M E M O R A N D U M

To: Paul Griffin (BLM)
CC: Cam Henrichsen, June Wendlandt, Bryan Fuell, Bea Wade (BLM)
From: Bruce Lubow, IIF Data Solutions
Date: 30 March 2016
RE: Statistical analysis for 2016 horse population surveys in Fifteenmile HMA Wyoming

I. Summary Table

HMAs and Dates*	January 25, 2016: Fifteenmile HMA (WY0011)
Type of Survey	Simultaneous Double-observer
Aviation Company	Bob Hawkins (pilot), Sky Aviation, Bell Long Ranger B206-L3 (N1078N)
Agency Personnel	Cam Henrichsen, Derek Trauntvein, Tim Stephens (BLM) Len Canella helicopter manager (BLM)

*HMAs are listed for any day on which they were surveyed, and any day on which an animal found outside the HMA boundaries was closest to that HMA.

Table 1. Estimated population sizes (Estimate) are for the numbers of horses in each surveyed area 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. Seen) leads to the estimated percentage of animals that were present in the surveyed area, but that were not recorded by any observer (% Missed). The estimated number of horses outside each HMA, is already included in the total estimate for that HMA.

Area	Age Class	Estimate (No. Horses)	LCL [a]	UCL	Std Err	CV	No. Horses Seen	% Missed	Estimated # of Groups	Estimated Group Size	Foals per 100 Adults	Est. No. Horses Outside HMA
Fifteenmile HMA (2014)[b]	Total	242	237	275	13.1	5.4%	240	0.6%	7	34.2	22.4	40
	Foals	44	44	50	2.5	5.7%						
	Adults	197	193	221	10.6	5.4%						
Fifteenmile HMA (2016)	Total	298[c]	292	305	7.9	2.6%	296	0.8%	22	13.4	0.7	14
	Foals	2	2	3	0.0	1.1%						
	Adults	296	290	303	7.9	2.7%						

[a] 90% confidence interval based on percentiles of bootstrap simulation results. The lower 90% confidence interval limit (LCL) is actually less than the number of animals sighted during the survey for some estimates. This is a normal statistical result and reflects the fact that a confidence interval expresses what would likely happen if the survey were repeated. If repeated many times, some surveys would miss more animals and produce lower estimates, even after corrections, than were actually observed during this survey. Clearly, I conclude that there are at least as many animals as were observed during this survey, rather than using the lower confidence limit as a minimum number.

[b] The estimated horse population size at the time of the 2014 surveys is slightly different here (242) than was reported in 2014 (240). The reason for this difference is that the additional data from 2016 allowed for a better analysis of the 2014 data. In both this report and the 2014 report, though, the estimated percentage of horses missed was very low, so the estimated population size was not much different.

[c] Excluding the 14 horses seen outside the HMA, the population estimate within the HMA is 284 horses.

II. Narrative

In September 2014 and again in January 2016, Bureau of Land Management (BLM) personnel conducted simultaneous double-observer aerial surveys of the wild horse populations in the Fifteenmile Herd Management Area (HMA) (Figure 1). Surveys were conducted using survey methods recommended by BLM policy (BLM 2010) and a recent National Academy of Sciences review (NRC 2013). I analyzed these data to estimate sighting probabilities for horses, which I then used to correct the raw counts for systematic biases (undercounts) that are known to occur in aerial surveys, and to provide confidence intervals (which are measures of uncertainty) associated with the estimated population sizes.

Results for 2014 were reported previously (See my memo dated 12/17/2014) but were considered unreliable at that time due to the very small sample size of horse groups observed in that prior survey. This memo reports on an analysis of the pooled data from both surveys. Results for 2014 have been very slightly revised in this report to reflect the improved models of sighting probability made possible by the larger, combined dataset.

Population Results

The estimated total horse populations (Table 1) within or associated with the HMA that were the focus of the surveys were relatively small, resulting in a sample size from the combined surveys of 29 horse groups (Table 2, Figure 1), although only 28 groups could be used for estimating sighting probability. All observations made during aerial surveys were used to inform the total estimates of population size. Only 7 horse groups were recorded in 2014 and 23 in 2016. The two surveys were conducted using the same methods and with three out of four of the same crew members, which facilitated pooling of the datasets.

