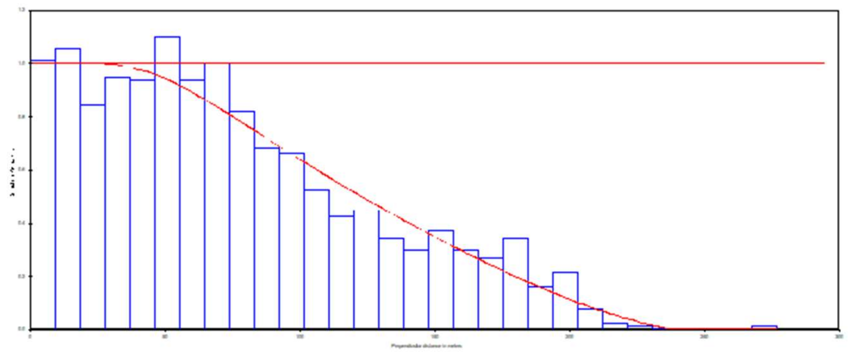


Distance Sampling exploits the fact that on average, an observer detects fewer animals at greater distance. This enables an estimate of how many animals are not seen, in addition to those which are detected and recorded. The method relies heavily on the transect locations being unbiased with respect to animal density. This requirement is well met by the systematic layout of straight east-west transects as illustrated in Figure 2. There is the risk of a biased result if transects are aligned with real features of the landscape, such as roads, ridges, rivers or tree lines.

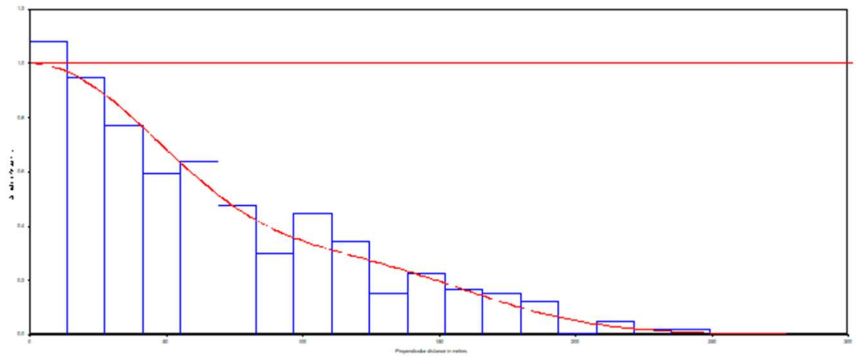
The distance from the transect to the sighted animals is plotted both as a histogram, and as a curved 'detection function'. Figure 4 provides examples from my own work with eastern grey kangaroos (*Macropus giganteus*) in grassland and open woodland at Googong (NSW) and illustrates different detection functions on the same transects in different years due to slightly different sighting conditions. All surveys were conducted within 2 h of first light when all kangaroos are upright and equally visible. Walking speed was slowed down to 1 km h^{-1}. Figure 4(a) represents near perfect sighting conditions, and the horizontal part of the red curve indicates that all kangaroos were seen from 0 m out to 30 m from the transect. Note that even in these ideal circumstances, a proportion of kangaroos was missed at all distances beyond 30 m. Most people are surprised to learn that experienced wildlife observers operating in ideal sighting conditions are not seeing every kangaroo that is standing upright within at least 150m from the transect.

Figure 4: Two different detection functions for the same species seen from the same transects in different years: bars indicate the proportion of clusters of kangaroos recorded at particular distances from the transects; and red curves are the equations that best describe the shapes of these relationships, (a) a hazard rate equation and (b) a half normal equation with cosine adjustment. Because the transect lines are on a systematic random pattern, it can be safely assumed that on average there will be, in reality, an equal number of clusters at all distances from the transect line. Therefore the area below the red curve represents the proportion of animals that were seen by the observer and the area between the red curve and the horizontal red line represents the proportion of animals not seen.

(a)



(b)



Six other horse count methods used in KNP as well as HLTDS

Three methods for estimating absolute abundance of wild horses using a helicopter were compared for future use in the AANP by Walter and Hone (2003), who recommended the **HLTDS** method.

Later Dawson and Miller (2007) evaluated conventional mark-resight analysis for isolated small populations. They recorded 50 horses in a 180 sq km area of the Bogong High Plains when they searched it by helicopter one day, flying 220 km along concentric transects during the search. The next day they repeated the search over the same area and recorded 78 individual horses. They analysed the data using four mark-resight analytic methods. The principle that underlies mark-resight methods is the well known Petersen-Lincoln estimator in which essentially:

$$N = S1 * S2/M2$$

Where N = the size of the population to be estimated; S1 and S2 are the numbers of individuals seen on the first and second surveys; and M2 is the number of individuals seen in both surveys. The population size was estimated by the four different methods to be 89 to 95 horses (so 23% to 32% of horses were never seen on either day). I refer to this method as Helicopter Mark Resight (**HMR**). With HMR it is necessary to video and carefully describe the horses, not necessarily an easy task. Dawson and Miller (2007) regarded the method as having potential only for small, isolated populations. The recognition of individual animals from images is rapidly becoming less difficult due to machine learning programs and ever faster computers however it is not yet advanced enough or widely available enough to solve this problem for thousands of horses.

Later, researchers in other countries developed the Mark Recapture Distance Sampling (MRDS) engine in the Distance computer program. It includes a mathematical way to combine line transect distance sampling analysis as used in conventional HLTDS with mark-resight analysis. Two observers are seated on the same side of the helicopter one behind the other. Animals recorded onto a multi-channel voice recorder by the front observer are considered the 'marked' sample. Those also recorded onto another channel by the rear observer (who is unaware what the front observer recorded) are deemed to be the 'recaptured' animals. Those animals seen only by the rear observer are considered 'new captures'. Dawson and Hone worked with one of the developers of the method to evaluate if for feral horses in KNP and found the combined method to be superior to all others (Laake *et al*. 2008). It overcame the tendency of HLTDS to underestimate. This method is referred to as Mark Resight Distance Sampling (**MRDS**).

However a new safety requirement was later introduced which required an independent safety observer to be seated in the front beside the pilot. Thus the seating required for MRDS was impossible in the types of helicopters readily available for counting. Subsequent counts were done with HLTDS. To meet the future need for more accurate surveys in smaller areas (including every retention area) a way should be found to re-commence using MRDS. I understand that the problem is being solved for kangaroo counting, therefore it should be applied to horse counts also.

Neither of the two remaining survey methods meet standard requirements for estimates of absolute abundance. This includes the annual helicopter surveys by NPWS staff which count all horses seen in the northern plains of KNP. Although this 'Wild Horse Helicopter Index' (**WHHI**) does not provide an estimate of absolute abundance it does provide a valid and useful index of relative abundance, at reasonable efficiency, and could potentially become a useful supplement to MRDS surveys.

Informal horseback counts have been carried out at various times by different individuals or groups of people on a once-only basis, but not to any consistent pattern, and not based on advice from professional ecologists. They covered only a small proportion of the area occupied by horses and the procedures were not clearly defined to enable easy repetition. Therefore the informal horseback counts carried out to date have had almost no evidentiary value.

Emerging technology for counting wildlife

Many count sceptics assert that drones (remotely piloted aircraft) provide a better way to count wildlife than whatever method is currently in use for the species of interest. Use of thermal cameras is also commonly advocated. Recent success with koalas is sometimes cited as an example. Again, the pattern is common to other wildlife controversies, but in this case such claims could be correct, for certain species and habitats.

The proof of a pudding is in its eating. In other words, what is needed before switching to any new count method is evidence published in a recognised ecology journal that the new method has produced population estimates that are less biased and more precise than established methods <u>for the relevant species and habitat</u>. A quick literature survey shows that drones (usually with thermal cameras) have proved successful in estimating the abundance of animals that inhabit open habitats or treetops, such as jellyfish, penguins, oran utans and koalas (e.g. Rowe *et al*. 2021). In all these cases, the areas searched were many times smaller than the horse counting blocks in KNP. A good example is the successful estimation of the size of a colony of Grey Headed Flying Foxes (McCarthy *et al*. 2021), a species that is exceptionally difficult to count by other methods, but which lives in tree top colonies that each occupy a small area.

Regarding large animals that live partly under trees such as deer, kangaroos and horses, the state of development, as indicated by the most recently published papers, could be summarised as '*promising, but needing more work and better technology to cover larger areas and see better through the tree canopy*'.

For instance, Beaver *et al*. (2020) used a captive deer population of known size in an enclosure of area 0.17 km^{-2} to test thermal drones flown at first and last light. On average, the deer population estimated from morning flights was 78% and that from evening flights was 92% of the true value, a promising result.

This year, Baldwin *et al*. (2023), working together with Beaver, successfully used a fixed wing drone to estimate the number of white tailed deer in a natural area of 10.24 km^{-2}. Also this year, Brack *et al*. (2023) used a drone of only 2 m wingspan and a thermal camera to estimate the abundance of swamp deer in open areas of a 203 km^2 section of the Sesc Pantanal Reserve, Brazil. Brack *et al*. (2023) recorded 66 deer from which they estimated a population of 1,856 (95%CI 951-3710) swamp deer for the reserve.

In all examples there was incomplete detection of the target species (McCarthy *et al*. 2021; Beaver *et al*. 2020; Baldwin *et al*. 2023; Brack *et al*. 2023). The potential attraction of a drone over HLTDS is that the method could be cheaper. There is no reason to suppose a drone would provide a better result. Whether surveys using drones provide better or worse estimates of the feral horse population than the HLTDS surveys needs to be determined with field trials.

None of these examples dealt with large areas comparable to what is needed at KNP and only Baldwin *et al*. (2023) worked with animals in wooded areas. Also note that in Australia, non-military drone pilot licences do not permit the flying undertaken in the 203 km^2 area surveyed by Brack *et al*. (2023) in which the drone was flown up to 20 km beyond the visual range of the pilot.

Suitable drone and camera technology to do the job at KNP has existed in Australia for more than a decade, e.g. the RAAF-operated Heron aircraft has more than sufficient flying capacity and imaging ability to estimate the population of horses across the entire AANP. However at this stage in Australia, drones with the necessary flying duration capability, and image resolution, required to estimate animal populations at the scale of KNP are mainly restricted to the military forces. Also, if the drone is larger than the helicopters used for the HLTDS (e.g. a Heron has a 50 m wingspan), costs far more to operate, and is far more challenging to operate, it is hard to see what advantage it provides over HLTDS.

Thermal imaging capability continues to become available in smaller cameras and both drone and thermal capabilities continue to move from military-only into the public domain, so it seems likely that the capacity to survey the KNP horse population using medium-sized fixed wing drones will become available in the future, especially if military support for the program can be obtained.

Criticism by Ms Claire Galea of the 2014, 2019 and 2022 HLTDS counts

A report titled *'Independent biostatistical report on the Brumby population in the Kosciuszko National Park'* dated 20 May 2023, referred to hereafter as Galea (2023), seeks to discredit the 2014, 2019 and 2022 HLTDS counts, and the Distance Sampling method generally, and recommends the cessation of horse control. The omission of the 2020 count report from Galea's criticism was probably just an oversight, and not because Galea approved of the 2020 count.

I have prepared a detailed review of Galea (2023), which is copied here as Appendix 3. It is important to recognise that neither Galea (2023), nor my response to it, have yet been subject to the normal quality control mechanisms of science such as editorial oversight and the anonymous peer review associated with publication in a scientific journal.

My review concludes that Galea (2023), '*is not a credible scientific document. Many of its assertions prove on closer inspection to be mistaken, based on a misreading of the reports being criticized, or based on a misunderstanding of ecological methods. In several cases, criticisms are repeated under a different title, creating a false impression of the number of problems found.*

'The criticisms of Helicopter Line Transect Distance Sampling to estimate the population abundance of feral horses in KNP are not supported by either evidence, such as references to scientific literature comparing superior alternative methods, or by published results of alternative counts in KNP using well understood methods of abundance estimation that are recognised in the scientific literature. No data are provided. There are very few references to the vast ecological literature on wildlife counting.

'There is already an established body of scientifically credible material available on the counting of the feral horse population in Kosciuszko National Park (Walter 2003; Walter and Hone 2003; Montague-Drake 2005; Laake et al 2008; Dawson 2009; Dawson and Hone 2012; Cairns 2019, 2020, 2022). Galea (2023) adds nothing either credible, or valuable, to this subject.'

Further, Galea (2023) provides no way forward; which is a critical deficiency because of the legal, ethical and ecological imperatives for horse population control (see below), and the dependency of control on counting. No wildlife population estimation method can be perfect so unless some alternative or some improvement can be identified, it is fruitless to focus much attention on deficiencies. Galea (2023) simply states (p. 12) that because of (claimed) deficiencies, distance sampling is '*not appropriate methodology for estimating wild horse populations*'. Galea (2023) does not either name any other survey method which might be superior or outline how an alternative population estimation method to HLTDS could be deployed. (Note that in some parts of KNP even helicopter counting is challenging, due to the terrain and vegetation.)

Many of the issues I identifed with Galea (2023) are of a statistical or semi-statistical nature. However at least five major errors are simple matters of scholarship, plainly evident to any reader of both Galea (2023) and the documents it attacks (Cairns 2019, 2022). For example, Galea claims there are no counts of foals (Galea 2023, p17). Yet the foal counts are obvious in the 2022 report. They are mentioned in both the Summary and the Methods, and dealt with at greater length in the 'Results and Discussion' (Cairns 2022). In total they occupy more than two pages of the 34 page report. Another example of poor scholarship includes misleading use of quotations from Cairns (2022) about co-variates. The quotations are misleading because critical words are omitted which answer the criticism that the quotations are used by Galea to demonstrate (see Appendix 3 'B3 - Use of covariates'). There are other examples of such errors in sections 'B1 – Statistical modelling', 'B2 Transformation of the data', and 'B4 - Assumptions' of Galea 2023 (all detailed in Appendix 3). Aside from the statistical issues, I would be surprised if an ecology journal that deals with wildlife abundance estimation methods would publish a paper containing such blatant errors of scholarship as these.

