MEMORANDUM

To: John Hall, Eric Duarte, Brandon Boshell (BLM), Ben Roberts (NPS)
CC: Paul Griffin, Jerrie Bertola, Annie Ebbers (BLM)
From: Michelle Crabb (BLM) WHB Program Population Biologist
Date: 03/11/2026
RE: Statistical analysis for 2026 survey of burro abundance in Tassi-Gold Butte Herd Management Area (HMA) and surrounding lands in Grand Canyon-Parashant National Monument (GCPNM), AZ

Summary Table

Survey Area and Dates	**Start date**	**End date**	**Area names**	**Area IDs**
	1/13/2026	1/14/2026	NPS portion of Tassi-Gold Butte HMA	AZ0001
	1/13/2026	1/16/2026	BLM portion of Tassi-Gold Butte HMA and surrounding lands	AZ0001
Type of Survey	Simultaneous double-observer			
Aviation Details	Pilots: Jake Brooks. Guidance Helicopters: Bell 407s, #N658HP (pilot seated right-front) and #N407US (pilot seated left-front)			
Agency Personnel	Observers: John Hall, Eric Duarte, Michelle Crabb (BLM) Helicopter managers: Cory Johnson, James Padden and Colter Richards (BLM)			

Summary Narrative

In January 2026 Bureau of Land Management (BLM) personnel conducted simultaneous double-observer aerial surveys of the wild burro populations in the Tassi-Gold Butte Herd Management Area (HMA) in the Grand Canyon-Parashant National Monument (GCPNM), and nearby lands surrounding the HMA. The HMA and the entire survey area falls completely within GCPNM. Both GCPNM and the HMA are jointly managed by the BLM and NPS.

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). These data were analyzed using methods in Ekernas and Lubow (2019) to estimate sighting probabilities for wild burros, 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 (Table 1). However, other studies indicate that even such estimates are at least 25% lower than true burro herd size.

Table 1. Estimated abundance (Estimated No. Burros) is for the number of burros 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 abundance. Number of burros seen (No. Burros Seen) leads to the estimated percentage of burros that were present in the surveyed area, but that were not recorded by any observer (Estimated % Missed). The estimated number of burros associated with the HMA but located outside the HMA boundaries (Est. No. burros Outside HMA) is already included in the total estimate for the HMA.

Area	Age Class	Estimated No. Burros[c]	LCL[a]	UCL	Std Err	CV	No. Burros Seen	Estimated % Missed	Estimated No. Groups	Estimated Group Size	Foals Per 100 Adults[b]	Est. No. Burros Outside HMA
NPS portion of Tassi-Gold Butte HMA	Total	392	263	843	192.6	49.1%	245	37.5%	89	4.4	7.4	0
	Foals	27	9	118	38.7	143.4%	9					
	Adults	366	253	747	173.4	47.4%	236					
BLM portion of survey area	Total	675	586	993	133.2	19.7%	537	20.4%	172	3.9	3.4	501
	Foals	22	19	29	3.6	16.5%	19					
	Adults	653	565	969	132.6	20.3%	518					
Survey Total	Total	1,067	867	1,857	305.5	28.6%	782	26.7%	261	4.1	4.8	501
	Foals	49	28	171	46.5	94.9%	28					
	Adults	1,019	834	1,685	278.2	27.3%	754					

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

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

[c] If conditions in this survey were similar to those in research by Hennig et al. (2022), actual wild burro abundance may be 25% greater than these values estimated by simultaneous double-observer methods.

Abundance Results

The estimated total burro abundance within the surveyed area is reported in Table 1. Observers recorded 189 burro groups, of which 175 burro groups had data recorded properly 'on protocol' that could be used to compute statistical estimates of sighting probability. Of the 189 groups seen, 182 observations were used to calculate the abundance estimate. Any burro groups that were seen twice (double counted) 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.

