MEMORANDUM

To: Tyrell Turner (BLM)
CC: Kymm Gresset, Lynae Rogers, Paul Griffin, Melanie Mitchell, Scott Fluer, Hollè Waddell (BLM)
From: Michelle Crabb (BLM) WHB Program Population Biologist
Date: 10/25/2023
RE: Statistical analysis for 2023 survey of wild horse in Sand Wash Basin HMA, CO

Summary Table

Survey Areas and Dates	**Start date**	**End date**	**Area name**	**Area ID**
	8/14/2023	8/15/2023	Sand Wash Basin HMA	CO0143
Survey Type	Simultaneous double-observer			
Aviation Details	Pilot: Megan Siler, Choice Aviation, Fixed-wing: Cessna 182, #N7254N			
Agency Personnel	Observers: Hunter Seim, Tyrell Turner, Matt Dupire (BLM)			

Summary Narrative

In August 2023 Bureau of Land Management (BLM) personnel conducted simultaneous double-observer aerial surveys of the wild horse abundance in the Sand Wash Basin herd management area (HMA), CO. Surveys were conducted using methods recommended by BLM policy (BLM 2010) and the National Academy of Sciences (NRC 2013) with detailed methods described in Griffin et al. (2020). 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 wild horse abundance in each area 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 each HMA but located outside the HMA boundaries (Est. No. Horses Outside HMA) is already included in the total estimate for that HMA.

Area	Age Class	Estimated No. Horses	LCL[a]	UCL	Std Err	CV	No. Horses Seen	Estimated % Missed	Estimated No. Groups	Estimated Group Size	Est. No. Horses Outside HMA
Sand Wash Basin HMA	Total	344	327	381	22.2	6.4%	327	4.9%	54	6.4	60

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

Abundance Results

The estimated total horse abundance within the surveyed areas is reported in Table 1. Observers recorded 50 horse groups, of which 48 horse groups had data recorded properly 'on protocol' and that could be used to compute statistical estimates of sighting probability. All of the 50 groups seen were used to calculate the abundance estimates. 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 6.4 horses/group across the surveyed area, with a median of 4.0 horses/group. 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 81.2% of the horse groups (89.3% of the horses) seen by any observer, whereas the back seat observers saw 79.2% of all horse groups (81.5% of horses) seen (Table 2). At least one observer (front or back) missed 39.6% 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 48 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. I evaluated 5 possible effects on sighting probability by fitting models for all possible combinations with and without the following additional effects, resulting in 32 alternative models. The 5 effects examined were: (1) horse group size; (2) distance from the flight path; (3) moderate background; (4) observations by front-seat observer on the pilot’s side; (5) backseat observers. Due to minimal support during preliminary analyses, I did not consider effects on detection probability of individual backseat observers. I did not consider effects on detection probability of percent vegetation cover, vegetation composition, percent snow cover, or rugged terrain 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 somewhat strong support for an effect of group size (64.0% of AICc model weight) There was moderate support for an effect of distance from the flightpath (34.9%), and an effect of moderate background (31.0%). There was weak support for the effect of backseat observer position (24.2%), and front pilot side (23.8%). As expected, visibility was higher for horse groups that were larger, and lower for groups further from the transect and on a moderate (vs simple) background (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 0.86-0.98. Sighting probability was <0.95 for 33 (66%), and <0.90 for 9 (18%) 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: 327 horses were seen, and adding another 5.2% of that number seen equals the total estimate of 344 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 (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 generally followed well and with enough consistency among flights to enable useful pooling of data for more precise estimates of sighting probability. As such, the overall wild horse abundance estimates in Table 1 should be reliable. Observers appear to have been well trained, except for not separately recording the number of foals and the number adults in several groups (although the correct total number of animals was recorded for those groups). During the survey 10 foals were seen (which would lead to an estimated number of 11 foals), but a ‘friends’ group’ in the area, knew of 23 foals at the time of the survey. This calls into question whether foals were correctly counted during the survey, and I recommend that management decisions from this survey only refer to the total number of wild horses, not the foal to adult ratio. 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. It is especially important to correctly record the number of adults and foals separately (not just the total number of animals in the group) because a fall estimate of foal:adult ratio is especially valuable in herds with relatively high levels of fertility control vaccine application. Visibility conditions were very excellent for the two days of the survey. There was a problem with the GPS device not accurately recording group location, as a result, over half of the locations of the groups observed were not documented. In the future the backup GPS should be used to record group locations in addition to recording the flightline.

The survey covered all parts of the Sand Wash Basin HMA, and extended beyond those borders in many places, particularly to the northwest, and east. There are no obvious natural deterrents to horse movements that would contain them within the boundaries of the survey areas. Consequently, it is difficult to be sure there were no additional horses outside of the HMA, in areas not surveyed, and results should be understood to represent the horses present only in the areas surveyed, which may not represent all horses that occasionally occupy the Sand Wash Basin HMA and immediate vicinity. Careful consideration should be given to where horses were located near the edge of the areas surveyed when planning whether to extend the survey area further in future surveys to ensure covering all areas potentially occupied by horses associated with the HMA, or to confirm that the current survey boundaries do cover the full extent of horses’ range in this area.

Table 2. Tally of raw counts of horses and horse groups by observer (front, back, and both) for the Sand Wash Basin HMA, CO, surveyed in August 2023.

Observer	Groups seen[a] (raw count)	Horses seen[a] (raw count)	Actual sighting rate[b] (groups)	Actual sighting rate[b] (horses)
Front	39	241	81.2%	89.3%
Back	38	220	79.2%	81.5%
Both	29	191	60.4%	70.7%
Combined	48	270		

[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 August 2023 survey of Sand Wash Basin HMA, CO. 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, not on the pilot side. 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 32 models considered (Burnham and Anderson 2002).

	Sighting probability		
	Front Observer[a]	Back Observer[b]	Combined Observers
Baseline	**76.4%**	**75.9%**	94.3%
Effect of Group size (N=1)	71.2%	70.6%	91.5%
Effect of Group size (N=10)	84.0%	83.6%	97.4%
Effect of Distance=0.375	72.2%	71.7%	92.1%
Effect of Moderate Background	72.4%	71.9%	92.2%
Effect of PilotSide	76.6%	**75.9%**	94.4%
Effect of back=front	**76.4%**	76.4%	94.4%

[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 2023 Sand Wash Basin HMA, survey tracks flown (black lines), approximate locations of some of the observed horse groups (black and white circles), HMA boundaries (blue).