I have re-used some of the text from my review of Galea 2023 in the body of this submission. I apologise for the resulting repetition between the body of this submission and Appendix 3.

In ecology all targets are moving

The statutory requirement is for reduction to a population of 3,000. But a population is like a pool in a river, with constant inflow and outflow. Before the population size (pool depth) can begin to be reduced, the removal rate must at least match the inflow. Thereafter, any artificial reduction in population size (pool depth) is temporary. The greater the rate of inflow, the shorter the duration of the reduction. Frequent maintenance is essential. A graphical example is provided under the heading '*The influence of population dynamics on animal welfare*' in TOR (i).

More frequent counts will be desirable during the final approach to the target

With the requirement to reduce the wild horse population from ~19,000 to ~3,000 by 30/6/27 the focus now must be on implementing an efficient method, rather than on refining the counting. However that will change after the population is below 5,000. More counting and at finer scale will be needed to hit the target.

The pattern of counting carried out so far is not appropriate for the finer resolution that will be needed in future. (The AALC paid for a survey every five years to estimate the horse population of the AANP [but six years from 2003-2009]. An additional survey was flown after the 2003 bush fire, resulting in surveys in 2001, 2003, 2009, 2014 and 2019. NSW paid for a survey of KNP plus adjacent state forest in 2005. Also NPWS conducted a survey of KNP following the 2019/20 bush fire and most recently another survey of KNP in 2022.)

I recommend a review involving external experts to develop a monitoring plan to be commenced after the estimated wild horse population of Kosciuszko is reduced to 5,000. The planned actions would reasonably include a change from HLTDS to MRDS and separate counts for each Retention Area and Removal Area

continuation of HLTDS, but at yearly frequency, not five-yearly, with the additional support of HMR or WHHI counts within each Retention Area and each Exclusion Area, whenever required, but at least annually. As far as possible, the HMR / WHHI counts should be in a different season to the shooting operations even though they will be the principal guide for the shooting.

Conclusion to term of reference (a)

Eight scientific estimates of horse abundance in KNP since 2001 are credible, and were the best that could be provided within a reasonable budget. The HLTDS method used to estimate the wild horse population in Kosciuszko National Park should preferably be replaced with MRDS, with the frequency increased to annual.

Criticism of the scientific estimates of feral horse abundance are no more than the normal criticisms which accompany nearly all wildlife controversies, including the unpublished comments by Claire Galea. Attempts to conduct alternative counts are also not unprecedented.

As the target population of 3,000 wild horses in KNP is approached, new counts will be needed to assist in achieving and maintaining the set number of wild horses in each retention area (and zero horses in removal areas). A review is recommended before then, involving external experts in the estimation of wildlife abundance, to make a plan for the required counting. As an interim suggestion, to be replaced by the result of the review if carried out, MRDS counts of each retention area and removal area should be conducted whenever needed to support the control operation, but at least annually. If necessary the WHHI method could also be used if problems emerge with MRDS in small areas.

(b) the justification for proposed aerial shooting, giving consideration to urgency and the accuracy of the estimated brumby population in Kosciuszko National Park;

For legal and ecological reasons there is no option other than swift reduction of horse population size. The NSW *Kosciuszko Wild Horse Heritage Act* (2018) requires a horse management plan which recognises and protects wild horse heritage values in KNP and enables active management of the wild horse population to reduce its impact on the park's fragile environment. Consequently, the Minister for Energy and Environment adopted the Kosciuszko National Park Wild Horse Heritage Management Plan (the Horse Plan) on 24 November 2021. The Horse Plan, a binding legal instrument, requires the current horse population to be reduced to 3,000 by 30 June 2027.

A further requirement for horse population management has been established by the listing of *'habitat degradation and loss by feral horses'* as a Key Threatening Process in Schedule 4 of the NSW *Biodiversity Conservation Act* (2016). The NSW government is thereby required to ameliorate the biodiversity threat where possible.

It has been plainly evident for years to anyone who took an interest in the counts, that the population was increasing exponentially. As well as increased abundance, also it is a common observation that the distribution of wild horses has been expanding (e.g. Dawson 2009). As a result of the previous counts we know that the wild horse population grew at an annual rate of 15% over the last 20 years (probably unaffected by the NPWS control efforts) and that the population was approximately 19,000 in October 2022 (Cairns 2022). The observed population growth rate means that the number of wild horses in KNP will now be approximately 21,600 in October 2023. The next annual increment of growth to October 2024 will be ~3,200 taking the total to ~25,000, unless action is commenced in 2024 which is sufficient to prevent this.

The wild horse removal programs have so far been restricted by government policy and are not even keeping up with population growth (left portion of Figure 5). More detailed analysis with free access to all of the data is needed, but it seems likely that the removals were outweighed by compensatory processes. In any case the 15% population growth rate (PGR) includes the removals and the effect of the 2020 bush fire. So possibly the true growth rate is higher. There are now two opposite directions that the population trajectory could take.

One of the future possibilities is a herbivore irruption. The herbivore irruption is a dominant paradigm in the ecology and management of herbivores (e.g., Leopold 1943; Caughley 1970, 1976; McCullough 1997; Forsyth and Caley 2006; Gross *et al*. 2010; Duncan *et al.* 2020; Figure 6). In an irruption, the herbivore population slowly, then rapidly, increases to peak abundance, then crashes to a lower abundance, then increases to a carrying capacity lower than peak abundance. The effect of the herbivore on the vegetation has a comparable pattern, with a ripple of extreme damage following behind the peak of herbivore abundance. However the vegetation does not recover to the same extent. The crash phase (Figure 6) would be an animal welfare disaster, with unimagined numbers of starving horses and carcasses, and it would be an unprecedented disaster for the KNP environment. Once the crash begins, it is unstoppable by any human means. But it appears to me there may still be time and we can cull the horses sufficiently and soon enough to prevent a herbivore irruption. Thus we come to the other alternative.

Figure 5 also illustrates the consequences of applying four alternative annual horse removal rates if the horse population growth rate (PGR) remains at 15% and if it increases to 20%. Culled horse populations in the USA have exhibited 22% PGR for many consecutive years (Eberhardt *et al*. 1982) so I have chosen 20% as a reasonable value for illustrating the effect of increased PGR. If removal continues at the current rate there will be ~36,000 horses on 30/6/27 (with 20% PGR) unless the crash phase of the irruption comes first. To meet its target by 30/6/27, the NSW Government must remove an estimated 6,800 wild horses per year for the remaining four years if PGR remains at 15% and 7,600 per year if it increases to 20% i.e. a total of ~30,500 by 30/6/27. This can also be expressed as the removal of at least 1.9 horses per square kilometre (1.9 horses km^{-2}). (The calculation is based on the statement in the Horse Plan that wild horses occupy 53 % of the 6,900 km^2 KNP, i.e., 3,657 km^2). Therefore, a method is needed which can achieve a mean annual removal rate of at least 1.9 horses km^{-2} over all 3,657 km^2 for four successive years.

It can be argued that the calculation underlying Figure 5 is unduly simplified therefore Figure 5 over-estimates the number to cull to achieve these outcomes, because I have assumed all mortality is compensatory rather than additive, i.e. I omitted any allowance for natural background mortality due to factors such as roadkill, dingo attack, hypothermia, or being trapped in winter snow. In reply, I would argue:

- The sources of mortality that would be independent of culling (eg roadkill) are relatively minor;
- Culled populations are younger, healthier, and fitter and enjoy higher fecundity and survival than pre-culling (Caughley 1983), all these things leading to increased population growth rate, and much of the natural mortality of the unculled population will be replaced by the culling (compensatory);
- Second that careful monitoring of the culled populations should be carried out to enable this calculation to be refined before it matters and also this analysis should be done for each retention area independently; and
- For animal welfare and conservation reasons outlined in TOR (i), it would be better to have erred by over-culling (which can be easily corrected) than by under-culling (which can have irreversible effects).

In the literature on control of large vertebrate pests (e.g. Caughley 1977; Hone 1994, 2007; Williams *et al*. 2001) there are only two classes of methods which have any prospect of achieving the required annual removal rate (see Figure 5) over an area of the required size in KNP (excluding extensive habitat modification such as urbanisation or cropping of the entire national park). The two methods are poison baiting and helicopter shooting. Poison baiting is currently inapplicable for wild horses (SCAAHC 1991) because there is no known combination of humane toxin and delivery method which would be sufficiently target specific. Thus, helicopter shooting is essential, because of the legal, ecological and ethical imperatives.

It is the nature of exponential population growth to seem slow for a long time while the population is relatively small, then to seem to increase rapidly when the population is larger. Thus, the risk to native Australian species of animals and plants has become more acute in the last few years now that the horse population is large, increasing rapidly and invading new areas. It is important to recognise that, as a result, although the first horses entered the area more than 150 years ago, in 2023 many plants and animals in the park will be encountering horses for the first time. Others will be experiencing high levels of horse impact for the first time. Thus, there is potential for horse control to save threatened species populations if the removal rate is of sufficient magnitude to prevent further increase in the abundance and distribution of horses.

The point above partly answers the question from some brumby lobbyists about how horses could be impacting things that they have been sharing KNP with for more than 150 years. The answer is that impact is not only a matter of the presence of horses but also depends on a number of other things including their density (horses km^{-2}) and the length of time that high density has applied. There are now a great many more horses in KNP than at any other time in the 150 years, and they are occupying a greater extent of KNP.

<u>Figure 5: The KNP horse population since 2001, and four future alternatives to 2027</u>. PAST: Eight solid green squares (■) are scientific estimates of horse population size in Kosciuszko National Park from 2001 to 2022, with error bars indicating 95% Confidence Intervals (also see Appendix 2). The blue dashed line (— —) represents 15% annual population growth rate (PGR) since the 2003 bush fire. Gold circles (●) are previous horse removals. **FUTURE**: The effect of 15% PGR (black lines) or 20% (red dashed lines) and four alternative horse removal rates (stated beside each scenario) is represented as the predicted annual horse population estimates in October. Only one scenario (— ■ —) allows the statutory target to be achieved, i.e. 3,000 wild horses on 30 June 2027, obtained by removing ~6,800 horses per year if PGR remains at 15% and ~7,600 per year if PGR increases to 20% in response to population reduction.

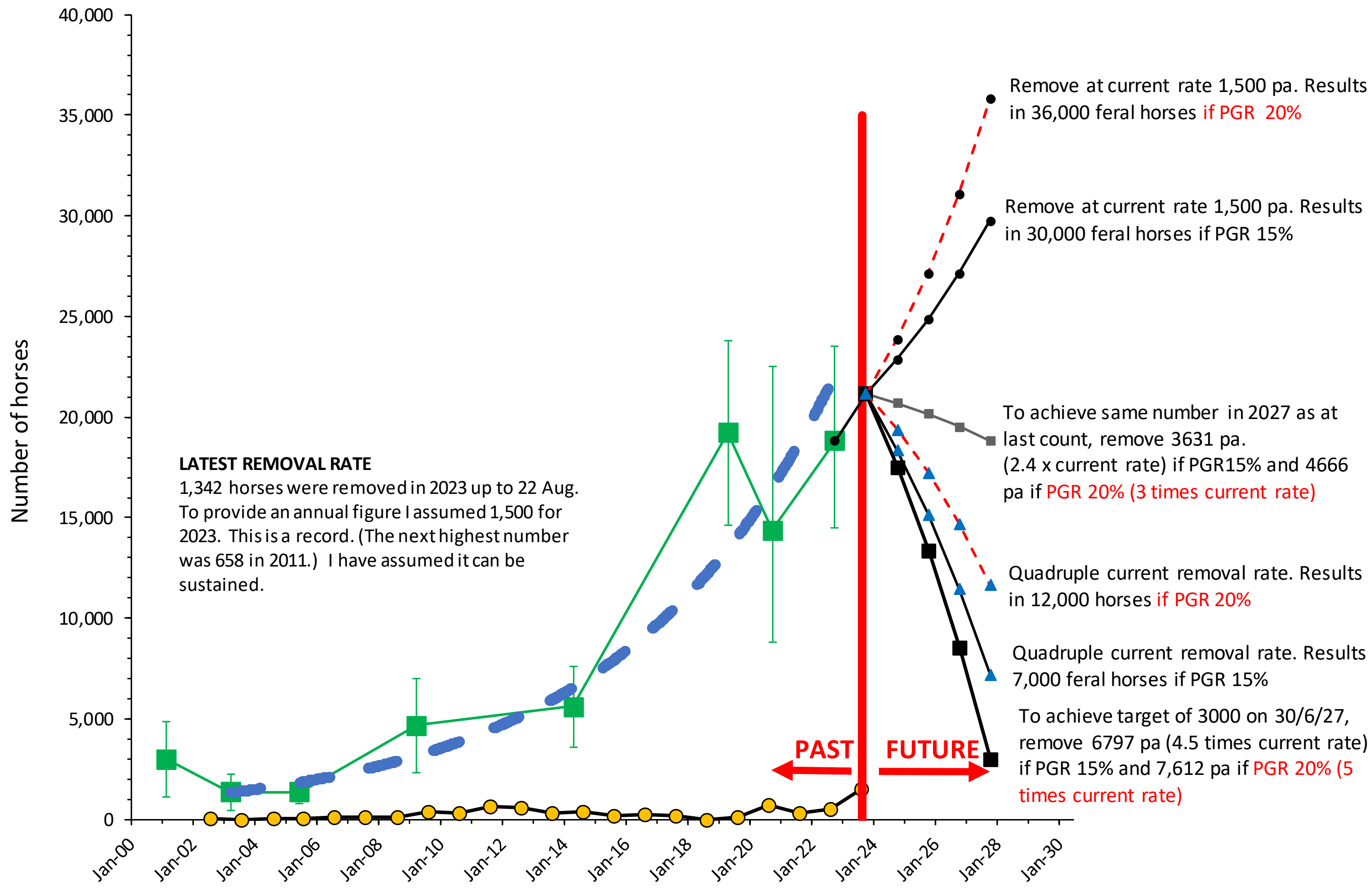


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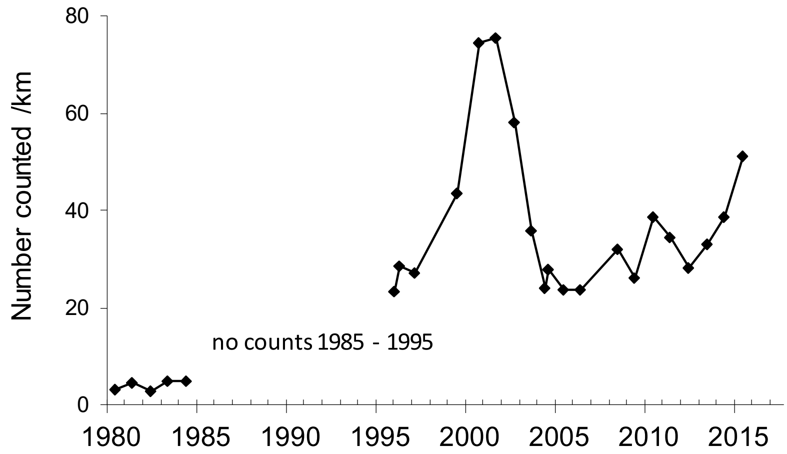
Figure 6: The pattern of a herbivore irruption demonstrated by spotlight counts of Eastern Grey Kangaroos (*Macropus giganteus*) at Googong, NSW, over 35 years following the removal of sheep grazing.