Double observer aerial surveys of burros typically contain unmodeled heterogeneity in detection probabilities (discussed below) that cause abundance estimates to be biased too low. Consequently, the abundance estimate presented in Table 1 is likely to be substantially lower than the true number of burros present in the surveyed area. For reference, double observer burro surveys and analyses of Lake Pleasant HMA (AZ), Fort Irwin National Training Center (CA) and Sinbad HMA(UT), underestimated burro abundance by approximately 25% compared to the true number of known individuals (Hennig et al. 2022). In the absence of better information, it is likely that the true abundance of burros in and near the HMA is at least 25% more than the values reported in Table 1 (Estimated No. Burros). However, it is not possible from the available data or the analysis presented here to assess the actual additional percentage that should be added.

The mean estimated size of detected burro groups, after correcting for missed groups, was 4.1 burros/group across the surveyed area, with a median of 3.0 burros/group. There were an estimated 4.8 foals per 100 adult burros at the time of these surveys (Table 1). Burros are known to foal year-round and surveys flown before July are unlikely to include all foals born in 2026, while surveys flown during or after July would not include foals that were born in 2026 but died before the survey.

Sighting Probability Results

The combined front observer saw 72% of the burro groups (73.4% of the burros) seen by any observer, whereas the back seat observers saw 79.4% of all burro groups (82.8% of burros) seen (Table 2). At least one observer (front or back) missed 48.6% of burro 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 175 burro 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.

Unmodeled heterogeneity in detection probability is a systematic problem in double observer aerial surveys of burros, and solving this problem is an area of active research. Burros are difficult to see from the air, and some types of groups are so difficult to see (e.g. groups that are small, standing still, and in heavy tree cover) that they are practically never detected by any observer. When certain types of groups are never seen, their sightability characteristics cannot be described by any set of covariates, and this class of groups disappears from the analysis. Conversely, other types of groups are easy to see (e.g. large groups in open vegetation, close to the helicopter, and running) and every observer sees them nearly every time. The “easy-to-see” types of groups thereby may become over-represented in the data. Furthermore, covariates that sharply reduce detection probability might never be described and thus cannot be modeled. As a result of heterogeneity, the double observer model tends to over-estimate detection probability for the burro population as a whole. When the detection probability estimate is biased high, the correction factor for how many groups were missed is biased too low. Consequently, unmodeled heterogeneity in detection probability causes double observer analyses to underestimate true burro abundance.

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 additional parameters in all models for effects of distance of burros from the flight path, rugged topography, observations by front-seat observer on the pilot’s side. I evaluated 7 more possible effects on sighting probability by fitting models for all possible combinations with and without these effects, resulting in 128 alternative models. The 7 effects examined were: (1) burro group size; (2) group activity; (3) contrast color animal in group (4) percent vegetation concealing cover; (5) complex background; (6) simple background; (7) effect for back-seat 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 lighting conditions, vegetation composition, or snow cover due to insufficient variation in the values of that covariate. Covariates and their relative effect on sighting probability are shown in 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.

There was strong support for effects of complex background (91.9% of AICc model weight); moderate support for the effect of group size (37.9%); and weak support for the effect of simple background (35.1%), contrast color animal (33.4%), back-seat observers (30.2%) group activity (28.6%), and percent concealing vegetation cover (28.5%). As expected, visibility was lower for groups that were further from the transect, in rugged terrain, on a complex background, in concealing vegetation cover, or on the pilot's side, and higher for groups that were larger, moving, contain a contrast color animal, or on a simple background (Table 3).

Estimated overall sighting probabilities, *p*, for the combined observers ranged across burro groups from 0.06-1.00. Sighting probability was <0.7 for 26 (14%), and <0.5 for 12 (6%) of observed groups. In aggregate across all observed groups, the overall "correction factor" that was added on to the total number of wild burros seen was 36.4%. That is to say: 782 burros were seen, and adding another 36.4% of that number seen equals the total estimate of 1,067 burros (Table 1). A different but mathematically equivalent interpretation is listed in Table 1 in the "Estimated % Missed" column, which shows that, overall, 26.7% of the burros that were estimated to be present during the survey were never seen by any of the observers (Table 1). However, as noted earlier, the true number of burros in the surveyed area is likely to be at least 25% greater than the values in Table 1, based on results from Hennig et al (2022).