Confidence intervals and coefficients of variation are within acceptable levels of precision for management purposes (Table 1), although the reliability of the estimates is somewhat diminished by the still small sample size available for this analysis. For 2016, I estimate the mean size of detected horse groups, after correcting for missed groups, to be 13.4 horses/group with a median of 10 horses/group. I note that the detected groups may have been composed of more than one social band. I estimate a composition of only 0.7 foal horses per 100 adults at the time of the 2016 survey (Table 1), but this number is a reflection of the winter season of the surveys and should not be interpreted as an indication of foaling rate for 2016.

Two groups observed in 2016 were far from the HMA boundaries, and represent a local cluster of horses that may be a mix of domestic and wild animals – these are referenced in the far right column of Table 1. As a result, the population estimate of horses within the HMA was 284. One mule was seen during the 2016 survey, but I make no estimate here of mule population size.

Sighting Probability Results

The front observer saw 89.7% of the horse groups (97.4% of the horses) seen by any observer, whereas the back seat observers saw 89.7% of all horse groups (92.5% of horses) seen (Table 2). These results demonstrate that simple raw counts do not fully reflect true population size, without statistical corrections for missed groups made possible by the double observer method and reported here.

The sample size of observations (7 usable groups) from the 2014 survey of horses was far less than desirable for parameterizing sighting probability functions. Pooling across the 2 surveys provided a still small, but substantially improved sample size. Accumulation of more data from future surveys of this and possibly similar areas in Wyoming, using a consistent set of observers,

aircraft, transect spacing, and field protocol could further increase confidence in the statistical estimates.

I considered 32 alternative models including the baseline model, which contained only an intercept term (constant sighting probability). In these alternatives, I considered all possible combinations of 5 covariates in addition to the intercept believed *a priori* to be likely predictors of sighting probability: (1) an additive effect for front observer's sighting probability for groups located on the pilot's side of the flight path, (2) horse group size, (3) horse movement, (4) the incremental effect of 2016 survey conditions, and (5) an average back-seat observer effect. Due to the small sample size of observations with each covariate value, I could not consider several additional parameters: topography, vegetation cover type, vegetation cover, snow cover, and high contrast lighting. I initially considered distance as a covariate, but dropped it after preliminary analysis estimated an implausible positive value with virtually no support.

Of the 5 covariates tested, support (% of AICc model weight) was minimal (36.9%) for group size and virtually nonexistent (<22.5%) for all of the remaining parameters. This is undoubtedly due to a combination of small sample size and high sighting probability, leaving very little variation among groups to be explained by the model. Sighting probability was higher for groups that were larger, active, or observed in 2016, and lower if on the pilot's side of the aircraft (Table 3), but all of these effects were inconsequential. Sighting probability was slightly lower, on average, for back-seat observers.

The estimated sighting probabilities for the combined observers ranged across horse groups from 98.2-99.7%. Comparing actual horses seen to the estimated population size computed from the estimated sighting probabilities, I estimate that 0.7% of the horses in these surveys were never seen by any of the observers (Table 1). A combination of skilled observers, low vegetation cover, and closely spaced transects contributed to these high sighting probabilities. Group size in 2016 was as high as 39 horses, though it was higher in September 2014 (maximum of 131 horses). There were 14 observed horse groups (48% of groups) with >10 horses, therefore large group size was also a major contributor to high sighting probabilities.

Assumptions and Caveats

Given several potential sources of bias, listed below, it is more likely that the estimates are somewhat lower, rather than higher, than the true population. The high sighting probabilities and precision estimated for these surveys, the population estimates I present here appear to provide a sound and reliable basis for management decisions. However, the small sample size available for this analysis cast some doubt on the reliability of the estimates because factors affecting sighting probability may not have been adequately measured and accounted for.

The reliability of results from any population survey that is based on the simultaneous double-observer method rests on several important assumptions. First, the results obtained from these surveys are estimates of the horses present in the areas surveyed at the time of the survey and should not be used to make inferences beyond this context. I must presume that pre-flight planning by the district specialist and the BLM aerial survey coordinator led to the surveyed areas including as much as possible of the areas used by each population of horses using the surveyed HMAs. The area surveyed in 2016 was a more complete coverage of the HMA than in 2014. Although fences and topographic barriers provide deterrents to animal movement that help to contain them within the areas surveyed (Figure 1), these barriers may not present either a continuous, unbroken barrier or an impenetrable one. However, the survey did not necessarily extend as far beyond the boundary as horses might move. The WH&B specialist (Cam

Henrichsen) indicated that, on the day of the survey, there was very likely to have been a group of 3 wild horses far to the south of the area surveyed, in an area that was not feasible to survey. Consequently, temporary emigration from the surveyed areas may have contributed to some animals of a given population not being present in the surveyed areas and the numbers of animals found within the survey areas at another time could differ substantially.