In the high country of NSW, for much of the last 150 years, wild horses were regarded as a pest species until recent decades, e.g. being reported as a pest species 152 years ago in 1871 by the Sydney Morning Herald, then in scientific publications in 1890 and 1932 (Dyring 1990). Legendary botanist Alec Coston warned of the need for horse control to protect biodiversity and water catchment values as long as 69 years ago in 1954. Then in response to a sharp increase in horse abundance during the 1950s, coordinated shooting by graziers anecdotally reduced the population by 50% (Dyring 1990). However it is worth noting that the population in that era was only tens to hundreds. Even by 1989 when the first scientific estimate was made of abundance in part of KNP, there were probably less than 1,000 feral horses in the whole of KNP. Throughout most of the last 70 years, scientists have been pointing to the need to control horse abundance, and how to do it, but getting ignored, including the extensive high quality work by Dawson (see reference list) and again in 2018 with the Kosciuszko Science Accord, signed by a large body of high-country scientists (Driscoll 2019). The problem now, with ~21,600 horses in KNP, may seem immense by comparison with the populations that concerned Costin and Dyring, but it is tiny compared to what it will be in future if ineffective action continues.

Kosciuszko is home to numerous endemic species, a few of which are also among the 15 threatened (EPBC listed) plants, 13 threatened animals and two endangered communities recognised to be directly threatened by wild horses, plus there would be others unrecognised as threatened species (NSW Threatened Species Scientific Committee 2018; Duretto 2019; Australian Threatened Species Scientific Committee 2023). But now it has become worse than a threat, with actual loss of populations having occurred due to horse activity, e.g. populations of the threatened tooarrana *(Mastacomys fuscus)* have been lost (Driscoll *et al.* 2019; Eldridge *et al.* 2019; Schulz *et al.* 2019) most likely through reduction of ground layer vegetation which is essential for this threatened native rodent to persist (Cherubin *et al.* 2019).

Thus, as well as the legal imperatives requiring management of the wild horse population, there are clear ecological imperatives to act. Consequently, there is also an ethical requirement not to allow preventable losses to biodiversity.

National and international studies have found that even low numbers of horses lead to environmental degradation (Driscoll *et al*. 2019n; Eldridge 2020). Therefore, even the reduction to the mandatory target will still leave considerable pressure on KNP's ecosystems. However the reduction to 3,000 is at present the only legal option.

Conclusion to term of reference (b)

Helicopter shooting is the only humane, target specific method that could reduce the current abundance to the statutory target.

(c) the status of, and threats to, endangered species in Kosciuszko National Park;

KNP contains four endangered ecological communities threatened by wild horses, 11 threatened animal species impacted through habitat destruction by wild horses, and 23 threatened plant species likely to be impacted by wild horses (NSW Threatened Species Scientific Committee 2018; Australian Threatened Species Scientific Committee 2023). These are the legally binding determinations by the relevant state and commonwealth ministers. In addition, *'habitat degradation and loss by feral horses'* has been declared as a Key Threatening Process in Schedule 4 of the NSW *Biodiversity Conservation Act* (2016).

Conclusion to term of reference (c)

It has been determined at law that wild horses are a threat to endangered species and communities in KNP.

(d) the history and adequacy of New South Wales laws, policies and programs for the control of wild horse populations, including but not limited to the adequacy of the 'Aerial shooting of feral horses (HOR002) Standard Operating Procedure';

Helicopter shooting operations and training courses are managed in relative secrecy due to death threats and other harassment by animal activists against involved staff and contractors, their partners, and their children. Therefore it can be difficult to obtain a reliable impression about this activity. Public servants have observed that politicians and their staff come and go every few years, whereas their own tenure in their profession is likely to be measured in decades, as is their membership of their community, so common sense makes them cautious.

Best practice Thermally Assisted Helicopter Shooting (TAHS)

Current best practice integrates horse control with the control of other species. For example, all large exotic vertebrates are shot in the same TAHS operation in the ACT, including fallow deer, sambar, feral pigs, wild horses, and feral goats (Pulsford *et al*. 2023, Elford pers comm.). The process starts with an operator inspecting an image on a computer monitor that is fed from a sensitive thermal camera, a GPS, and other equipment mounted on a helicopter. When the operator sees animals of any of the target species, they use verbal instructions and a laser pointer that is collinear with the camera, to help the pilot and shooters find the nearest of the target animals.

Is NPWS likely to be capable of delivering a high-quality program of helicopter shooting?

- I am aware of the high standard of helicopter shooting required and achieved by the *Feral Animal Aerial Shooting Team (FAAST)* training program developed many years ago in the NSW Department of Primary Industry and the NPWS which has involved a growing body of NPWS staff in recent decades (FAAST 2003).

- I am aware that NPWS staff not only perform leadership roles in the FAAST system but also have been involved in ballistics and animal welfare research published in leading international journals (e.g., Hampton *et al*. 2021a, 2021b).
- I also note that the helicopter shooting method is being applied by NPWS in a wide variety of vegetation and terrain across NSW, because the NPWS web page *Feral Animal Aerial Shooting Team (FAAST) training* lists 51 *parks related to this program*, presumably meaning parks where helicopter shooting operations are undertaken. (I suspect this count to be an underestimate because e.g., KNP is not included although numerous helicopter-shooting operations have been undertaken there to target all large vertebrate pests except wild horses). Experience in this wide variety of terrain and vegetation will improve expertise in relation to individual programs, including the required program at KNP.
- I am aware that a wide variety of exotic and native species are being killed in NSW using helicopter shooting, including several deer species, feral pigs, feral goats, native dingoes, and wild horses outside NPWS areas, and I consider this will bring increased expertise to the KNP program.

I have briefly served as an animal welfare observer in a helicopter shooting operation. What I observed was that the pilot successfully matched the speed and direction of movement of the target animal and safely operated the helicopter down to a range of about 20 m on average. (This is extremely close range). All first shots appeared to me to be kill shots but with the (mandatory) semi-automatic firearm it was easy for the shooter to place additional shots into the animals.

I regarded the helicopter shooting I witnessed as more humane than most other approved pest animal control methods I had experienced in regular use, including:

For feral pigs	poisoning, trapping and ground shooting.
For rabbits	fumigation of warrens with Phostoxin, blasting of warrens, ripping of warrens, poisoning with 1080, ground shooting, cage trapping, and inoculation with Myxoma virus.
For dingoes	poisoning with 1080 and soft-jaw trapping followed by shooting.
For foxes	poisoning with 1080 and soft-jaw trapping followed by shooting.
For feral cats	cage trapping and soft-jaw trapping followed by shooting.

I believe that helicopter shooting of wild horses in KNP, if it is allowed to take place, and if it is adequately funded, could potentially be based on a deep body of expertise equal to the best international standards, if the appropriate staff are selected for the relevant roles. This should enable high standards of safety and animal welfare to be achieved.

Conclusion to term of reference (d)

The Standard Operating Procedures have been developed nationally by experts in the business and I believe the FAASTS program is of very high standard. My advice is not to tinker with what is not broken.

(e) the animal welfare concerns associated with aerial shooting;

Also see my comments on TOR (d).

There are concerns in the general community about the degree of suffering caused by aerial shooting but the fact is that aerial shooting when carried out properly is one of the least cruel of control methods which have been used by humans on sentient vertebrate species. The requirements for humane shooting of feral livestock are stipulated in various documents particularly SCAAHC 1991;

FAAST 2003 and Sharp 2011. Helicopter shooting is a well established and well understood practice in NSW, e.g. the NSW government shot well over 200,000 large animals from helicopters in the last three years.

Feral horses, feral pigs, deer species, feral goats and feral donkeys may be shot from helicopters, everywhere in all jurisdictions, except feral horses may not be shot from helicopters in national parks of NSW, by ministerial direction. Yet there is no suggestion that wild horses in national parks differ in their capacity for suffering from wild horses outside national parks. Nor is there evidence that horses in national parks of NSW differ from horses in national parks of other states. In NSW, the same shooter and aircraft may shoot horses outside the park but only pigs, deer, etc inside. The inconsistency in the current NSW situation is indefensible on animal welfare grounds, and ecologically. This illogical anomaly has persisted for 23 years. I hope we can do better in future with animal welfare rulings.

It is rarely understood by the public that the range at which shooters generally operate is much less in helicopter shooting than ground shooting. As well as placing the helicopter close to the target group of animals, the pilot should attempt to approximately match their speed and direction of movement, thereby minimising the relative movement of the target animals. Thus, the shooting demands are considerably less than most people imagine. With horses, camels and deer, the better shooters who I have spoken to are capable of consistently achieving brain shots rather than the usual heart – lung shots. Multiple shots are applied in case the first shot was inaccurate, in order to ensure a humane kill (SCAAHC 1991; FAAST 2003). Wounded animals can mostly be dealt with immediately by additional shots (semi-automatic firearms are mandatory) but if a wounded horse managed to run away, in a helicopter it could easily be followed, something that is generally impossible with ground shooting of wild horses. It is standard practice to fly back over shot animals, shooting them again if required to be certain they are all dead.

The humaneness of aerial shooting operations has been evaluated by independent veterinarians using both observation during shooting operations and necropsy of more than 600 horse carcasses and more than 700 camel carcasses. The method was found to be satisfactory. Skill of individual shooters was the most important determinant of animal welfare (Hampton *et al*. 2014, 2017).

Ground shooting enables well aimed shots and high levels of accuracy at greater range (which is necessary because the flight distance of target animals means that the range at which shots are taken on the ground is likely to be greater, on average, than the usual range with helicopter shooting), but wounded horses cannot be followed. Also far lower kill rates are possible with ground shooting (Pulsford *et al.* 2023). Ground shooting will not enable the target to be achieved of 3,000 horses by 30/6/27.

The need for public education to maintain social licence

There have been numerous wildlife controversies in the world including some in which management agencies were ultimately prevented from completing wildlife management programs due to erosion of their social licence (Hampton and Teh-White 2019). In modern times increasingly, the critical issue is perceived or actual problems with animal welfare. Even as long ago as the 1970s, the unsustainable harvests of the great whale species were closed down, not because of overharvesting, but due to animal welfare issues (Hampton and Teh-White 2019). It is possible this could happen with helicopter shooting of wild horses in KNP, especially if no plan is put in place to reduce the risk of it.

During the process for the preparation of the 2016 draft Wild Horse Management Plan, surveys were conducted that showed that, once presented with all the facts, members of the general public recognised helicopter shooting as an appropriate method of control. The requirement for a public education program about the realities of helicopter shooting has been pointed out to the NSW government for years, but now is more urgent. It is often forgotten that there is a health benefit to consider. If such a program reduces the angst felt by members of the public about horse control, it will be an important service in various ways.

Conclusion to term of reference (e)
Animal welfare concerns associated with helicopter shooting are exaggerated. Public education is advisable.

(f) the human safety concerns if Kosciuszko National Park is to remain open during operations;

It is my understanding that, if helicopter shooting of wild horses in KNP is implemented, NPWS will close the shooting area to the public the same as it already does with helicopter shooting of feral pigs, feral goats, sambar and fallow deer in KNP. If the area was not closed, from what I have seen of helicopter shooting the chance of a human being shot is insignificant. However this matter should be referred to people who have done a lot of helicopter shooting in parks, and people from other states and other countries who have the same experience.

The use of military standard thermal viewing equipment in daylight (early morning) lessens the risk of accidentally shooting a non-target species (including humans), because as well as what is visible, animals (or parts of animals) that are obscured behind foliage or camouflage clothing can often be imaged using the thermal sensor.

Conclusion to term of reference (f)
Refer this TOR to true experts.

(g) the impact of previous aerial shooting operations (such as Guy Fawkes National Park) in New South Wales;

The prior communication and consultation regarding the helicopter shooting at Guy Fawkes National Park in 2000 was badly managed. When the program became controversial, the politics was handled just as badly. To this day the project is still attracting criticism, so efforts by Minister Debus to close down the issue were, at best, only partly successful.

In spite of being illogical, the decision to ban helicopter shooting of wild horses in NSW national parks has lasted for 23 years, while allowing the helicopter shooting of horses outside parks, horses inside parks not in NSW, and other species including pigs which are at least as sentient as horses.

Conclusion to term of reference (g)
The Guy Fawkes shooting operation was badly managed especially in terms of public communication. And helicopter shooting Codes of Practice have been revised since that time.

