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24 March 2025

[redacted]
NSW National Parks and Wildlife Service
Kosciuszko Road Jindabyne

Dear [redacted]

Re: Wild horse population survey

I've now read "A survey of the wild horse population in Kosciuszko National Park, NSW, October-November" by [redacted].

I make the following comments:

Survey design, data collection and analysis

- The aerial survey methods used (aircraft type, aircraft speed and height, human observers) are suitable for surveying feral horses.
- The methodology appears sound.
- It's good to see mark-recapture distance-sampling methodology being used. Given the relationship between group size (impacted by control) and detectability, it is needed for setting removal targets.

Estimated change in horse populations

- The assumption in Table 2 of the report that the population in the northern block would have increased at 22.5% is unlikely to be true. This rate of population increase is probably close to the maximum (r_m) for the species in this environment, and only applicable when resources aren't limiting (e.g. during the early stage of invasion). Changes in population estimates derived from surveys of the northern block in 2019, 2020, 2022 and 2023 point to a much lower likely rate of increase. After accounting for known removals, the average annual rate of increase for the Northern Block is *c.* 0% across all the 2019-2023 surveys and *c.* 7% if the 2019 survey is ignored. So it's entirely plausible the population in the northern block had effectively ceased growing by the time of the 2023 survey – a not unexpected result given the length of time it has been present and largely uncontrolled (see Forsyth and Caley 2006). Furthermore, given that the removals occurred part-way during the year, any density-dependent recruitment in foals from surviving mares would not be expected until the summer following the 2024 survey.
- Notwithstanding the previous point, even allowing for minimal/no population growth following the 2023 survey, there remains a considerable discrepancy between the estimated population sizes from the 2024 survey and the expected population size based on known removals.
- There is no reason to seriously question the estimated number of horses in late 2023 prior to the aerial control campaign in 2024, especially given the congruence of the 2023 estimates with those from 2022 and 2020. Neither is there any reason to be overly concerned about the lower-than-expected (based on known removals and 2023 survey) population estimate in 2024 is due to a methodological problem. The discrepancy could arise from sampling variation (in both 2023 and 2024), movement of horses out of the control area in response to control, or a combination of both

factors. Population estimates based on sampling will always have some uncertainty arising from sampling variation, arising from spatial variation in the location of horses with respect to transects.
- It should be possible for the authors to provide confidence intervals around the population estimates derived from the 2024 survey.
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Effect of aerial shooting operations on horse behaviour

Short-term movements in response to approaching helicopter

- It is my opinion that prior to the aerial shooting from helicopters, the response of horses to an approaching helicopter will be limited – there will be some flushing behaviour from close to the transect centre line, though only from when the aircraft if close enough that counting and distance classification has already begun. Movement away/off the transect is inconsequential. Following on from this, in context of transects spaced at 1.5 km, movements between transects will be inconsequential. However, following the aerial shooting operation, evasive movements in response to an approaching helicopter are plausible and to be expected at some level. I note that the detection functions in Figures 8 and Figures 9 in the latest report appear to be considerably flatter than those presented in the analysis of surveys from 2019, 2020, 2022 and 2023. This could arise from observers having consistently differing search patterns between the 2024 survey and previous ones, or that horses in 2024 were moving earlier in response to approaching helicopter. I would consider the differing observer search pattern unlikely, with leaves the possibility that either the horses were behaving differently in response to the approaching aircraft, or that the result arises from chance variation in the distribution of horses on the surveyed transects. More investigation is needed.
- If the helicopter surveys generate larger short-term movements towards areas of density cover and steeper terrain that are outside the survey area, this should manifest in average Day 1 counts being higher than average Day 2 Counts.

Longer-term movements in response to widespread aerial shooting operation

- Again, it is entirely plausible, and even expected, that horses will substantially change their behaviour in response to the aerial shooting operation. Horses are intelligent animals, and them being present during the aerial shooting operation, followed by the presence of horse carcasses spread through their environment would be expected to generate an avoidance response. Whether a substantial proportion of the surviving horses have moved outside of the survey area is unknown with the available information, although the difference between the expected post-cull and post-survey estimates would infer this to be the case.
- Ongoing surveys will clearly help resolve this uncertainty.

Recommendations

- The current helicopter-based aerial surveys should continue, with the inclusion of mark-resight distant sampling as started in 2024.
- The application of non-helicopter-based methods for estimating horse population densities should be explored.
- Quantifying broadscale horse movement behaviour in response to aerial shooting behaviour is needed.
- A post-hoc comparison of population estimates arising from Day 1 surveys only versus Day 2 surveys only (with pooled sighting detection parameters) would shed light on any short-term movement off the survey blocks arising from exposure to aircraft noise.

I'm happy to answer any follow-up queries.

Regards,

[redacted]
Adaptive and Integrated Monitoring and Surveillance Team
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[redacted]

References

Forsyth DM and Caley P (2006) Testing the irruptive paradigm of large-herbivore dynamics. *Ecology* **87**, 297–303.

