MEMORANDUM

To: Tyrell Turner (BLM)
CC: Lynae Rogers, Paul Griffin, Scott Fluer, Paul McGuire (BLM)
From: Michelle Crabb (BLM) WHB Program Population Biologist
Date: 07/31/2024
RE: Statistical analysis for 2024 survey of horse abundance in Sand Wash Basin HMA, CO

Summary Table

Survey Areas and Dates	Start date	End date	Area name	Area ID
	5/29/2024	5/30/2024	Sand Wash Basin HMA	CO0143
Type of Survey	Simultaneous double-observer			
Aviation Details	Pilot: Megan Siler, Choice Aviation, Fixed-wing: Cessna 172, #N316CA			
Agency Personnel	Observers: Lynae Rogers, Tyrell Turner, Matt Dupire (BLM)			

Summary Narrative

In May 2024 Bureau of Land Management (BLM) personnel conducted simultaneous double-observer aerial surveys of the wild horse populations in the Sand Wash Basin herd management area (HMA; Figure 1). Surveys were conducted using methods recommended by BLM policy (BLM 2010) and a recent National Academy of Sciences review (NRC 2013) with detailed field methods described in Griffin et al. (2020). These data were analyzed using methods in Ekernas and Lubow (2019) to estimate sighting probabilities for horses, with sighting probabilities then used to correct the raw counts for systematic biases (undercounts) that are known to occur in aerial surveys (Lubow and Ransom 2016), and to provide confidence intervals (which are measures of uncertainty) associated with the abundance estimates. Estimated abundance in and near the HMA is listed in Table 1, below.

Table 1. Estimated abundance (Estimate No. Horses) is for the number of horses in the surveyed areas at the time of survey. 90% confidence intervals are shown in terms of the lower limit (LCL) and upper limit (UCL). The coefficient of variation (CV) is a measure of precision; it is the standard error as a percentage of the estimated population. Number of horses seen (No. Horses Seen) leads to the estimated percentage of horses that were present in the surveyed area, but that were not recorded by any observer (Estimated % Missed). The estimated number of horses associated with the HMA but located outside the HMA's boundaries (Est. No. horses Outside HMA) is already included in the total estimate for the HMA.

Area	Age Class	Estimated No. Horses	LCL[a]	UCL	Std Err	CV	No. Horses Seen	Estimated % Missed	Estimated No. Groups	Estimated Group Size	Foals Per 100 Adults[b]	Est. No. Horses Outside HMA
Sand Wash Basin HMA	Total	447	430	484	16.6	3.7%	425	4.9%	87	5.1	10.1	38
	Foals	41	40	44	1.6	4.0%	40					
	Adults	406	390	441	15.9	3.9%	385					

[a] The lower 90% confidence limit is based on bootstrap simulation results or the number of horses seen, whichever is higher.

[b] The estimated ratio of foals to adults reflects what was observed during this May survey and does not represent the full cohort of foals for this year.

Abundance Results

The estimated total horse abundance within the surveyed area is reported in Table 1. Observers recorded 77 horse groups, of which 77 horse groups had data recorded properly 'on protocol' and that could be used to compute statistical estimates of sighting probability. Of the 77 groups seen, 76 observations were used to calculate the abundance estimate. Any horse groups that were seen on two separate occasions (i.e., double counted), or that were identified as domestic and privately owned, were not used to calculate abundance; however, such groups can be used to parameterize sighting probability if they were recorded on protocol. Coefficient of variation (Table 1) values of less than 10% indicate high precision resulting from high detection probabilities; values between 10-20% indicate medium precision resulting from lower detection probabilities; and values greater than 20% indicate low precision resulting from very low detection probabilities.

The mean estimated size of detected horse groups, after correcting for missed groups, was 5.1 horses/group across the surveyed area, with a median of 4.0 horses/group. There were an estimated 10.1 foals per 100 adult horses at the time of these surveys (Table 1). Surveys flown before July are unlikely to include all foals born this year, while surveys flown during or after July would not include foals that were born this year but died before the survey.

Sighting Probability Results

The combined front observers saw 79.2% of the horse groups (89.7% of the horses) seen by any observer, whereas the back seat observers saw 83.1% of all horse groups (89.5% of horses) seen (Table 2). At least one observer (front or back) missed 37.7% of horse groups seen by the other. These results demonstrate that simple raw counts do not fully reflect the true abundance without statistical corrections for missed groups, made possible by the double observer method and reported here. Direct counts from aerial surveys underestimate true abundance because some animals are missed by all observers; this analysis corrects for that bias (Lubow and Ransom 2016). The analysis method used for the surveyed areas was based on simultaneous double-observer data collected during these surveys.