Second, 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. 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. Each of these surveys was completed on a single day, which should have helped to reduce the risk of double counting. Additionally, groups that were never available to be seen (for example, due to temporary emigration from the study area or due to moving, undetected, from an unsurveyed area to one already surveyed) can lead to estimates that are negatively biased compared to the true population size. The identification of 'marker' horses (horses with unusual coloration) in each group was recorded for some groups on paper but, more importantly, the survey crew was conscientious in using photography to distinguish groups. Only a few of the very smallest groups were not photographed. Variation in group sizes also probably helped the observers to reduce the risk of double counting during aerial surveys. As a result, the crew lead could have distinguished groups that were recorded more than once using photos. Indeed, one group of 28 horses was detected twice, but local staff confirmed that these two observations were, in fact, the same group – in population analyses the group was only used once. The results presented here are based on a survey design and methods that assume that any unobserved movements were random, so the effects would cancel each other out.

Third, this 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 the population. Although the relatively good sighting conditions that led to very high predicted sighting probabilities during this survey suggest that this issue may be unimportant.

A fourth assumption is that the number of animals in each group is counted accurately. In very large groups it may be common to miss a few animals unless photographs are taken and scrutinized after the flight. Relying on raw counts made from a helicopter could lead to biased low estimates of population size. Observers in this survey, though, circled over large groups to get as accurate a count as possible and used photography to confirm aerial counts of almost all groups, thereby minimizing the risk of undercounting group size.

Recommendations for Future Surveys

Several observations about the data may offer opportunities to improve future surveys.

1. More reliable estimates will be possible after accumulating more data from future surveys. However, to realize the benefits of pooling across years, it is important to use the same observers for future surveys as much as possible to reduce the uncertainty introduced by observers with minimal data history. This was done in the case of the 2014 and 2016 surveys, where the same pilot and two of the same observers were present in both years. Alternatively or in addition, survey data from these HMAs could be combined with surveys of other similar HMAs so that data can be pooled and common sighting characteristics estimated across the larger data set. For example, if the nearby McCullough Peaks HMA were ever to be surveyed by helicopter, then combining future

surveys with results from that area would improve results and survey efficiency for both areas.

2. Data were recorded for 8 horse groups that suggest some misinterpretation of the field protocols. In these 8 cases, observers in the back-seat on both sides of the aircraft were marked as having seen the group; however, the group was indicated to be on either the left or right side of the aircraft. Back-seat observers should never spend time looking out the opposite side of the aircraft as was apparently done on these surveys. Consequently, I recommend some additional training of observers before future surveys.

3. I emphasize the importance of continuing to use photography for large horse groups (>10) to ensure that such groups are counted accurately, exactly as was done in this survey. The current draft of the standard operating procedures for aerial surveys requires use of photography for all groups of 20 or more horses; however I advise that it be used for groups of 10 or more. Given that at least some of the animals in these HMAs may have a tendency to form very large groups, it is all the more important to have accurate counts of group size for each large group. Surveys should continue to use a reliable, high-resolution camera with an adequate telephoto or zoom lens for the distance between observer and horses for this purpose.

Table 2. Tally of raw counts of horses and horse groups by observer (front, back, and both) for combined data from the September 2014 and January 2016 Fifteenmile HMA surveys.

Observer	Groups Seen (Raw Count)	Horses Seen (Raw Count)	Actual Sighting Rate[a] (groups)	Actual Sighting Rate[a] (horses)
Front	26	522	89.7%	97.4%
Back	26	496	89.7%	92.5%
Both	23	482	79.3%	89.9%
Combined	29	536		

[a] 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. Baseline case (**bold**) for horses presents the predicted sighting probability for a group of 10 horses (the median group size observed) during the 2016 survey that were not on the pilot's side and not moving. Other example cases vary a covariate or observer, one effect at a 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	Sighting Probability, Back Observer
Baseline	**89.6%**	**88.4%**
Effect of Pilot's Side	88.8%	**88.4%**
Effect of group size (N=1)	88.0%	86.7%
Effect of active group	90.7%	89.6%
Effect of 2014 Survey	89.5%	88.4%

Literature Cited

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Lubow, B., and J. I. Ransom. 2009. Validating aerial photographic mark-recapture for naturally marked feral horses. Journal of Wildlife Management 73:1420-1429.