Assumptions and Caveats

Results from this double observer analysis are a conservative estimate of wild burro abundance. True abundance values are likely to be at least 25% higher, and almost certainly 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 burros 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 burros 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 burros 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 burros. 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 burros fleeing and thus never having the opportunity for being detected. Wild burros tend to move more slowly than wild horses. Despite this, because observers can account for burro movements leading to double counting, but cannot account for movement causing burros 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 burro 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. This is particularly true for simultaneous double-observer based wild burro abundance estimates, which Hennig et al. (2022) showed should be expected to underestimate true wild burro abundance by 25% or more.

5. The analysis assumes that the number of animals in each group is counted accurately and that foals are all correctly distinguished from adults. 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. Undercounting can be common for burro groups, some members of which may stay immobile and under cover, even when a helicopter circles back overhead for counting. Any such undercounting would lead to biased estimates of abundance. Burro foals can be born throughout the year, and in some conditions it may be hard to differentiate older foals from adults from the air.

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. Visibility conditions were excellent for the 4-day survey. Flightlines were flown at a reasonable survey speed. The last two flight segments (out of 8) were flown in a different helicopter that had a different configuration, with the pilot seated on the left side instead of the right side as is much more common.

The survey covered all of the Tassi-Gold Butte HMA except for the extreme upper ends of both Pigeon and Snap Canyons on the east side that is very steep and rugged. The survey extended beyond the HMA boundaries well to the north (Figure 1). Burro groups were generally not observed near the edge of the survey area except for where it abuts Gold Butte HMA in NV. However, results should still be understood to represent the burros present only in the area surveyed at the time of the survey, which may not represent all burros that occasionally occupy the survey area, and immediate vicinity. In general, careful consideration should always be given to where burros were located near the edge of the area surveyed when planning whether to extend the survey area further in future surveys to ensure covering all areas potentially occupied by burros associated with the HMA, or to confirm that the current survey boundaries do cover the full extent of burros' range in this area.

Table 2. Tally of raw counts of burros and burro groups by observer (front, back, and both) for combined data from Tassi-Gold Butte HA, AZ, surveyed in January 2026.

Observer	Groups seen[a] (raw count)	Burros seen (raw count)	Actual sighting rate[b] (groups)	Actual sighting rate[b] (burros)
Front	126	539	72.0%	73.4%
Back	139	608	79.4%	82.8%
Both	90	413	51.4%	56.3%
Combined	175	734		

[a] Includes only groups and burros 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 burro groups for both front and rear observers during the January 2026 survey of Tassi-Gold Butte HMA, AZ. Baseline case (bold) for burros presents the predicted sighting probability for a group of 4 burros (the median group size observed) that were <100m from the transect, not moving, in zero percent vegetation cover, in smooth terrain, on a moderate background, not on the pilot's side, 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 128 models considered (Burnham and Anderson 2002).

	Sighting probability		
	Front Observer[a]	Back Observer[b]	Combined Observers
Baseline	**92.3%**	**91.9%**	99.4%
Effect of Group size (N=1)	91.8%	91.3%	99.3%
Effect of Group size (N=10)	93.2%	92.8%	99.5%
Effect of Distance = 100-200m	87.6%	86.8%	98.4%
Effect of Distance = 200-300m	80.5%	79.4%	96.0%
Effect of Distance = 300-400m	70.7%	69.3%	91.0%
Effect of Moving	92.8%	92.4%	99.5%
Effect of Veg 30%	91.3%	90.8%	99.2%
Effect of Veg 60%	89.7%	89.1%	98.9%
Effect of Rugged	63.4%	61.8%	86.0%
Effect of Contrast	93.1%	92.6%	99.5%
Effect of Simple Background	93.3%	92.8%	99.5%
Effect of Complex Background	69.8%	68.4%	90.5%
Effect of Front Pilots Side	66.2%	**91.9%**	97.3%
Effect of Back=Front	**92.3%**	92.3%	99.4%

[a] Sighting probability for the front observers acting as a team, regardless of which of the front observers saw the burros first.
[b] Sighting probabilities for back observers for burro 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 2026 Tassi-Gold Butte HMA, AZ, with survey tracks flown (black lines), approximate locations of observed burro groups (black and white circles), HMA boundaries (blue), and monument boundary (purple).