The sample size of observations following protocol was 77 horse groups. Survey datasets with sample size less than 20 groups cannot be analyzed using these methods; sample sizes of 20 to 40 groups are considered low and have high risk of containing unmodeled heterogeneity in sighting probability; sample sizes of 41-100 groups are moderate and can estimate effects of many but likely not all potential sightability covariates; and sample sizes >100 groups are large and can account for most sightability covariates.

All models used in the double-observer analysis contained an estimated intercept common to all observers. Informed by *a priori* reasoning and preliminary analyses showing overwhelming support, I also included an additional parameter in all models for effect of: (1) horse group size. I evaluated 4 additional possible effects on sighting probability by fitting models for all possible combinations with and without these effects, resulting in 16 alternative models. The 4 effects examined were: (1) background complexity; (2) distance from the flight path; (3) observations by front-seat observers on the pilot's side; (4) back-seat observers. Due to minimal support during preliminary analysis, I did not include effects on detection probability of individual backseat observers. I did not consider effects on detection probability of snow cover, percent vegetation cover, rugged topography, group activity, or lighting conditions due to insufficient variation in the values of these covariates. Covariates and their relative effect on sighting probability are shown in Table 3.

There was moderate support for an effect of distance from the flight path (38.9% of AICc model weight), and weak support for an effect of moderate background complexity (28.8%), backseat observers (27.9%), front-seat observers pilot side (25.1%). As expected, visibility was higher for larger groups, and visibility was lower for horse groups that were further from the transect, in moderate background complexity (compared to simple) (Table 3).

Groups that were recorded on the centerline, directly under the aircraft, were not available to backseat observers. For these groups, backseat observers' sighting probability was therefore set to 0. Sighting probability for groups visible on both sides of the aircraft was computed based on the assumption that both backseat observers could have independently seen them, thereby increasing total detection probability for these groups relative to groups available to only one side of the helicopter.

Estimated overall sighting probabilities, $\hat{p}$, for the combined observers ranged across horse groups from 0.57-1.00. Sighting probability was <0.8 for 15 (19%), and <0.7 for 13 (17%) of observed groups. In aggregate across all observed groups, the overall "correction factor" that was added on to the total number of wild horses *seen* was 5.2%. That is to say: 425 horses were seen, and adding another 5.2% of that number seen equals the total estimate of 447 horses (Table 1). A different but mathematically equivalent interpretation is listed in Table 1 in the "Estimated % Missed" column, which shows that, overall, 4.9% of the horses that were estimated to be present during the survey were *never seen* by any of the observers during the survey (Table 1).

Assumptions and Caveats

Results from this double observer analysis are a conservative estimate of abundance. True abundance values are likely to be higher, not lower, than abundance estimates in Table 1 because of several potential sources of bias listed below. Results should always be interpreted with a clear understanding of the assumptions and implications.

1. The results obtained from these surveys are estimates of the horses present in the surveyed area at the time of the survey and should not be used to make inferences beyond this context. Abundance values reported here may vary from the annual March 1 population estimates for the HMA; aerial survey data are just one component of all the available information that BLM uses to make March 1 population estimates. Aerial surveys only provide information about the area surveyed at the time of the survey, and do not account for births, deaths, movements, or any management removals that may have taken place afterwards.

2. Simultaneous double-observer analyses cannot account for undocumented animal movement between, within, or outside of the surveyed area. Fences and topographic barriers can provide deterrents to animal movement, but even these barriers may not present continuous, unbroken, or impenetrable barriers. It is possible that the surveys did not extend as far beyond a boundary as horses might move. Consequently, there is the possibility that temporary emigration from the surveyed area may have contributed to some animals that are normally resident having not being

present at the time of survey. In principle, if the level of such movement were high, then the number of animals found within the survey area at another time could differ substantially. If there were any wild horses that are part of a local herd but were outside the surveyed areas, then Table 1 underestimates true abundance.

3. The validity of the analysis rests on the assumption that all groups of animals are flown over once during a survey period, and thus have exactly one chance to be counted by the front and back seat observers, or that groups flown over more than once are identified and considered only once in the analysis. Animal movements during a survey can potentially bias results if those movements result in unintentional over- or under-counting of horses. Groups counted more than once would constitute 'double counting,' which would lead to estimates that are biased higher than the true number of groups present. Groups that were never available to be seen (for example due to temporary emigration out of the study area or undetected movement from an unsurveyed area to an already-surveyed area) can lead to estimates that are negatively biased compared to the true abundance.

