**Review of 'A thermal camera survey trial of the wild horse populations in Kosciuszko National Park, NSW, October-November 2024'**

(A report to NSW Department of Climate Change, Energy, the Environment and Water, February 2024 by [redacted])

[redacted]
June 2025

The report describes an aerial thermal camera survey of feral horses in Kosciuszko National Park (KNP) in late 2024. Two cameras were attached to a helicopter that was surveying the horse population using aerial line transect sampling and has been reported ([redacted] 2024), and reviewed, previously. This provides a logical and cost-effective assessment of the ability of thermal cameras to monitor the horse population. Aerial line transect sampling using trained observers is an accepted method globally of monitoring populations of large vertebrates such as horses in open to semi-open environments (i.e. not closed canopy) on a broad scale such as the survey area here (>2,000 $km^2$). Aerial photography (still or video) offers several advantages over aerial surveys using observers. These include include safety (particularly with drones), verifiable data, cost, and simplified analysis (Buckland et al. 2023). The method is not yet considered a replacement for aerial survey with human observers, requiring assessments such as these, which will prompt modifications and help provide operational guidelines.

There are no major concerns with the survey and data recorded, or the analysis. Some comments and queries are provided below.

1. Page 2-3. In the abstract (abstract point 8), and indeed in the main text, it is important to point out that MRDS differs from MCDS in adjusting for horses missed by observers on the trackline (=zero distance). This then helps explain why thermal camera estimates of horse abundance are comparable to observer MCDS estimates but below those for observer MRDS estimates.
2. Page 3. Rather than state whether camera estimates were higher or lower than observer estimates, the percentage difference could be given. This would indicate the extent of any problem. The thermal survey estimate for KNP is 23% below the MRDS estimate.
3. Page 3 (abstract points 9 and 10). Flushing appeared to be a problem, but thermal MCDS estimates were still comparable to observer MCDS estimates. There are other possible causes for the differences between estimates. Many horses may simply have been hidden in the camera images. This is discussed in more detail below.
4. Page 3 (abstract points 9 and 10) '…*furthest* sighting zones.' '…lower *horse* detections by cameras, ...'
5. Page 5. In the fourth paragraph of the introduction, it is important to highlight that MRDS corrects for animals missed on the trackline [p(0)<1]. That estimate is therefore more accurate than MCDS. No correction is attempted or possible here for p(0)<1 for the thermal survey.
6. Page 7. ESW is referred to in paragraph 4 and readers should be referred to its definition on page 9.
7. Page 9. CV is not a great indicator of model fit. It is mainly influenced by the variation in sightings between transect lines.
8. Page 10. What were the sample sizes in each survey block? This will give confidence in the modelling of the detection function.
9. Page 10. The last two sentences are odd statements and unnecessary without further explanation.
10. Page 11. In Table 1, what is 'Temp(Strata)'?