(h) the availability of alternatives to aerial shooting;

As stated under TOR (b), in the literature on control of large vertebrate pests (e.g., Hone 2007, 2012) there are only two methods which have ever achieved the required annual removal rate over an area the size of KNP, i.e., poison baiting and helicopter shooting. Poison baiting is currently inapplicable for wild horses SCAAHC (1991) because there is no known combination of humane toxin and delivery method which would be sufficiently target specific. Thus, helicopter shooting is essential, because of the legal, ecological and ethical imperatives to reduce the horse population in KNP.

Conclusion to term of reference (h)

There is no alternative to aerial shooting. For horses, it should be a preferred method over trapping or ground shooting, for animal welfare reasons. (But trapping or ground shooting could still be required in restricted circumstances.) Whenever ground shooting of horses is being carried out, a helicopter should be on standby which can respond to a wounded horse if necessary.

(i) any other related matters.

Evidence-based decisions

Decisions and recommendations about animal welfare obviously are made in a context that is subject to strong emotions. Also, such decisions and recommendations can have significant consequences, not only for animal welfare, but also in other areas such as biodiversity conservation or human health. With these two points in mind, extra vigilance and extra work are appropriate to ensure that animal welfare recommendations and decisions are based on the best available evidence and rational interpretation. Further, some animal welfare decisions can attract scrutiny, or even legal challenge. Decisions are more defensible if they are evidence-based. By insisting on an evidentiary basis for claims about animal welfare issues, we not only direct animal welfare attention to where it does the most good; we also contribute to a better, more sustainable and more efficient society.

That means we should generally eschew opinions and sources which revel their poor scholarship poor thinking or general unreliability through wildly exaggerated claims and poor expression, often using military terms, such as referring to helicopters used for aerial shooting of wildlife as 'helicopter gunships', the killing of animals as 'murder' and the people involved with such work as 'monsters', or 'Dr Death'; or just using exceptionally poor expression, such as this example, which is commenting on the Guy Fawkes cull that took place 23 years ago (accessed 25/9/2023) '*World disgrace and cruelty accompanied national condemnation of the Guy Falkes* (sic) *murder and inhumane executions of our national heritage Brumby in October 2000 by the NSW National Parks. Keep in mind that only by a stop on gunship shooting by Debus, from massive public damnation, can be lifted at anytime and that is very much on the cards.*

Whatever we think of such uninspiring writing, and the reliability of other statements on the same web page, it is important for animal welfare, and a healthy society, that we maintain an insistence on evidence based animal welfare recommendations and decisions.

The influence of population dynamics on animal welfare

It is well accepted that the animal welfare impact of any procedure depends on both the degree of individual suffering caused by the procedure, and the number of animals to which the procedure is applied. This thinking is reflected in the well known '3 Rs' principle for scientific research involving animals. The second 'R', for reduction, means minimisation of the number of animals affected (NHMRC 2013, 2019). However in discussions around the humaneness of wildlife management, the number of animals experiencing the treatment receives too little consideration. Also some aspects of population dynamics are counter-intuitive so I have stated them in detail below.

If a control program removes animals at too low a rate, compensatory mechanisms prevent the population from decreasing. So whatever animal suffering was involved in the program occurred completely in vain because nothing was gained from the control program. The required rate applies to the proportion of the population removed, not to the number removed, so as the population grows, it becomes harder and harder to achieve the necessary rate. The KNP horse removal program fitted this description for many years when it was based on trapping, for re-homing or transport to a knackery, because the removal rate was too low to affect population size. Until more data become publicly available it is unclear whether the recent introduction of ground shooting (with the population now being much greater) has overcome the problem, but indications so far are that it has not.

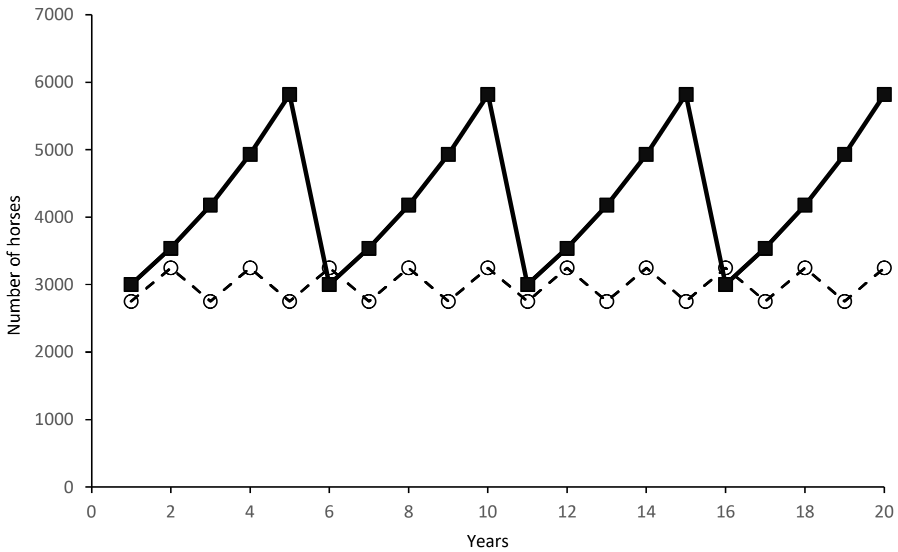
If the rate of removal is somewhat greater than described above, and is sufficient to reduce the population gradually, many more animals will be killed than if the removal rate is high enough to cause rapid population decline. So this is a case where it is clearly much kinder to take strong action (and also to commence it as early as possible). It is also possible that a method which was more effective at reducing the population, but involved greater suffering per animal, would be more humane overall, than a method which was a little better in terms of humaneness but took longer to reduce the population so that many more animals had to be killed.

These considerations apply to the reduction from the current population (~21,600 in October 2023) to the target population of 3,000. The more quickly it is done, the fewer animals will be killed. They also apply to the maintenance of the target population, but in a slightly different way.

Two different interpretations of a target population of 3,000 are illustrated in Figure 6. An unsophisticated alternative would be to cull the wild horse population to 3,000, then following the AALC practice of 5-yearly counts, the population could continue to be counted every five years in order to accurately cull it back to 3,000. In this alternative the number 3,000 is effectively treated as the minimum population size. This alternative would be one of the least desirable options for animal welfare. Many people are surprised to learn that even with a species as slow breeding as the horse, this approach entails the killing of ~15,000 horses per ten years, (an average of 1,500 per year).

A second alternative is to anticipate the inevitable population growth by culling to below 3,000 and culling annually (or even more frequently). In this alternative, 3,000 is the average population size. This alternative is one of the better options for animal welfare (9,900 horses are killed per ten years, 64% as many horses as in the first alternative, i.e. 990 per year) and this alternative is the closest possible fit to the legal prescription, and better for the environment than the first alternative.

Figure 6: Two possible interpretations of maintaining the required population of 3,000 horses assuming population growth rate of 18% per year: — ■ — culling the population down to 3,000 every five years; - - o - - **annual culls to 2,752 so average population size = 3000. Over 10 years 15,453 horses are killed in the first scenario and 9,900 in the second.**



Implicit in the previous discussion is recognition that the smaller the residual population, the fewer animals are required to be treated to maintain it, whether that treatment is by killing, fertility control, fencing or something else. The extreme of this principle is the idea that pest eradication is the best option for animal welfare. The horse is probably the only species of exotic animal in Australia for which eradication might be possible in parts of the mainland, however that option is ruled out by law within the boundaries of KNP. In other places it can be achieved, e.g. horses were present for more than half a century in the area now known as Namadgi National Park, at times numbered more than 200, and were subject to constant shooting by rangers whenever the opportunity arose, until the last horses were removed in 1987 in accordance with the first Management Plan for Namadgi National Park. All that is now required is to deal with occasional incursions from KNP.

If we are wrong

Irreversible harm will be done if biodiversity is reduced at KNP by wild horses causing the loss of KNP-endemic species. It would be worse to cull insufficiently, leading to the irreversible loss of native species, than to cull excessively and have to either refrain from culling for a subsequent period, or even, under current law in KNP, to reintroduce feral horses to meet the legislated requirement for a residual population. That is, to avoid doing irreversible harm, it would be better to risk over-culling than to risk under-culling.

Similarity of wildlife controversies- hidden motivations and Compassionate Conservation

As mentioned previously, the current controversy over management of wild horses in the AANP shares some features with most other wildlife management controversies. In particular, there are almost always other motivations in play than are evident from public commentary.

A quasi-religious philosophical belief in the right of selected 'sentient' species to be protected from killing is an example, e.g. the belief expressed on radio 2CN to journalist Genevieve Jacobs, by a leading spokesperson for Compassionate Conservation (UTS undated; Wallach *et al*. 2020), that saving species of reptiles from extinction cannot ethically justify the killing of an individual kangaroo.

The spokesperson justified that opinion because kangaroos are regarded by him as sentient and reptiles are not. Advocates for Compassionate Conservation confer 'personhood' on animals of species they deem to be sentient (e.g. Wallach *et al*. 2020) and are opposed to killing animals for any reason (Wallach *et al*. 2018; Oommen *et al*. 2019). In spite of their denials, advocates of Compassionate Conservation are in effect adopting traditional animal right-to-life opinions (Bobier and Allen 2020).

The rationale for this belief is mostly beyond the reach of science, like that for religion, and also mostly beyond the range of political and government debate, but its consequences are not beyond debate. The consequences are a nett reduction in animal welfare and reduced biodiversity (Fleming 2018; Driscoll and Watson 2019; Hampton *et al*. 2019; Hayward *et al*. 2019; Oommen *et al*. 2019), contrary to the assumption by proponents of compassionate conservation. Underlying the advocacy for protection of sentient animals, there are numerous factual errors (eg that India is a model country for animal welfare, Ommen *et al*. 2019) or that the minds of birds and reptiles are less well developed than mammals, as well as failure to understand the ecological and animal welfare consequences that would follow if their opinions were acted on (Fleming 2018; Driscoll and Watson 2019; Hampton *et al*. 2019).

Whatever one thinks of the merits or otherwise of the compassionate conservation thesis, it is important to recognise two things about it. First it is a minority opinion in Australia at this time. Second, all Australian governments are necessarily on an opposing platform because of their participation in biodiversity agreements. All species (including plant species and fungi) contribute equally to biodiversity, irrespective whether they are sentient. From a biodiversity perspective, all Australian governments will agree that saving non-sentient species of organisms from extinction can ethically justify the lethal control of other species. On this point at the present there appears to be no prospect of reconciliation between governments and Compassionate Conservation advocates.

Commercial interests are also in play. This has been suggested many times in regard to the wild horse issue in KNP, where tour operators whose family businesses run commercial horse trekking tours are among the most active opponents of any horses being killed. Commercial interests too are only rarely admitted, but there has been an occasional exception from the most prominent leader of the NSW brumby campaign, former National Party MLA Peter Cochran (now a member of Pauline Hanson's One Nation). Cochran hopes for the end of KNP and a return of high country grazing and sees the preservation of the horses as a step toward that goal. '*Its a bigger picture than the brumbies. …. It goes back to the way people were treated when they were kicked off the high country*' he says (Slattery and Worboys 2020 p326). Observers of all sides in the dispute, like journalist Ricky French have noted that '*the brumbies are symbolic of a bitter land dispute, one that was supposed to be resolved in the late 1960s, when the last cattle were removed from the newly minted Kosciuszko National Park. Many grazing families are still not prepared to relinquish this high-country holy ground'* (Slattery and Worboys 2020 p326).

In wildlife controversies, typically much time is spent focussed on topics like whether counts are accurate, whether other species are really at risk, whether methods are sufficiently humane and so on, only to find out that even if all these points are agreed, the killing is wrong according to its opponents, just 'because it is wrong'. Such quasi-religious philosophical belief or commercially motivated campaigning is mostly brought into the open only reluctantly, perhaps partly because its proponents fear ridicule but mainly because they believe it will not win the argument. Therefore much time is wasted in disagreement about whether counts are accurate, whether other species are really at risk, whether methods are sufficiently humane, etc.

Ironically, the price paid for all the delay is likely to be reduced animal welfare, due to exponential increase in the population of concern (as well as increased environmental impacts and financial cost).

Considering the impact of horse population control on animal welfare of other species

Effective control of a species for conservation must increase the abundance of at least one other species that is impacted by the target species (otherwise it is not effective control). At least where the impacted species are vertebrates, cephalopods or the larger crustaceans, there is a clear benefit for animal welfare. An example with wild horses is the endangered tooarrana (*Mastacomys fuscus*) whose habitat disappears at moderate or high horse density, due to grazing and trampling (Schulz *et al*. 2019; Eldridge *et al*. 2019). Without long grasses to hide their runways, tooarrana are an easy meal for native and introduced predators, and several populations have disappeared in this way. Another example is the endangered Riek's crayfish (*Euastacus rieki*) whose habitat is destroyed by pugging. Unable to hide from predators in their burrows, the crayfish too make an easy meal for predators.

Each horse potentially impacts a large number of these small native species. When the animal welfare costs of horse population reduction are being weighed up, the animal welfare benefits to large numbers of small animals, including tooarrana and Riek's crayfish, are an offsetting factor.

Considering the effect of horse population control on human welfare

There is no longer any doubt that wildlife controversy has a human cost in the form of stress and its consequences. And there is a cost to all sides of the disagreement. To minimise that cost, we need to resolve conflict swiftly and explain decisions clearly.

Conclusion to term of reference (i)

1. Due to the nature of animal welfare business, a particularly strong effort is appropriate to make evidence-based recommendations and decisions.
2. In the context of pest management, animal welfare is improved by conducting control operations more frequently; and by controlling to a lower residual population size, as well by selection of more humane methods of control. Ecological advice should be sought about required rates of removal of pest species before commencing operations.
3. The welfare of species relieved from horse impacts by the reduction of horse populations should be considered as an offset against the animal welfare cost of horse control methods.
4. The human costs can be reduced by resolving conflict swiftly and explaining decisions clearly.

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Helpful comments were provided on a draft version of this document by Linda Groom, Isobel Crawford and John Brickhill. My comments on counting methods benefited greatly from a discussion with Emeritus Professor Jim Hone.