Survey SOPs (Griffin et al. 2020) call for observers to identify and record 'marker' animals (with unusual coloration) on paper, and variation in group sizes helps reduce the risk of double counting during aerial surveys. Observers are also to take photographs of many observed groups and use those photos after landing to identify any groups that might have been inadvertently recorded twice. Unfortunately, there is no effective way to correct for the converse problem of horses fleeing and thus never having the opportunity for being detected. Because observers can account for horse movements leading to double counting, but cannot account for movement causing horses to never be observed, animal movements can contribute to the estimated abundance (Table 1) potentially being lower than true abundance.

4. The simultaneous double-observer method assumes that all horse groups with identical sighting covariate values have equal sighting probability. If there is additional variability in sighting probability not accounted for in the sighting models, such heterogeneity could lead to a negative bias (underestimate) of abundance. In other words, under most conditions the double-observer method underestimates abundance.

5. The analysis assumes that the number of animals in each group is counted accurately. Standard Operating Procedures (Griffin et al. 2020) specify that all groups with more than 20 animals are photographed and photos scrutinized after the flight to correct counts. Smaller groups, particularly ones with poor sighting conditions such as heavy tree cover, could also be undercounted. Any such undercounting would lead to biased estimates of abundance.

Evaluation of Survey and Recommendations

It appears that survey protocols were followed well and with enough consistency among flights to enable useful pooling of data for more precise estimates of sighting probability. Observers appear to have been generally well trained, and visibility conditions were excellent for the 2-day survey. Unfortunately the GPS was not working correctly so there are no waypoint of approximate group locations.

While some of the pre-planned flightlines were followed well, some of them were not, possibly due in part to pilot inexperience flying horse surveys. This led to some flightlines being flown very close to each other (in a few cases actually crossing over previously flown lines), which also led to large gaps between other flightlines (sometimes exceeding 1.9 miles), when the pre-planned flightlines were generally spaced approximately 1 mile apart, spacing in a few areas that had more terrain was approximately 0.65 miles apart. This leads to the possibility that a number of horse groups were missed in those areas with large gaps between flightlines.

The survey covered all parts of the Sand Wash Basin HMA and extended beyond the boundaries of the HMA in a most places (Figure 1). Because the GPS unit was not working correctly there are not locations of the horse groups so assessing if horses were near the edge of the surveyed area is not possible. Results should still be understood to represent the horses present in the areas surveyed, which may not represent all horses that occasionally occupy the HMA and immediate vicinity.

Table 2. Tally of raw counts of horses and horse groups by observer (front, back, and both) for combined data from Sand Wash Basin HMA surveyed in May 2024.

Observer	Groups seen[a] (raw count)	Horses seen (raw count)	Actual sighting rate[b] (groups)	Actual sighting rate[b] (horses)
Front	61	385	79.2%	89.7%
Back	64	384	83.1%	89.5%
Both	48	340	62.3%	79.3%
Combined	77	429		

[a] Includes only groups and horses where protocol was followed.
[b] Percentage of all groups seen that were seen by each observer.

Table 3. Effect of observers and sighting condition covariates on estimated sighting probability of horse groups for both front and rear observers during the May 2024 survey of the Sand Wash Basin HMA. Baseline case (bold) for horses presents the predicted sighting probability for a group of 4 horses (the median group size observed), that are <1/4 mile from the transect, on a simple background environment, not on the pilot side, and with the average back-seat observer. Other example cases vary a covariate or observer, one effect at time, as indicated in the left-most column, to illustrate the relative magnitude of each effect. Sighting probabilities for each row should be compared to the baseline (first row) to see the effect of the change in each observer or condition. Baseline values are shown in bold wherever they occur. Sighting probabilities are weighted averages across all 16 models considered (Burnham and Anderson 2002).

	Sighting probability		
	Front Observer[a]	Back Observer[b]	Combined Observers
Baseline	**74.5%**	**75.7%**	93.8%
Effect of group size (N=1)	44.3%	45.9%	69.9%
Effect of group size (N=10)	97.5%	97.7%	99.9%
Effect of distance = 0.375	71.0%	72.3%	92.0%
Effect of Moderate Background	71.7%	73.0%	92.4%
Effect of PilotSide	74.6%	**75.7%**	93.8%
Effect of back=front	**74.5%**	74.5%	93.5%

[a] Sighting probability for the front observers acting as a team, regardless of which of the front observers saw the horses first.
[b] Sighting probabilities for back observers for horse groups that are potentially visible on the same side of the aircraft as the observer. Sighting probability in the back is 0 for groups on the opposite side or centerline.

Literature Cited

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Figure 1. Map of 2024 Sand Wash Basin HMA, survey tracks flown (black lines), HMA boundaries (blue), HA boundaries (purple).