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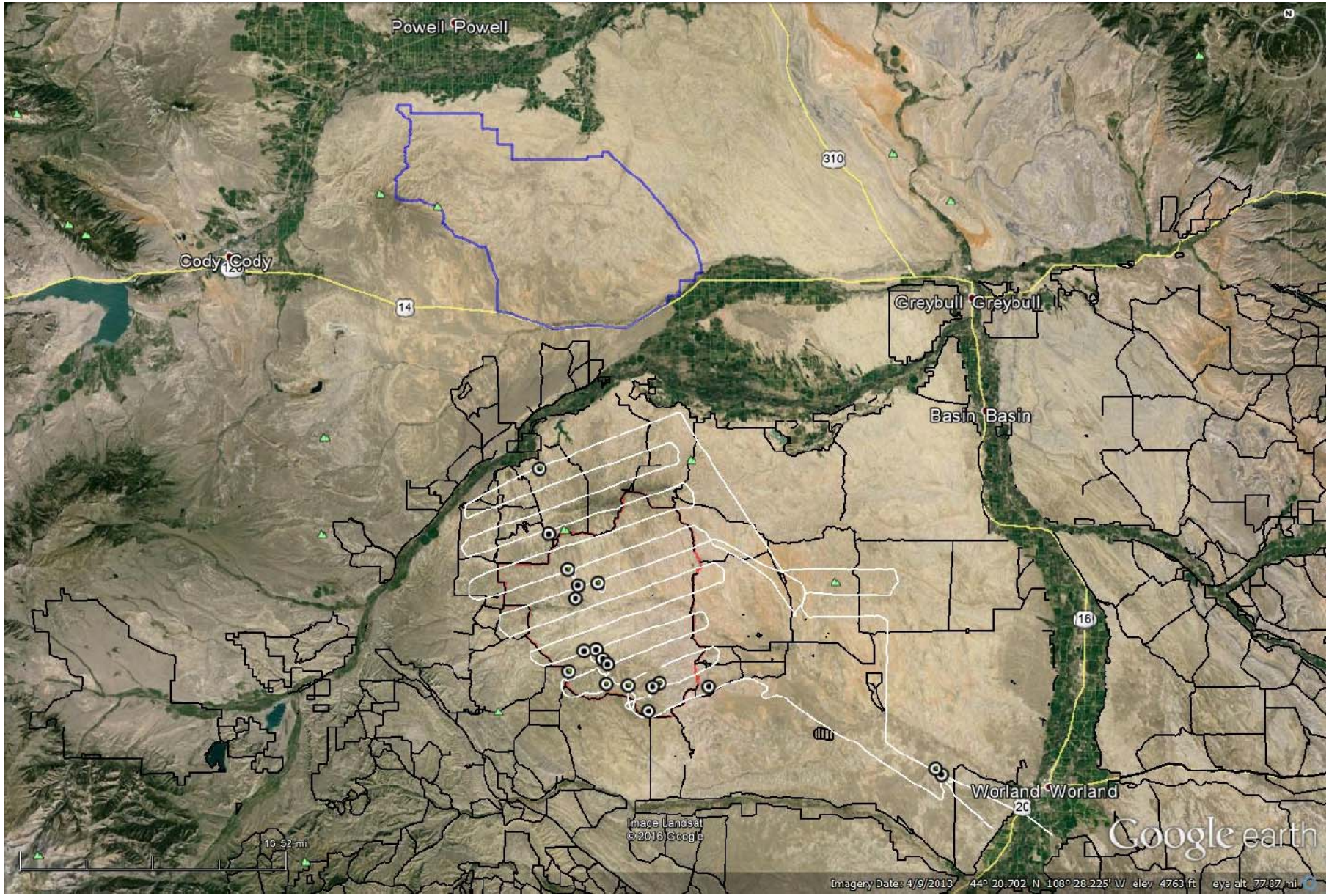
Figure 1. Map of Fifteenmile HMA survey area boundaries (Red), nearby McCullough Peaks HMA (blue), and fence lines (black). Results for 2016 survey: tracks flown (white lines) and locations of horse groups (black and white circles).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