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APPENDIX 1: Qualifications and experience of the author

I am an ecologist who is retired but still active, leading a citizen science project that is researching the conservation of the threatened Rosenberg's Goanna. In the ACT all animal researchers must pass a test of their knowledge about animal ethics every three years, as well as having all of their research procedures approved by a legally constituted Animal Ethics Committee.

My career included periods as a park ranger in NSW and the ACT. Later I served as the first Animal Welfare Officer in the ACT. It was my job to finalise an animal welfare policy which in effect became the ACT *Animal Welfare Act* (1992). This task involved a great deal of thinking about animal welfare, consultation with a wide range of interest groups and experts on animal welfare and the law, and processing of many public submissions. Also in the 1990s I briefly acted as an animal welfare observer during a helicopter shooting operation.

My PhD was in population dynamics and I am knowledgeable about the estimation of animal abundance, in particular the use of Distance Sampling (the method used for estimating the size of the horse population in the AANP).

During most of my years as a professional ecologist, I participated strongly in research with university and CSIRO partners to evaluate fertility control methods for eastern grey kangaroos. We pioneered three main approaches, including both of the agents now being used in horses. One of the three proved extraordinarily successful in eastern grey kangaroos. Our research was attacked at every opportunity by animal rights campaigners. Unfortunately a young PhD student was seriously injured during one event. After a 2 year pause, research continued and demonstrated higher than expected success. Former colleagues are now taking dart-delivered Gonacon to the next level in this species (i.e. small unfenced culled populations), and have trialled Gonacon in other macropod species. (Unfortunately the situation with Gonacon in the horse is much less favourable.)

During this time I served for two terms (about four years) until 2016, on the Animal Ethics Committee at the University of Canberra. Experience on the committee was valuable in exercising my thinking and my communications about animal welfare. Recently I was asked if I was willing to serve again on the University of Canberra committee.

APPENDIX 2: Horse population estimates in KNP and how calculated

Date	Area surveyed	Report	Size of area surveyed (sq km)	Horse Popn estimate	Lower 95% Conf Limit	Upper 95%Conf Limit	Horse Popn in KNP (calc from AANP survey as needed)	Upper 95%CI for KNP	Lower 95% CI for KNP	How KNP portion calculated
Mar-01	AANP	Walter and Hone 2003	2,789	5,200	1,979	8,421	3,000	1,858	1,858	Kosciuszko NP component estimated by Walter (2005)
Apr-03	AANP	Walter 2003	2,717	2,369	3,937	3,937	1,367	905	905	Same proportional adjustment as above (0.58)
Jun-05	KNP	Montague-Drake	1,052	1,357	759	1,955	1,357	598	598	No change necessary
Apr-09	AANP	Dawson 2009	2,860	7,679	CV 25.4%		4,684	2,332	2,332	Adjusted by the proportion of horse groups counted in Kosciuszko NP, given in Dawson (2009 Table 1), ie 0.61.
May-14	AANP	Cairns 2019	7,443	9,187	7,484	11,595	5,604	1,984	1,984	Adjusted by the proportion of horse groups counted in Kosciuszko NP, given in Cairns (2019 Table 3), ie 0.61 excluding the Bago Maragle block and half of the Byadbo-Victoria count.
May-19	AANP	Cairns 2019	7,443	25,318	CV 12.3%		19,242	4,581	4,581	Adjusted by the proportion of horse groups counted in Kosciuszko NP, given in Cairns (2019 Table 3), ie 0.76 excluding the Bago Maragle block and half of the Byadbo-Victoria count. Confidence Limits estimated from CV.
Oct-20	KNP	Cairns 2020	2,673	14,380	8,798	22,555	14,380	8,175	5,582	No change necessary
Oct-22	KNP	Cairns 2022	2,675	18,814	14,501	23,535	18,814	4,721	4,313	No change necessary
	AANP = Australian Alps National Parks; KNP = Kosciuszko National Park									

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APPENDIX 3:

COMMENT ON *'Independent biostatistical report on the Brumby population in the Kosciuszko National Park'*

Don Fletcher PhD, PSM
4 October 2023

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Contents

INTRODUCTION AND GENERAL REMARKS

What report is referred to?

The report I comment on *'Independent biostatistical report on the Brumby population in the Kosciuszko National Park'* dated 20 May 2023, is available at https://meetourhorsemeat.com/wp-content/uploads/2023/05/Independent-Biostatistical-report-into-the-counting-of-wild-horses-Claire-Galea.pdf. I refer to the report hereafter as Galea (2023).

Not a scientific process

It is important to recognise that neither Galea (2023), nor this commentary, have been subjected to the normal quality control processes that apply in science, i.e. they have not been published in a journal which deals with wildlife counting methods, which would have subjected them to serious editorial inspection, and the opinions of two or three anonymous peer-reviewers. Also there is the potential for subsequent criticism to be published later in the same journal.

However, any publicly available report such as Galea (2023), which is concerned with scientific matters such as the estimation of animal abundance, should rightly be open to fair criticism or comment on factual and scientific grounds. The justification for such evaluation is increased in this case because the report recommends a major change to the current management of Kosciuszko National Park. Also because the report has not only been placed on the internet, but also sent to the offices of most of the relevant politicians who are involved with management of feral horses in Kosciuszko National Park (KNP).

Not personal

Nothing in the following comments about the content of the report should be read as personal criticism of Mrs Claire Galea herself. I presume she is a fine professional in her own field, as evidenced by the impressive number of scientific papers which she has co-authored, and her acceptance by a university as a PhD student.

Similarity of wildlife controversies

Current controversies over management of feral horses in Australian conservation areas share some features with most other wildlife management controversies. It is particularly common for scientists' population estimates to be disputed. For example, many critics of wildlife management programs have little respect for ecological expertise, and believe there are no more animals present than they have observed themselves.

Importance of this response to Galea 2023

Galea (2023) has been claimed to be both 'independent' and to be based upon greater expertise than that of the professional ecologists and public servants responsible for the official counts of horses in KNP. However I show below that there are numerous deficiencies of science, logic and statistics in the report. On the basis of these deficiencies and the legal, ecological and ethical imperatives outlined below for feral horse population reduction, I challenge the only recommendation in the report, which is for '*Immediate moratorium on the killing of all wild horses in the Kosciuszko National Park and an independent investigation into all population trends and subsequent control needs to be urgently undertaken'.*

Independence

The report title says it is 'independent'. Presumably the reader is meant to infer that the report is unbiased because its author has no links to either side of the horse controversy in KNP. However perusal of the report uncovers instances where a more detached statistician would probably have made a more logical conclusion (see below) or avoided making an error of scholarship (identified below). This made me wary of the claim for independence.

The report displays no understanding of the legal, ecological and ethical contexts of the horse counts

The NSW *Kosciuszko Wild Horse Heritage Act* (2018) requires a horse management plan which recognises and protects wild horse heritage values in Kosciuszko National Park and enables active management of the wild horse population to reduce its impact on the park's fragile environment. Consequently, the Kosciuszko National Park Wild Horse Heritage Management Plan (the Horse Plan) was adopted by the Minister for Energy and Environment on 24 November 2021 following a massive exercise in democracy, including extensive consultation with expert committees, thousands of public submissions and the approval of several key Cabinet Ministers in the NSW Parliament, including the Deputy Premier, John Barilaro who was responsible for introducing the bill that required the plan to be prepared. The Horse Plan, a binding legal instrument, requires the current horse population (estimated in 2022 to be ~19,000) to be reduced to 3,000 by 30 June 2027.

A further requirement for horse population management has been established by the listing of *'habitat degradation and loss by feral horses'* as a Key Threatening Process in Schedule 4 of the NSW *Biodiversity Conservation Act* (2016). The NSW government is thereby required to ameliorate the biodiversity threat where possible.

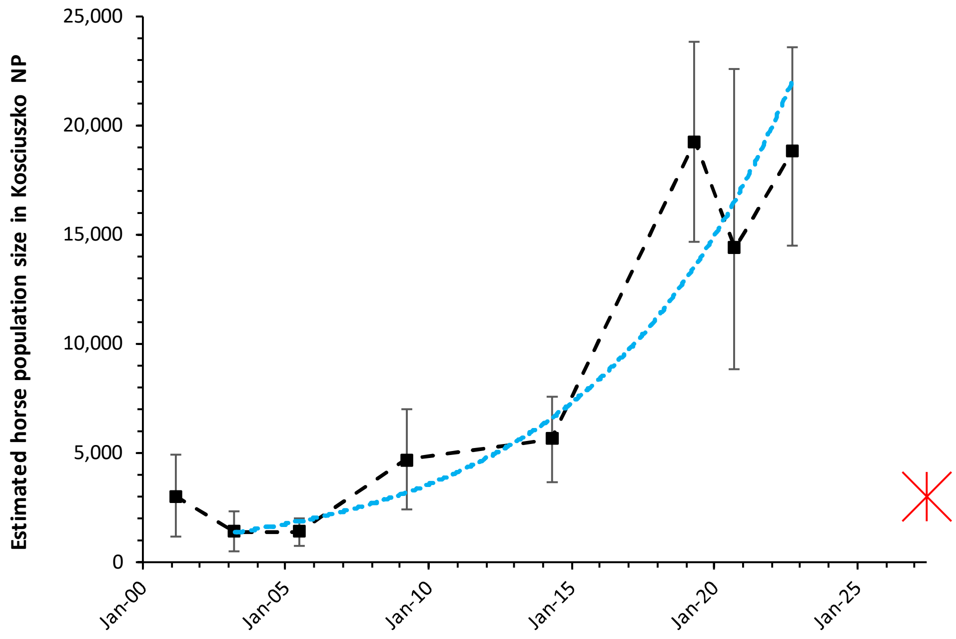
Scientists have estimated the size of the horse population in KNP nine times. The first was in the late 1980s by Dyring (1990). Eight estimates since 2001 all used Helicopter Line Transect Distance Sampling (HLTDS), a method explained below. For years, the exponential increase of the horse population has been plainly evident to anyone who has been interested in the counts (Figure 1 and Appendix table).

It is the nature of exponential population growth to seem slow for a long time while the population is relatively small, then to seem to increase rapidly when the population is larger. Thus the risk to native Australian species of animals and plants has become more acute in the last few years, now that the horse population is large and increasing rapidly.

As a result, although the first horses entered the area more than 100 years ago, in 2023 many plants and animals in the park will be encountering horses for the first time. Others will be experiencing high levels of horse impact for the first time.

Scientists have been pointing to the increasing threat to biodiversity associated with the increasing horse abundance and distribution for 70 years, since 1953. But now it has become worse than a threat, with actual loss of populations having occurred due to horse activity; e.g. populations of tooarrana *(Mastacomys fuscus)* have been lost (Driscoll *et al.* 2019; Eldridge *et al.* 2019; Schulz *et al.* 2019) most likely through reduction of ground layer vegetation which is essential for this native rodent to persist (Cherubin *et al.* 2019). Thus, even if there was not the legal imperative requiring management of the horse population, there are clear ecological and ethical imperatives to act.

Figure 1: Eight estimates of the horse population in KNP (squares) were accompanied by wide 95% confidence intervals (error bars). But overall there has been a consistent trend of 15% annual increase (dashed blue curve) since the 2003 bushfire, except around the time of the 2020 bushfire. The red star marks the commencement of the requirement for there to be only 3,000 horses from 30/6/27. See the Appendix for details.



In this legal, ecological and ethical context, there is no option to recommend that the horse population should not be reduced. Yet that is the only recommendation of this report (Galea 2023, p. 4). On that basis, the report can be regarded as being somewhat adrift from the current legal, ethical and ecological circumstances. In addition there are numerous flaws in the case it presents for doubting the horse counts, as detailed below.

The report does not suggest a better survey method, or provide any way forward

The Horse Plan indicates that feral horses can be found in 53% of the 6,900 sq km KNP, i.e. in an area of 3657 sq km. This area probably includes all places where rangers have seen groups of horses, but counting is limited to a smaller area where horses are more likely to be encountered, i.e. 2,745 sq km. No experienced ecologist would imagine that a population of wild horses spread over even this 2,745 sq km part of KNP could be reduced accurately to 3,000, from more than 10,000 individuals, without further counting. And the estimated population size in 2022 was not 10,000 but was almost twice as large, i.e. 19,000 approximately (Cairns 2022).

As the horse population is reduced closer to the target population size, counts of good precision and accuracy will be needed more frequently than ever before, to guide the culling program so that it achieves a result of acceptable precision and accuracy. The legal, ecological and ethical imperatives referred to above make horse control, and therefore horse counting, essential between now and June 2027. The most suitable counting method available for the terrain and population size at KNP is Helicopter Line Transect Distance Sampling (HLTDS) (Walter and Hone 2003), which is the method used for all eight surveys carried out in the last 22 years.

Galea (2023) identifies many causes of claimed inaccuracies. However, the report does not state whether the claimed problems would make the counts too low, or too high. The important question of whether the claimed inaccuracy is positive or negative appears not even to have been thought of. The author has simply assumed that errors would result in overestimation of horse abundance.

No counting method is perfect. Internationally, distance sampling has more often underestimated than overestimated, and in particular, distance sampling has been shown to be underestimating the count of horses in KNP (Laake *et al.* 2008). If all the methodological deficiencies claimed in Galea (2023) were real, there may be far more horses than suspected and an even greater problem than experts currently appreciate.

Another conceptual omission from the thinking behind the report is the lack of any way forward; which is an extremely important gap, considering the legal, ethical and ecological imperatives mentioned above.

No wildlife population estimation method is perfect but unless some alternative or improvement can be identified, it is fruitless to focus much attention on any deficiencies. Galea (2023) does not outline how an alternative population estimation method to HLTDS could be deployed in the terrain and vegetation of KNP. (In some parts of KNP even helicopter counting is challenging, due to the terrain and vegetation.)

In fact the report does not refer to any alternative scientific method of measuring population size. It simply states (p. 12) that because of (claimed) deficiencies, distance sampling is '*not appropriate methodology for estimating wild horse populations*'. It does not name any other survey method which might be superior.