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

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

[redacted]
March 2025

An aerial survey of feral horses was undertaken in 2024 similar to that in 2023, again using accepted methods for this species. An important difference from the 2023 survey is that mark-recapture distance sampling (MRDS) was also used allowing adjustment for the common failure of aerial surveys using distance sampling [conventional distance sampling (CDS) or multiple covariate distance sampling (MCDS)] to not meet the assumption of detecting all animals on the transect line (i.e. zero distance). In other words, the probability of detection on the transect line $p(0)<1$. This required a third observer seated at the front left of the helicopter allowing simultaneous counts by two observers on the left-hand side. By not meeting the assumption of certain detection on the line, abundance will be underestimated. The problem is well recognised, and the solution of using MRDS is well described and often implemented (Laake et al. 2008, Burt et al. 2014, Buckland et al. 2015).

MRDS can provide an estimate of abundance based on using just the counts of the two left-hand observers, which is effectively one set of independent observations. An alternative, used in this survey, is to use the left hand observers to calculate p(0), and then apply this to the counts of the two rear observers, which are two sets of independent observations. This increases both sample size (roughly double) and the area surveyed (double), which should improve precision and modelling of detection functions. A potential downside is that the right-hand observer counts have not been used to determine p(0). The assumption is that p(0) applies to all observers and seating positions. This could not be tested with these data. Observers were rotated among seating positions. This was a reasonable compromise.

Removal of >5,000 horses since the 2023 aerial survey meant the horse population would be smaller and possibly less evenly dispersed. The survey design needed to be altered to achieve precision comparable to previous surveys. Line length was appropriately increased. Another way of improving precision would have been to take advantage of the stratification by block and increase survey effort in the higher abundance, northern block, relative to the other blocks. Precision of 21-22% for the three survey blocks combined (Tables 10 and 12) is nevertheless reasonable despite being poorer than that reported for the 2023 survey (~14%). Adequacy of precision will depend on the use of the population estimate, such as the probability that a target density has been reached.

While there are no major concerns with the survey and data recorded or the analysis, a number of specific queries are provided as comments on the PDF of the report. The main concerns are provided below.

1. Different estimates of horse abundance are provided in various tables for the three survey blocks combined (KNP). (i) 4,045 for horses and foals in retention areas, (ii) 3,885 for horses and foals in KNP, and (iii) 3,949 for horses in KNP. The differences are relatively small but are not adequately explained and will lead to confusion for a reader.
   For(i) vs (ii) & (iii), the data need to be reanalysed. A more appropriate analysis is to have retention and removal areas as substrata of each of the survey blocks. The population estimates

and standard errors can then be combined as for normal stratification. This was done by [redacted] for the 2023 survey data.
For (ii) vs (iii), the difference looks mostly due to p(0) and not g(x). N(horses and foals) is greater than N(horses) from Tables 5 and 7. The MRDS analysis would need to be examined to determine the cause of the difference. A less confusing approach would be to just present the estimate for horses and foals. Better still would be to just present the estimates for horses and foals in the retention and removal areas within blocks and then combined at the block level, then at the KNP level.

2. Furthermore, two different estimates of KNP horse density are provided in Tables 12 (1.467) and 13 (3885/2536 = 1.53). This is likely due to stratified vs unstratified estimation. The disparity is unnecessary, and the confusion could be avoided by providing just one estimate.

3. In a similar vein, the CDS estimates are unnecessary. Table 3 can be combined with Table 4, showing CDS models are poorer based on AIC.

4. Summary tables (Tables 5, 7, 11, 13 and 14) need to provide horse abundance, density and associated 95% confidence intervals for the three blocks combined (KNP). Confidence intervals for KNP are important to compare with previous surveys, target densities and making risk-based decisions. Decisions such as how many horses to remove to retain 3,000 are made at the KNP level rather than at the block level. The KNP estimate has better precision than the block estimates and this needs to be quantified with confidence intervals.

5. The report highlights the disparity between predicted and actual number of horses in KNP. Some plausible explanations are given and reasonable suggested corrections offered. Additional explanations include the lack of the assumed increase (22.5%, Table 2) and indeed a possible natural decline between the 2023 and 2024 surveys in addition to the removals.

6. Some terminology in the report needs correcting. Two prominent examples are:
   - p(0) is probability of detection on the transect line and is only one component of perception bias.
   - It is stated for several analyses that the data were ‘post-stratified’. However, the strata (blocks) were geographic, so surely standard stratification was used. Post-stratification in the Distance literature refers to non-geographic strata.

References

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

Burt ML, Borchers DL, Jenkins KJ, and Marques TA (2014) Using mark–recapture distance sampling methods on line transect surveys. *Methods in Ecology and Evolution* **5**, 1180-1191.

Laake J, Dawson MJ, and Hone J (2008) Visibility bias in aerial survey: Mark–recapture, line-transect or both? *Wildlife Research* **35**, 299-309.