11. Page 13. Paragraph at bottom of page. Surely the analysis was standard geographic stratification (strata = the four blocks) rather than post-stratification. The latter refers to unstratified designs, which is not the case here. Data can be post-stratified by gender or habitat, for example, and enables density estimates to be determined for these components (Buckland et al. 2015).
12. Page 14. Global detection functions seem reasonable for the two datasets despite strata not being considered as a covariate. Habitat is considered as a covariate and is the most likely reason for any differences in detection probability among strata.
13. Page 16. As mentioned in the discussion, standard errors overlap when comparing abundance estimates in each block. A KNP estimate for the three survey methods (thermal, MCDS and MRDS) would provide a succinct summary of the results, particularly given there is no discussion as to why the disparity between methods varies among blocks. KNP estimates have better precision, although the standard errors still overlap.
14. Page 19. In paragraph 5 it is suggested that p(0) may vary between blocks. While possible, it must also be considered that horses were hidden from the cameras and in subsequent imagery. In other words, p(0)<1 for aerial photography. It would be worth devising a way to quantify p(0).
15. Page 19. Paragraph 6. This was a useful exercise. Flushing will cause bias which may only be small if animals only shift a short distance. If they shift off the strip, then bias will obviously be larger. Interestingly, there was no evidence of flushing in the histograms of sightings (Figure 2), but responsive movement is not always obvious in these.
16. Page 19-20. Aiming cameras forward would help detect animals before they move, as observers can do. As pointed out, this can create measurement problems. An alternative would be to attach cameras underneath the helicopter and view directly in front in a strip (Buckland et al. 2023) and, possibly, directly behind. By viewing in both directions, problems caused by the angle of the sun can be accommodated. Mark-recapture may also be possible by using the two cameras.
17. Page 19 (paragraph 3). '… due *to* their *response* to helicopters.' (rather than *wariness*)
18. Page 20 (paragraph 3). '… horses were not *resting* at the time of the survey in thicker canopies.'
19. Page 20. Final paragraph. It is stated that *aerial photography is not suitable, particularly under canopies*. This statement needs some support, clarification (e.g. canopy closure) and ideally a reference. Similarly, in the following two sentences, the new technologies need to be named, or a reference provided.

**References**

Buckland ST, Rexstad EA, Marques TA, and Oedekoven CS (2015) 'Distance sampling: Methods and applications.' (Springer: London, UK)

Buckland ST, Borchers DL, Marques TA, and Fewster RM (2023) Wildlife population assessment: Changing priorities driven by technological advances. *Journal of Statistical Theory and Practice* **17**, 20. doi: 10.1007/s42519-023-00319-6.

[redacted] (2024) A survey of the wild horse population in Kosciuszko National Park, NSW, October–November 2024. Report to the NSW Department of Climate Change, Energy, the Environment & Water, November 2024.

**Comments on A thermal camera survey trial… 2024, by [redacted], Feb. 2025**

**General comments**

The report is a useful summary of methods and results of the Oct-Nov 2024 wild horse survey in Kosciuszko National Park. The report states that the thermal cameras appear to miss some horses and provide lower estimates of horse abundance. There are concerns about the quality of analysis and scientific writing with details provided below.

**Specific comments**

*Abstract*

Point 6. Temperature is identified as the covariate having greatest effect of detectability. The AIC analysis shows that temperature and several other covariates had nearly identical AIC values so temperature itself was not clearly and solely associated with detectability. Temperature is discussed later in this report.

Point 6. The estimates for adult horses and adults plus foals are very similar. The report doesn't state or mention whether the survey months (Oct.-Nov.) are in the early stages of a seasonal summer breeding of the horses, so very few foals would be expected to be seen and hence counted. A reference should be included for the season of births and hence foals.

Point 8. The text states that various estimates were higher than other estimates yet does not state the actual estimates, so the reader has to search for the estimates in the report.

**Introduction**

**Background**

The section describes some of the background to the study. However, it omits reference to published literature on MRDS and thermal imagery including of wild horses. For example, the feral horse study of Ludow & Ransom (2016) that reported unbiased estimates to overestimates is not cited. Also not cited are four studies of use of thermal cameras which reported unbiased estimates for feral horses (Schoenecker et al. 2018), to underestimates of white-tailed deer (Potvin & Breton 2005), and of feral pigs (Hvala et al. 2023), and of donkeys (burros) (Hennig & Schoenecker 2023).

Some references are cited in the Background section, yet are not listed in References at the back of the report, for example, Environment & Heritage Group 2021; amended 2023, and Thomas et al. 2006.

The section states MRDS uses 3 observers yet it can be done with 2.

**Methods**

**Study area**

The first line has a typographical error – "of the " is repeated.

**Survey design**

The section refers to [redacted] (2020; 2022;2023) yet none are listed in References.

The last sentence states the transect layouts are shown in a report, yet they are shown herein Figure 1.

The section should state the sampling intensity used in each survey block.

**Thermal cameras**

Spelling error in 4th last line – "be" should be "been".