The report suffers from a lack of experience with ecology

The author of the report is an experienced medical statistician whose name is included in the author-list of a large number (~50) of papers published in peer-reviewed medical journals. Possibly she provided the statistical services needed for data analysis in those projects. Galea is also listed on the Linked-In website (https://www.linkedin.com) as a PhD candidate in the Faculty of Medicine at Macquarie University, Sydney. An on-line article from the university says Galea is *'leading the world's first global evaluation of Dolly Parton's Imagination Library including a research focus on children in the NSW town of Tamworth*'.

I found no evidence of ecological training or experience in Galea's background and there is nothing like this report (Galea 2023) published in any ecology journal. Measuring the abundance of wildlife is a notoriously challenging area of ecology which requires not only skill with the particular statistical challenges of ecology (e.g. see 'B2 Transformation of the data – p. 12') but also a good deal of field experience. The report reads as if it rests on limited field experience in ecology.

In estimating the numbers of horses in national parks like Kosciuszko, the challenges include the impossibility of uniquely identifying all the individual horses in large populations* and the impossibility of seeing all the horses on any one occasion. In the medical studies co-authored by Galea, each person involved would have had unique identifiers (name, date of birth etc). And there is no evidence that Galea's research has involved patients who could not be seen by the researchers. Thus Galea's extensive experience in medical statistics appears unlikely to include experience in two of the main challenges of counting wild animals.

* Individual identification of horses <u>can</u> be used to estimate population size by Mark-Resight analysis, if the population is small enough. Dawson and Miller (2007) observed 50 horses in a 180 sq km area of the Bogong High Plains when they searched it by helicopter one day. The next day they searched it again and recorded 78 individuals. Some of these were seen more than once on the same day and the total number of individual horses seen on either day was 72. From this, the population was estimated to be 89 to 95 horses (so 23% to 32% of horses were never seen on either day). The statistical analysis used the well known Mark-Recapture method. The authors speculated that the method may have practical application for aerial surveys of small populations, subject to methodological improvements such as a change to video rather than still imagery to recognise individual animals (Dawson and Miller 2007). The method of recognising individual horses was not considered suitable for estimating the number of horses to be counted in KNP, which is hundreds of times more. Nor does the counting budget allow time for horse photography and the careful observation required with this method.

Too many simple mistakes

There is a distinct impression that the report (Galea 2023) was written in haste because it has so many simple errors. One example is the mistaken claim that the Kosciuszko HLTDS surveys do not count foals separately (Galea 2023, p17). Yet the foal counts are obvious in the 2020 and 2022 reports. In Cairns (2022), the foal counts are mentioned in the Summary, in the Methods, and in the Results and Discussion. And they occupy more than two entire pages. (see more details in my response to criticism C3). Similar mistakes are mentioned in my comments on criticisms 'B1 – Statistical modelling', 'B2 Transformation of the data', 'B3 - Use of covariates' and 'B4 - Assumptions'. Also there is repetition of the same criticisms under different headings.

The prevalence of such easily identified errors (no statistical knowledge needed) might lead a reader to lose confidence in the main claims of the report.

It is the latest survey (Cairns 2022) which is the most important so it is odd that the report gives no reason for its focus on the 2014 and 2019 surveys with only occasional mention of the latest (2022) survey, and no mentioned at all of the 2020 survey which was completed between those surveys that are mentioned. The omission of the 2020 count report from Galea's criticism was probably just an oversight, and not because Galea approved of the 2020 count.

About the horse counts to date

Over the past 22 years, the feral horses in Kosciuszko have been counted eight times by a number of different people from independent universities and the NPWS. Until recently, most of the counts were funded by the Australian Alps Liaison Committee (AALC), and most provided a single combined estimate of the horse population of the alpine national parks in Victoria and NSW.

In spite of limitations, collectively the set of eight horse counts has provided a consistent and plausible result (Figure 1). The counts are remarkably consistent in showing an average annual increase of 15% except when the horse population was reduced by the bushfires of 2003 and 2020 (Figure 1).

As previously mentioned HLTDS was the method used for all surveys. In the name 'Helicopter Line Transect Distance Sampling', the words 'line transect' refer to the straight lines from which the horses are observed. These transects are parallel east-west lines (in one or two cases over the 20 years a different direction was used in small steep areas) and within a survey block the lines are equidistant (*e.g.* Cairns 2022) so this design is referred to as a 'systematic' layout. Each set of transects has a randomly chosen start point, hence the design is sometimes referred to as 'systematic random' (*e.g.* Cairns 2022). 'Distance Sampling' refers to the analytic method used for statistical analysis of the data, typically using the free program '*Distance*' or an equivalent package in statistical program R. (There are other ecological methods based on transect lines which are not distance sampling and there are other examples of distance sampling which are not from lines or which are not done from helicopters).

In brief, Distance Sampling exploits the fact that fewer animals are detected at greater distance from an observer, in order to enable an estimate of how many animals are not seen, in addition to those which are detected and recorded. The Distance Sampling method (Thomas *et al.* 2010 and https://distancesampling.org/whatisds.html#online-bibliography) is one of the most widely used methods in the world for estimating abundance of wildlife populations. Its mathematical and statistical foundation is comprehensively explained in two books, particularly Buckland *et al.* (2001), and a second book covering more advanced applications (Buckland *et al.* 2004). The results have been evaluated against known populations on numerous occasions and found to be accurate (*e.g.* Hone 1988; Hounsome *et al.* 2005; Glass *et al.* 2015). Thousands of published, peer-reviewed scientific papers exemplify its use. More than 1,400 of them can be found in the bibliography at https://distancesampling.org/dbib.html. There is a wide range of species whose populations have been counted using Distance Sampling, including insects, crabs, fish, reptiles, antelopes, deer, kangaroos, feral pigs, fruit bats, primates, polar bears, whales, dolphins and mice, as well as inanimate objects such as birds' nests, mammal burrows and carcasses (Buckland *et al.* 2001 p11). There is no reason to doubt the Distance Sampling method itself.

In the Australian Alps, HLTDS has been compared to two other counting methods to estimate abundance of horse populations. The study authors recommended HLTDS for future use (Walter and Hone 2003). Since then, the design, analysis and reporting of recent surveys by Cairns (2019, 2020, 2022), and the results obtained, have been reviewed and found acceptable on several occasions by different groups of truly independent scientists who are themselves experienced with statistical analysis of wildlife counts. Overall, there has been a considerable body of scientists who approve of the use of HLTDS, and how it is being applied in KNP to estimate horse abundance.

Aside from the three methods compared by Walter and Hone (2003), only one other method of counting feral horses in the high country has been peer reviewed and published (Dawson and Miller 2007). It relies on recognition of individual horses in small sub-populations, as explained above under the heading 'The report suffers from a lack of experience with ecology'. But it is not the earlier surveys which matter. The most recent survey (Cairns 2022) is the most important for horse management.

The length of transect traversed in the latest survey (survey effort) was 1,496 km. To traverse this distance in a much slower platform than a helicopter (for example on horseback) would contravene statistical requirements (see below) as well as being impractical. To survey a shorter length of transects by helicopter would result in a higher coefficient of variation (i.e. greater uncertainty around the population estimate; see below). There seems almost no chance that a ground based survey method could be found which would enable the horse populations in KNP to be estimated reliably across their full extent.

Accuracy and precision are less important now than later

The upward trend in the horse population is obvious (Figure 1) and corresponds with the experience of long-term observers who have seen at first-hand the horse distribution expanding and the abundance increasing. The expanding distribution of horses has also been reported by several observers including Dawson (2009).

What is apparent from Figure 1 is that previous and current population control measures have not reduced the size of the horse population, nor its rate of increase. While the horse population is growing exponentially, each year the number of horses moves further from the target of 3,000 and the distance it moves away from the target is greater every year.

Therefore at the present time, there is a limit to the importance of accuracy and precision of the count. Count accuracy and precision will become more important after the commencement of a horse control method which has the capability to reverse the current trend and cause the population to move toward the target of 3,000 individuals. Rather than wasting funds and human effort on greater precision and accuracy when the horse population is in the range of 10,000–30,000 individuals, it would be better to focus on the attainment of a program which can actually reduce the horse population as required, and save the counting precision for when it will be needed.

Therefore a detailed discussion of claimed statistical imperfections in the horse count (Galea 2023) is of limited use or importance at this time.

COMMENT ON PARTICULAR CRITICISMS IN GALEA 2023 –

1 Cluster size – page 6

In spite of the title, this criticism is actually about the number of clusters. My response is in three parts.

Ecologically naive statistical approach which is aimed at the wrong survey

The main criticism under this heading is that in some sub-populations of horses counted in the 2014 and 2019 surveys, the number of clusters was below the minimum number recommended for Distance Sampling, i.e. 60. It is the latest survey, conducted in 2022, that should be our main focus but for an unknown reason, this particular criticism is applied only to the 2014 and 2019 counts.

The aim of the surveys was to estimate the number of horses in the Australian Alps (Cairns2014, 2019) or in KNP (Cairns 2022). Therefore both surveys necessarily and rightly included some areas of high horse abundance and some areas of low horse abundance. For all three surveys the total number of clusters was well beyond the minimum of 60 required, i.e. 301, 458 and 419, respectively. The number of clusters was fewer than 60 only in some sub-component areas. Surveys across the range of horses within KNP (or of any species anywhere) inevitably must (and should) include areas where the population is advancing into new areas, or for other reasons is at low density. In these sub-components of the surveyed area it is inevitable that fewer clusters will be recorded than elsewhere. In the 2022 survey fewer than 60 clusters were observed only in the Snowy Plain sub-population, i.e. 47 clusters.

More funds would have enabled more counting over the same ground until at least 60 clusters were seen at Snowy Plain, in order to obtain a better estimate of the number of horses in that site and keep at bay any criticism such as that in this report. (The extra survey effort in that small area would not bias the result, contrary to Galea's Criticism 4, as explained under that heading.) But it would be wrong to apply extra effort to Snowy Plain for a different reason, i.e. because Snowy Plain contained only 4% of the total horse population, so a small improvement in the estimate there would have made negligible difference to the total count. If extra counting could have been done, the effort could have been used more efficiently in the open plains of northern KNP which contained 68% of the estimated population.

The number of clusters counted in the Bago Maragle block in 2014 and 2019 is also criticised on p. 7. The Bago-Maragle block (on the western edge of KNP near Cabramurra) contained 11% of the horses seen in 2014 and only 4% of the horses seen in the 2019 survey. The same comments apply to this criticism.

The *Distance* computer program allows for stratification across different surveys, and after the 2019 survey, Cairns (2019) combined the data for this block from both surveys to obtain a better population estimate. Galea (2023) raises theoretical concerns with the practice of combining surveys, and concludes 'no reliable population estimates can be determined'. Galea (2023) does not indicate what alternative action Cairns (2019) could or should have taken, but the obvious alternative would be a foolish one, to reduce the survey effort where horses were abundant in order to spend more survey effort counting such places as Bago–Maragle where they were uncommon, until more than 60 clusters were seen in each and every sub-population. Instead, by combining results from both surveys, Cairns (2019) has prudently responded to the reality that some survey blocks have few animals.

The report goes on to compound this misunderstanding by complaining that the number of clusters seen in the individual 'medium terrain' stratum within the north Kosciuszko block are too few. The point is that the numbers of clusters seen in the whole block are sufficient, i.e. 84 + 20 =104 in 2014 and 226 + 43 = 269 in 2019. Note that the numbers in the table on p. 6 of Galea (2023) are correct, but mistakes were made when they were repeated in the text on p. 7.

Criticism of kangaroo counting exemplifies ecological naivety

On page 6 of Galea (2023) there are two tables labelled 'Table 3'. The second one presents data from a kangaroo count in New England. The table shows the numbers of Eastern Grey Kangaroos, Wallaroos, Red Necked Wallabies and Swamp Wallabies counted by HLTDS. The district count was subdivided into six sub-component areas. Several of the counts in sub-components recorded fewer than 60 clusters, but never for the main species of interest, the Eastern Grey Kangaroo, only for Wallaroos or the two Wallabies, which are evidently much less common in these areas than Eastern Grey Kangaroos. In these circumstances it is absurd to complain that the uncommon species did not record 60 clusters. I will explain using an example - in semi-arid western NSW where Red Kangaroos and Western Grey Kangaroos dominate, the occasional Eastern Grey Kangaroo is found in some years, but they are less than 0.1% as numerous as the primary species. It would be absurd, and perhaps impossible, to try to record 60 clusters of Eastern Grey Kangaroos in such places. All species are not common in all habitats! However there is an interest in any change over time in the relative abundance of them all, and in their conservation, so it makes sense to record them.

Misunderstood meaning of 'cluster'

The report has misunderstood the meaning of 'cluster' in Distance Sampling. It states that '*a cluster is considered to be more than one animal*'. In fact, the recording and analysis of data in Distance Sampling is based on the reality that animals occur in all sizes of groups or clusters from 1 animal upward (Buckland *et al.* 2001). And, this is a central feature of the method. The importance of clusters arises from the Distance Sampling developers' insistence on rigorous statistical standards, as explained in the next paragraph. If Galea's definition of clusters were adopted, all the animals seen as singletons would be omitted from the count.

To understand clusters in Distance Sampling, we begin with the statisticians' awareness that when an observer has seen one of the animals in a group, there is an increased likelihood that other animals in the group will also be seen. So if animals were recorded separately, as if they had been detected individually, the variance of the population estimate would be underestimated. To achieve impeccable statistical rigour, the observer in Distance Sampling is required to record details of animal clusters (i.e. groups) and the data analysis is done in two parts. The density of animal groups or clusters is estimated (i.e. average number of clusters per unit area) and its variance. Separately, the average size of clusters is estimated, and its variance. Then the two are combined. (In reality however, the analysis is more complex, for example the estimate of group size is usually done as a regression of distance from the observer because observers tend to perceive larger groups at greater distance -Buckland *et al.* 2001).

2 Cluster observation – page 7

The report says '*given insufficient clusters of wild horses …. were seen …. No reliable population estimate can be determined*'.

First, it is not true that insufficient clusters were seen, as explained above. Second, Galea's criticism that mean cluster size is prone to be affected by outliers, reveals a misunderstanding of the mechanics of cluster size analysis in the *Distance* computer program. The estimation of mean cluster size is based on the regression of size over distance (not a simple mean) and has been considered valid by numerous statisticians of international repute. On this point Galea (2023) is incorrect, statistically speaking.

3 Lack of precision – page 8

The criticism here on p. 8 is repeated on p. 15 where it is headed 'B8 Width of the confidence intervals'. One small difference is that under this heading the report focusses on Cairns (2019) but under heading B8 it is Cairns (2022) which is criticised.

To avoid repetition, and because the latest count is the one which matters most, I have responded to this point under B8.

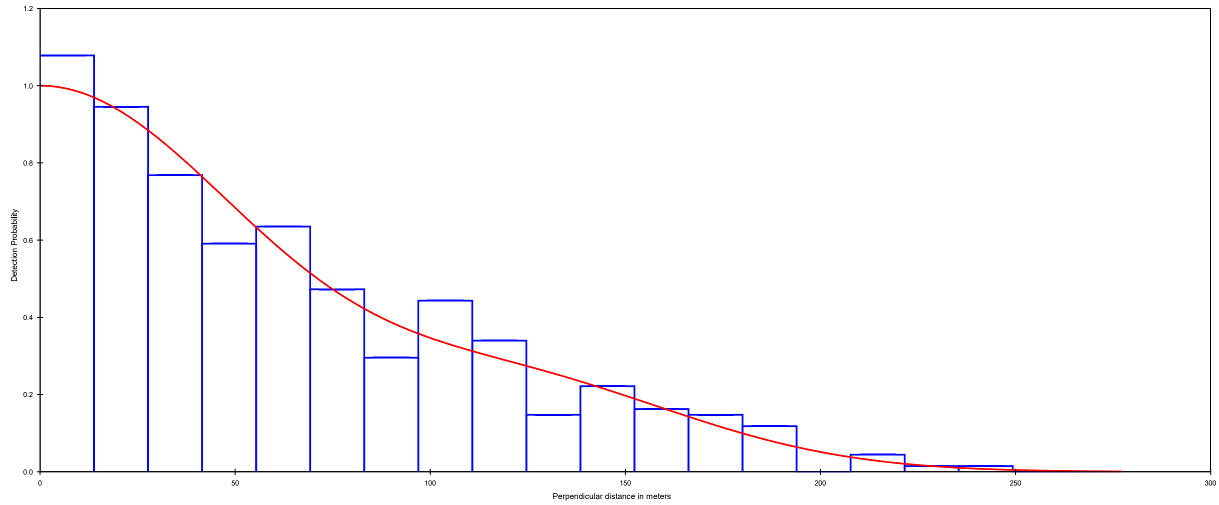
4 Bias sample location – page 11

The report is concerned that counting effort should be applied evenly across the distribution of horses to avoid bias. This comment is plain wrong statistically. It is perfectly acceptable, and in some cases desirable, to apply different levels of survey effort in different parts of an area being surveyed, in order to improve accuracy or precision of the result of the survey (Buckland *et al.* 2001). In Distance Sampling, additional effort can be applied within a stratum, potentially to improve precision and the estimation of the shape of the detection function (explained below). This would improve the accuracy of the estimate of density (horses/sq km) for that stratum. The estimates of the number of horses in the individual strata are subsequently combined to obtain the total population in the counted areas.

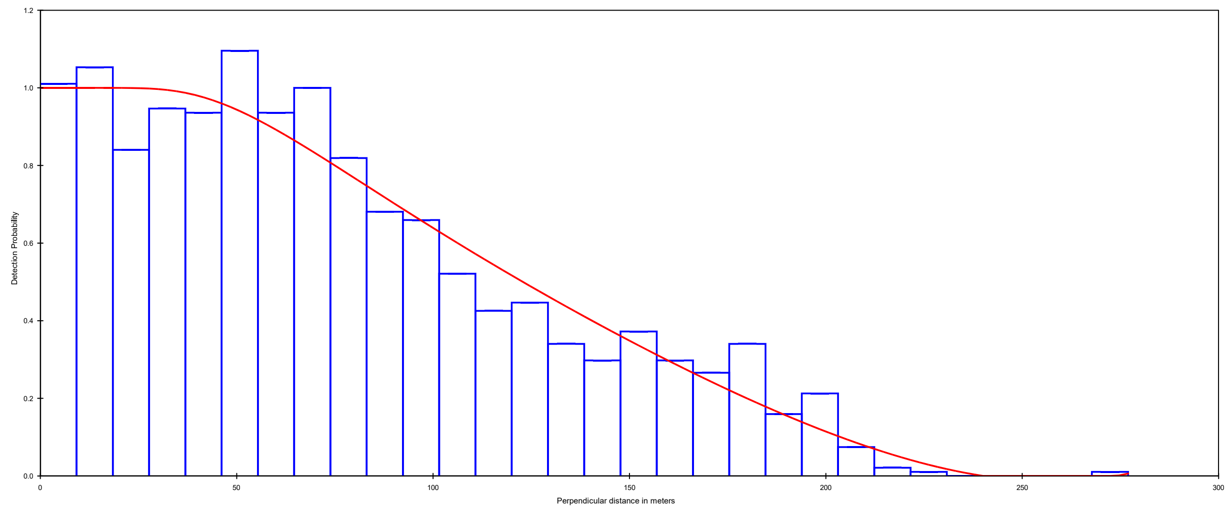
The detection function is the mathematical equation that best describes the proportion of animals present that were actually seen and recorded, as a function of distance from the transect, as illustrated below for two kangaroo surveys. It is a model representing the probability of detecting an object in relation to the covariate of the perpendicular distance that the object might be from the transect centreline, and any other relevant covariates that are measured and recorded. In relation to this is the expectation that objects on the transect centreline (x = 0) will be detected with certainty (g(0) = 1).

Figure 2: Different detection functions in Distance Sampling: bars indicate the proportion of clusters recorded at particular distances from the transects; and red lines are the equations that best describe the shapes of these relationships, (a) a half normal equation with cosine adjustment and (b) a hazard rate equation. Because the transect lines are on a random systematic pattern, in a properly conducted survey it can be safely assumed that on average there will be, in reality, an equal number of clusters at all distances from the transect line. The red lines show the proportion that were seen by the observers.

(a)



(b)



<u>5 Use of line transects with respect to speed of wild horses – p. 12</u>

The report asserts that HLTDS (referred to as '*use of line transects*') is '*not appropriate methodology for estimating wild horse populations*'. Strong claims such as this require strong evidence but the assertion is not even lightly supported with evidence. Also, one might ask what survey platform should be used to count horses if helicopters are too slow to do the job? A large body of highly qualified statisticians with impeccable reputations disagrees with Galea's (2023) assertion. Galea's claim is based on three things:

(i) Advice given by Buckland *et al.* (2001, p. 31) (which was repeated in notes for university students by Owusu 2019, which is the reference cited by Galea) that in order for mobile animals flushed by the survey platform to be recorded at their original location, the animals should travel at no more than half the speed of the survey platform.
(ii) The helicopter speed when counting horses is 93 km/h (Cairns 2022).
(iii) Reference to a web page about racehorses in North America to state that horses can run at 64 km/h.

During counting operations, the feral horses in Kosciuszko do not behave like trained thoroughbreds being ridden hard along the mown track at a racecourse, possibly urged along with whips and spurs. When flushed, the Kosciuszko horses do not move half as fast as the aircraft travelling at 93 kph, at least not for any appreciable distance. In practice it is almost always possible to record their original location, which is all that is required by the Distance Sampling method. Even wild horses which had recently had a bad experience of helicopters, responded to a counting helicopter by moving only 1 km on average from their starting point (Linklater and Cameron 2002).

In any case, it is likely that the theoretically based advice given by Buckland *et al*. (2001) is of a precautionary nature and can be carefully disregarded without biasing the population estimate. My former staff and I compared three counting methods to estimate kangaroo population size in five nature reserves, including Walked Line Transect Distance Sampling (WLTDS) from 220 km of transect. Other methods were Total Counts and Faecal Pellet Counting. For the WLTDS, the observers were required to travel at only 1 km/h. Flushed kangaroos usually travelled much faster than this, yet the population estimates by the three methods were the same. That is, the population estimates were neither significantly different statistically ($p< 0.05$), nor was there any consistency in which method produced the highest or lowest estimate in a reserve (Snape and Fletcher, unpublished data). So the advice about speed of the survey platform in relation to the speed of the animals is not an absolute requirement.

Horses in different countries are comparable to a reasonable extent so Galea's reference to a North American source for the maximum speed of a racehorse is perfectly legitimate but it is inconsistent with her complaint on p. 16 that the examples of high population growth of feral horse populations (Cairns 2019) were observed overseas, as if that somehow makes them less valid.

B1 Statistical modelling … requires … three time points – p. 12

The report (Galea 2023) says the 2019 count report '*applied complex statistical modelling techniques*' to data '*comprising only two points*'. Without a more specific reference, it is hard to be sure what this refers to. Most of the modelling in the report is based on the clusters, of which there were 458 in total. So I assume this comment refers to the bootstrap calculation of variance for the population growth rate between the 2014 and 2019 population estimates on p. 40. That is not statistical modelling in the normal sense that most readers would assume. And it is done to calculate the variance of the population growth rate, not the population growth rate itself.

It is perfectly legitimate, and commonplace, to calculate a population growth rate (PGR) between two counts. For example if the population of Melbourne was 2.5 million people in 2010 and 3 million a year later, we might say it had grown 20% that year. And use of the bootstrap method to calculate an estimate of variance around the PGR is also legitimate, and is far better than having no indication of variance, which is the alternative. If indeed this criticism refers to p. 40, it is a surprising one because the method is widely adopted by statisticians.

B2 Transformation of the data – p. 12

Galea (2023) states:

> '*When applying statistical modelling techniques there are various assumptions that the data need to meet in order to apply the techniques. The main one used is for the data to be what is called "normal", that is the raw data follows a normal distribution. When the data does not adhere to this then it is common practice to apply a transformation to the data depending on the shape of the original data. Cairns (2019) states that the "*estimates of cluster density and population density were slightly positively skewed, indicating that the data were not normally distributed*"'.*

Galea (2023) then goes on to speculate that Cairns (2019, 2022) may have applied a log transformation to the data in an incorrect way (by not accounting for zero values) and concludes:

> '***CONCERN:** If log-transformations are being applied to the raw counts, then all 0 counts will need to be increased and could significantly overestimate the population. Appropriate transformations should be applied that take into consideration 0 counts*'.

This section displays limited experience working with ecological data. First, the report makes the mistake of thinking of data that are not normally distributed as a problem to be fixed, but this is the wrong outlook. Ecological data are almost never normally distributed and therefore require the use of appropriate statistical methods and distributions in their analysis.

Log transformations, or any other transformations, were not needed in this case (not that they are problematic anyway, if applied correctly). Cairns (2019, pp. 36-37) states "*Bootstrap coefficients of variation and confidence intervals were calculated for all estimates, with the bootstrap confidence intervals being given in preference to standard normal-theory confidence intervals (Tables 7 and 8). This approach is becoming more common and is recommended because it relaxes the constraint of assuming that data are normally distributed and [that] confidence intervals are therefore symmetrical (Crawley 2005). The confidence intervals for both the estimates of cluster density and population density were slightly positively skewed, indicating that the data were not normally distributed*."

So, in short, no transformation was used.

Galea (2023) is incorrect that data need to be normally distributed. It depends what procedure is being used. The comment about log-transformation is based on a total lack of evidence and in spite of the description by the author which clarify that no transformations were involved (Cairns 2019, pp 36-37). This is most likely another example of a criticism written in too much haste but the result has the unfortunate appearance of an attempt to make a target where there is none, or in other words to 'create a straw man' for the purpose of having something easy to criticise.

B3 Use of covariates – p. 13

Galea (2023) says that the count reports (i.e. Cairns 2019, 2022) do not make clear which covariates were used in the detection function modelling and that the reports are 'confusing' in this regard. Galea (2023) concludes '*Determining what covariates were included and what impact they had on the accuracy of the models cannot be determined from the reports given the conflicting information provided and therefore the generalisability of the results across the entire four blocks should be interpreted with caution*'.

In fact, the opposite is true. Cairns (2019, 2022) is quite clear about what was done and why. It appears likely that Galea simply overlooked the important words on this topic in both reports, i.e. 'CDS' and 'MCDS', which stand for Conventional Distance Sampling and Multiple Covariate Distance Sampling. As the name suggests, covariates are used with MCDS. Covariates cannot be used with CDS.

Unfortunately, Galea's quotations from Cairns (2019, 2022) omitted the crucial information which answers her criticism. I provide the full text from Cairns (2019) in the two following paragraphs, with underlined text indicating the words that were quoted by Galea (2023) as evidence of '*confusion'*.

On page 19: '*DISTANCE 7.3 has three different analysis engines that can be used to model the detection function (Thomas et al. 2010). Two of these, the conventional distance sampling (CDS) analysis engine and the multiple-covariate distance sampling (MCDS) analysis engine were used here. In analysing survey results using the CDS analysis engine, there is no capacity to include any covariates other than the perpendicular distance of a cluster of horses from the transect centreline in the modelling process. ……… If the MCDS analysis engine is used, additional covariates can be included in the analysis.*

On page 21: '*The MCDS analysis engine allows for the inclusion in the detection function model of covariates other than the perpendicular distance from the transect centreline (Thomas et al. 2010). ……* The covariates used in these analyses were related to individual detections of clusters of horses and were identified as observer, cloud cover score and habitat cover at point-of-detection. All these covariates were categorical. There were three observers (DS, MS and SS), three grades of cloud cover (1 = clear to light, 2 = medium, 3 = overcast to dull) and two categories of habitat cover at point-of-detection (1 = open, 2 = timbered), indicating that horses were either sighted in the open or in timbered habitat. The three covariates were included in the analysis either singly or in pairs.'