**Thermal footage processing & animal counts**

The first line cites "Lethbridge 2019" yet this is not listed in References. Similarly, on page 8 the text cites "Lethbridge 2018" yet it is not listed in References.

**Multiple Covariate Distance Sampling**

The text states that temperature data were taken from the BOM Thredbo rain gauge, though presumably it means the Thredbo weather station as rain gauges don't measure temperatures. Given the three survey blocks, the temperature data should have been obtained from weather stations closer to each block. For example, the northern block could use data from Cabramurra and/or Adaminaby, the southern block should use Thredbo data (as done), and Snowy Plains use Jindabyne data. Continuous data from each weather station should be obtained from BOM and could be more directly related to survey times, though may need to be purchased.

The analysis used AIC, which leads to the question, why not AICc?

The final section sentence starts "uNLIKE Analyses" which requires an explanation or reference so a reader can follow-up the details.

A comment is that the Methods section should have a Table showing the actual metrics used for each covariate, and the range of actual data for each measure. At the moment, the text does not state details of each metric used.

**Results**

**MCDS**

Table 1 lists the density estimates for each combination of covariate. It is surprising that the adult horse density estimates are so similar given the AIC values differ by up to 25 and 26.

Figure 3 shows the detectability at three different temperatures matching the range of temperatures during which surveys occurred. The text doesn't help the reader assess the probability of each temperature. For example, was 15°C much more representative of actual temperatures, which it appears it may have been given the shape of the 15°C line in Figure 3 and fitted line in Figure 2. Potentially the results shown in Figure 3 confound temperature and time of day, reflecting the rising temperatures occurring each early morning and the decreasing temperatures occurring each late afternoon.

Top of page 14. “The detection function … was determined globally for all blocks.” Does this mean one function was used for all blocks?

Pages 15, 16, 17 and 19 have no page numbers.

Table 3. It would be helpful to managers for the table to show density and abundance estimates with measures of precision, such as 95%Cis, for the combined three blocks overall.

The text could consider why the MRDS estimates are higher for adult horses than adult plus foal horses in Figures 4 and 5. The differences are not major or significant but deserve comment.

**Discussion and Summary**

**Key findings**

The absence of a true population number is acknowledged. However, published literature (cited earlier) shows where others have tried similar aerial surveys and reported actual bias. The current report should use such literature to help reach its conclusions.

Page 19, fifth paragraph. “The was “ should be “There was”.

Page 19, sixth paragraph. “saw in had” needs editing.

**Limitations**

Page 21. The section is helpful as it reflects on the survey and results. The final paragraph could be more specific as to what “new technologies are emerging” and cite some references to help readers find out details of the new technologies.

**References**

The section lists 32 references. Only 6 are cited in the report! This suggest the list was taken from a different report or left over from a previous report.

Additional references on bias in aerial survey, not cited in the report.

Hennig, J. D. & Schoenecker, K. A. 2023. Comparing methods to estimate feral burro abundance. Wildlife Society Bulletin 47 (4), e1495.

Hvala, A., Rogers, R. M., Alazab, M. & Campbell, H. A. 2023. Supplementing aerial drone surveys with biotelemetry data validates wildlife detection probabilities. Frontiers in Conservation Science 4, 1203736.

Ludow, B. C. & Ransom, J. I. 2016. Practical bias correction in aerial surveys of large mammals: validation of hybrid double-observer with sightability method against known abundance of feral horse (*Equus caballus*) populations. PLoS ONE 11 (5), e0154902.

Potvin, F. & Breton, L. 2005. Testing 2 aerial survey techniques on deer in fenced enclosures – visual double counts and thermal infrared sensing. Wildlife Society Bulletin 33 (1), 317-325.

Schoenecker, K. A., Doherty, P. F., Hourt, J. S. & Romero, J. P. 2018. Testing infrared camera surveys and distance analyses to estimate feral horse abundance in a known population. Wildlife Society Bulletin 42 (3), 452-459.

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