In regard to the quoted text Galea (2023) says:
'It is unclear throughout the report from Cairns (2019) as to what covariates were included and when. On page 19 it states that *"there is no capacity to include any covariates other than the perpendicular distance of a cluster of horses from the transect centreline in the modelling process"* yet on page 21 it states that *"The covariates used in these analyses were related to individual detections of clusters of horses and were identified as observer, cloud cover score and habitat cover at …….".*

The evidence shows that it was Galea, not Cairns, who was confused. And it was Galea who was responsible for creating confusion by making an incorrect criticism and misquoting (by omission).

The report (Galea 2023) goes on to apply the same level of scholarship to the corresponding sections of Cairns (2022).

Then there is a third mistake under this heading. Referring to a kangaroo counting report (Cairns 2016) Galea (2023) conflates the listing of putative co-variates for statistical evaluation (such as would be found in the Methods section of a scientific report), with the reporting of which of these putative co-variates had come through the statistical evaluation to prove worthy of retention in the model (typically found in the Results section). This is a surprising mistake for an experienced statistician to make. It is yet another instance in Galea (2023) where ordinary normal text by Cairns (2019, 2022) has been misunderstood or misquoted.

In summary, the criticism under this heading is wrong. The horse counting reports of Cairns (2019, 2022) are not confusing in regard to co-variates.

B 4 Assumptions – p. 14

The report quotes Cairns (2019) who, in full, stated:

'*There were parts of each block that were not surveyed either because of the steepness of the terrain or because the land was under private ownership and were therefore not included in the calculations of population abundance (see Section 2.1). ……*

Given along with the population abundances in Tables 9 and 10 are a second set of population densities. These are densities derived in relation to the total areas of the survey blocks. Implicit in their estimation are the assumptions that the horse population in a block would be aggregated in its distribution and that the density of horses in the very steep country within the survey blocks would be at trace levels; i.e. *near to zero. This assumption could be open to challenge, but could only be refuted with comparable survey results*.'

In the quoted paragraphs, Cairns is explaining his assumption that there were no horses in the areas he did not count. If that assumption is wrong, then the population size will have been UNDERestimated. Yet Galea comments that '*without comparable survey results there is no way of knowing if this assumption had a significant impact on the … population estimates*'. (Is this an 'own goal' by Galea?) Again, no practical alternative is suggested. To apply counting effort where horses are so sparse that they probably can't be detected from the helicopter, would not be reasonable.

B 5 Grouping of Zones for modelling – p. 14

Galea (2023) states that '*In both the [Cairns] 2019 and 2022 reports the populations across the blocks are merged with a global detection function model applied and a single estimate determined. However, it is clearly evident from the report that the blocks provide significant differences in the wild horse counts along with the sizes and expected detection being different.*
…..
CONCERN: *Independent modelling of the four blocks should be undertaken and no overall population estimate reported.*'

This too is wrong. Cairns (2022, p. 2) states '*The survey of the wild horse population in KNP was conducted in four survey blocks that were identified by NSW NPWS as being in areas known to support wild horses'*. A different level of precision was specified for each block as presented in Table 1 on p. 2 of Cairns (2022), ranging from 20% to 40%. (Precision refers to the uncertainty or variance of each estimate, or in other words, the relative length of the error bars shown with each estimate).

Because of the requirements for different levels of precision the blocks could not be combined into a single analysis, nor were they. Tables 4, 5, 6, and 7 (Cairns 2023) present results separately for each block.

B6 No increase in the population over 2 surveys – p. 15

The point is made by Cairns (2022) that the higher population estimate in 2022 is not significantly different statistically (at the conventional 0.05 level) from the count in 2020. It may seem paradoxical to those without ecological experience, but that does not mean the population is not increasing.

The reason is that because all estimates of population size have a confidence interval, estimates that are close enough in time can not differ significantly (Figure 1). An example may communicate this better, so imagine a population of animals that is increasing constantly. If the population size is estimated often enough, e.g. every day or every week or every month, consecutive estimates would not differ from each other by very much even if the confidence intervals around the estimates of population size were unrealistically small (say 5%). Yet we know for certain that this hypothetical population is increasing because we made it that way. The answer is not to spread out the time between counts so that the differences between consecutive counts will be significant. The opposite is true, the more often we count the population, the better we will know it.

The answer is that testing whether consecutive counts are significantly different is a poor way to determine whether a population is increasing, stable or decreasing. There are better ways described in many ecology textbooks (but I do not need to go into them here). Suffice it to say that the horse population is probably still increasing, but even if it were stable, Galea's assertion that this would mean culling should stop is illogical.

The need to reduce the horse population is determined by the impact of the number of horses and by whether the number is higher or lower than the statutory requirement to achieve a population of 3,000 horses. The requirement for culling is unaffected by whether the number is increasing, decreasing or stable. To explain in an easier way, using an example, Galeas' assertion is like claiming that no parachute is needed when jumping from aeroplanes flying level, only for aeroplanes that are climbing.

B7 Implausible population estimates – p. 15

The 2019 survey actually saw and counted 1,374 horses, from which the population was estimated to be 15,687, which is 11.6 times as many. Galea evidently thinks this ratio is too high. But it is often unavoidable in ecology, e.g. the leading edge application of thermal drone technology (Brack *et al*. 2023) which estimated the population of swamp deer in Sesc Pantanal Reserve, recorded 66 deer from which they estimated the population in the reserve was 1,856 (95% CI 951–3710), which is 28 times as many. Yet Galea (2023) reports the result with horses to be '*implausible'* without quoting any other evidence or any kind of analysis. This is not scientific.

It is common in human medical research for there to be an interaction with every human subject, something virtually unknown in ecology. A pasture ecologist, for example, cuts and dries vegetation samples from quadrats whose area might represents one millionth of the vegetation patch about which the ecologist will make descriptive statements and predictions. An ecologist studying insect species may never see 99.999% of the individuals of the population under study. Thus the design and practice of sampling is a core activity in ecology, but less central to medical research. Perhaps that is why a medical statistician made this mistake.

B8 Width of the confidence intervals – p. 15

The report points to the width of the 95% Confidence Interval for the 2022 survey i.e. 14,501 to 23,535 as a reason the population estimates from horse surveys are '*unreliable'*.

This result was better than the owners of the survey had intended. Their requirements for precision were stated in advance (Table 1 in Cairns 2022) and were bettered in all survey blocks (Table 6 in Cairns 2022).

How can it be that a level of precision that is better than what the experienced people responsible for the survey had paid for, is regarded by Galea as unacceptable?

Wildlife surveys only rarely provide tight precision and to improve precision is often impossible or at best inordinately expensive. Many component measurements are being combined, including the height of the aircraft, its position, the distance from the transect to the horses, and the distribution of horses between transects. In addition, the animals move in and out of view and during the course of the survey there may be births, deaths, immigration and emigration. These potential sources of errors magnify, resulting in wider confidence intervals than would be achievable in some other circumstances, such as lab-based research.

The reference given to support Galea's opinion that the confidence intervals are too wide (Bonham 1989) is actually a web page about the beauty of racehorses and does not contain any such statistical comment.

Please note that precision is expressed in the survey report (Cairns 2022) in terms of the Coefficient of Variation (CV%). This is the normal metric for the purpose and is widely used. Galea's use of the 95%CI as a percentage of the mean is one I have not seen before. It results in a higher percentage than the CV.

C1 Implausible population increases – p. 16

Among brumby activists there is a persistent idea that some of the rates of population increase observed in the wild are impossible. Doubt about the population growth leads to the thought that the population estimates must be wrong. Such observers sometimes point out that their well fed mares only produce a foal every second year. Even if the population comprised an equal number of male and female breeding adults, that would corresponds to 25% increase per year so real populations would increase at lower rates.

Early research on the Kosciuszko feral horses produced an estimate of 22% for the intrinsic rate of increase of horses (Dawson 2002, p. 70). This has been variously misquoted as a maximum population growth rate (PGR) for horses, but the two are different. (Confusion is not helped by a commonly used representation of the intrinsic rate of increase as r_{max} or r_m). A population grows at the intrinsic rate of increase for that species if it has a balanced sex and age distribution, and is not limited by food or other resources, or externally imposed mortality such as harvesting or predation (Caughley 1977). The details of this definition are important.

Most populations, most of the time, have PGR close to zero (Caughley 1977; Hone 1999, 2012; Sibly and Hone 2002), much lower than the intrinsic rate of increase for the species, but population growth rates higher than the intrinsic rate of increase are possible in unusual cases, for example a female biased population can grow faster than the intrinsic rate of increase and so can a population that is biased toward the maximum breeding age. Farmed animal populations normally exhibit both features. So PGRs greater than Dawson's (2002) estimate of 22% for horse r_m are possible and have been observed. Wild horse population growth rates up to 39% have been observed by researchers (Scorolli and Lopez-Cazorla 2010).

In addition, horses move into and out of the areas counted, for example between KNP and parks in Victoria. Changes in the estimated population size that are greater than 22% have been partly attributed to such movement (Cairns 2022). The extent and frequency of such movement has not been researched, so unfortunately there is no way to determine how much of the large increases in estimated population size are due to breeding, how much to immigration, and how much to counting error. In the absence of that research, Galea's (2023) criticism is unfounded.

C2 Movement of horses – p. 17

The report says that because horses are capable of crossing the line bounding the counted area, '*the possibility of double counting cannot be eliminated*'

This is illogical. Observers were not counting the same area more than once so there is no question of so called '*double counting*' due to local movement of horses. If animals move into the counted area before the day of counting they will be included. If they move out before the count, they will not be included. Animals whose home ranges straddle the boundary of the counted area contribute to the inherent variability between successive wildlife counts by being inside the counted area in some years and outside it in others.

The report also says about the Kosciuszko horses that '*a true count cannot be determined*'. Here Galea may have begun unwittingly to uncover an important concept. The important idea is to accept that estimating the size of a wild animal population is not analogous to normal counting (of human research subjects, for example, or farm animals in a yard) where the exact number of counted objects can be determined.

A wild population is more like a river flowing constantly. While the count is underway and after it has been completed, animals are dying, and being born, and moving into and out of the area, and these changes are unseen by the person doing the counting. The exact number of animals in the population at any instant is unknowable. Even the geographic extent of a population at a particular time is usually impossible to know exactly, except perhaps on an island or in artificial settings.

Ecologists almost never determine an exact number for wildlife population size but an exact number is not required. What is needed is an estimate of population size that is good enough for the purpose for which the count was done.

C3 Foals and joeys – p. 17

The report claims that the surveys provide no counts of foals. First, this is a gratuitous claim because separate counts of foals have never been shown to be necessary. There are numerous examples of vertebrate species being managed successfully without separate counts of juveniles. But in any case, foal counts are plainly evident in the reports, for example in Cairns (2022) they are mentioned in the Summary, the Methods on p. 16, in Table 7 that occupies all of p. 27, and their discussion occupies almost an entire page in the Results and Discussion (p. 26). The count of foals goes above and beyond what is required for the management of the Kosciusko horses and is so difficult to miss that it leaves the reader scratching their head how this claim came to be made.

C3 is yet another mistaken claim by Galea (2023).

CONCLUSION

Galea (2023), the report named in the title of this commentary, is not a reliable scientific document because many of its criticisms prove on closer inspection to be mistaken, based on a misreading of the reports being criticized, or based on a misunderstanding of ecological methods. In some cases, criticisms are repeated under a different title, creating a false impression of the number of problems found.

The criticisms of Helicopter Line Transect Distance Sampling to estimate the population abundance of feral horses in KNP are not supported by either evidence, such as references to scientific literature comparing superior alternative methods, or by published results of alternative counts in KNP using well understood methods of abundance estimation that are recognised in the scientific literature. No data are provided and there are very few references to the vast ecological literature on wildlife counting.

There is an established body of scientifically credible material available on the counting of the feral horse population in Kosciuszko National Park (Walter 2003; Walter and Hone 2003; Montague-Drake 2005; Laake et al 2008; Dawson 2009; Dawson and Hone 2012; Cairns 2019, 2020, 2022). Galea (2023) adds nothing either credible, or valuable, to this subject.

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APPENDIX: Horse population estimates in KNP and how calculated

Date	Area surveyed	Report	Size of area surveyed (sq km)	Horse Popn estimate	Lower 95% Conf Limit	Upper 95%Conf Limit	Horse Popn in KNP (calc from AANP survey as needed)	Upper 95%CI for KNP	Lower 95% CI for KNP	How KNP portion calculated
Mar-01	AANP	Walter and Hone 2003	2,789	5,200	1,979	8,421	3,000	1,858	1,858	Kosciuszko NP component estimated by Walter (2005)
Apr-03	AANP	Walter 2003	2,717	2,369	3,937	3,937	1,367	905	905	Same proportional adjustment as above (0.58)
Jun-05	KNP	Montague-Drake	1,052	1,357	759	1,955	1,357	598	598	No change necessary
Apr-09	AANP	Dawson 2009	2,860	7,679	CV 25.4%		4,684	2,332	2,332	Adjusted by the proportion of horse groups counted in Kosciuszko NP, given in Dawson (2009 Table 1), ie 0.61.
May-14	AANP	Cairns 2019	7,443	9,187	7,484	11,595	5,604	1,984	1,984	Adjusted by the proportion of horse groups counted in Kosciuszko NP, given in Cairns (2019 Table 3), ie 0.61 excluding the Bago Maragle block and half of the Byadbo-Victoria count.
May-19	AANP	Cairns 2019	7,443	25,318	CV 12.3%		19,242	4,581	4,581	Adjusted by the proportion of horse groups counted in Kosciuszko NP, given in Cairns (2019 Table 3), ie 0.76 excluding the Bago Maragle block and half of the Byadbo-Victoria count. Confidence Limits estimated from CV.
Oct-20	KNP	Cairns 2020	2,673	14,380	8,798	22,555	14,380	8,175	5,582	No change necessary
Oct-22	KNP	Cairns 2022	2,675	18,814	14,501	23,535	18,814	4,721	4,313	No change necessary
	AANP = Australian Alps National Parks; KNP = Kosciuszko National Park									

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