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CENSUS METHODS FOR WILD HORSES AND BURROS

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CONTENTS

INTRODUCTION

Objectives for this research project as outlined in the original proposal and subsequent contract are:

1. Select 2 to 3 western U.S. regions in which to evaluate census approaches.
2. Test accuracy and precision of these approaches:
   a. complete counts
   b. mark-resight estimation
   c. strip-transect estimation
3. Develop a set of criteria by which to choose the appropriate approach for a given area with particular habitat characteristics.
4. Investigate the effect of such variables as weather, vegetation, terrain, herd size, and horse distribution on probability of observation.
5. Prepare reports and census manual.

Several BLM districts in Nevada, Oregon and California were visited by project personnel during August 1980 to examine potential study sites suggested by BLM. Three areas were selected: Beatys Butte Herd Management Area (Lakeview District, Oregon), Pah Rah Mustang Area and Pine Nut Mountains (both Carson City District, Nevada). Burro censusing was observed on a fourth area, the Black Mountains in the Phoenix District, Arizona.

Color and radio collars were placed on wild horses on the Pah Rah and Pine Nut areas during October and November 1980. Census trials were initiated on these areas and the Beatys Butte area during January 1981 and are continuing.

STUDY AREAS

Beatys Butte HMA

This area encompases 396,000 acres and is located in south-central Oregon in BLM's Lakeview District. The area has rolling topography with maximum relief being approximately 1500 feet. It consists mainly of broad flat plateaus. Fences isolate the area from adjacent wild horse areas.

Pah Rah Mustang Area

Spanish Springs Peak with an elevation of 8500 feet, is 3500 feet above the valley floor. There are numerous other smaller peaks and canyons in this rugged, mountainous area. The area contains 184,000 acres which are mostly covered by sagebrush with occasional juniper. The area is well delineated by fences and roads.

Pine Nut Mountains

The bulk of this 322,000 acre mountainous area is covered by pinyon-juniper. There are large open sagebrush areas at some of the lower and higher elevations. Several large peaks are present, with the highest being Mt. Siegel whose elevation is over 9500 feet. The area is isolated by a river, fences and roads.

Black Mountains

This area lies along the Colorado River running from Hoover Dam south to Topock, Arizona. It is an area with varied topography, mostly rugged. The area is characterized by flat mesas cut by deep, steep-sided canyons. An alluvial fan drops gently off from the canyon area to the Colorado River.

METHODS

Calibration of an Index by Removal

A gathering of wild horses on Beatys Butte HMA during February 1981 was used to evaluate a technique demonstrated by (Seber 1973:376; Eberhardt, submitted) that uses removal data to calibrate indices. If indices to the number of horses on a given area before and after a removal are available (total counts can be used for the indices) the number removed can be used to calibrate the indices to obtain a population estimate. The estimate for the proportion counted is:

$$p = (X_1 - X_2)/R$$

where

p = estimate of proportion counted

X_1 = count before removal

X_2 = count after removal

R = number removed.

Replicate counts were conducted before and after a removal of 272 horses during February 1981 on Beatys Butte HMA. A population estimate and an estimate of the proportion counted were derived using this method.

Mark-Resight Estimation

Numbered collars with and without radio transmitters were placed on horses on the Pah Rah and Pine Nut HMA areas during October and November 1980 (Table 1).

All collars were constructed of 4" wide 3 ply food conveyor belting. The white-colored belting was tapered to 1 1/2" wide in the area that fits under the neck to minimize wear and irritation to the horse that might develop from neck movement. All collars were numbered with 2" x 3" orange cattle tags for each digit. A 2" x 3" tag was also marked with a "T" for collars equiped with radio transmitters and left blank for collars that served as marker collars only. This was the only difference between marker and radio collars other than the radio.

Tag loss for collars was determined by relocating animals with radio collars. The effect of collaring on reaction to aircraft was evaluated by comparing the reaction of bands with collared animals to bands without collared animals.

Since we were always able to estimate the number of collars on an area they provided the basis for calculating a Lincoln-Peterson Index:

$$N = \frac{Mn}{m}$$

where

N = estimated number of animals

M = number of available collars on an area

n = number of animals resighted (both collared and uncollared)

m = number of collars resighted

Table 1. Wild horses collared on Pah Rah Mustang Area and Pine Nut Mountains, Carson City district, Nevada. Estimated tag loss was determined from radio collars.

Area	Collar Type Radio	Collar Type Color	Total	Estimated Tag Loss	Available Collars
Pah Rah Mustang Area	37	39	76	2	74
North end - Pine Nuts	49	39	88	0	88
South end - Pine Nuts	9	0	9	3	6
Totals	95	78	173	5	168

One B-2 helicopter flight of the Pine Nuts was conducted 18-20 Feb. 1981. A total count estimate as well as a Lincoln-Peterson estimate were obtained.

Five Piper Supercub and 1 B-2 helicopter flights were conducted on the Pah Rah area during late April and early May 1981. Total counts as well as Lincoln-Peterson estimates were obtained.

Collars were also used to obtain an estimate of double counting during the helicopter flight on the Pah Rah Area. During this flight, all collar numbers were noted. Double counting was estimated to be the percentage of collars that were noted more than once out of the total number of collars observed.

Group Size Visibility Bias

Visibility bias of different group sizes was evaluated using the 2 observer design of Cook and Jacobson (1979). In this model, the observability of a particular band size is determined as follows:

$$\alpha s = 1 - \frac{X_{2s}}{X_{1s}}$$

where

αs = probability of observing a band of size s by an observer

X_{1s} = number of bands of size s seen by the primary observer

X_{2s} = number of bands of size s seen by the secondary observer that were missed by the primary observer.

Two observers are required for this model; therefore, a Cessna 180 was utilized on Beatys Butte. Both observers sit on the same side of the airplane. The person in front serves as the primary observer while the person in back serves as the secondary observer. The primary observer serves as the primary locator, noting all bands he sees. The secondary observer only notes bands the primary observer fails to see. Once a band is spotted both observers aid in determining how many horses are in the band. The pilot and any other observers in the plane were instructed to inform the primary and secondary observers of the presence of a band only after the plane had well passed the band and the primary and secondary observer had failed to note it. In this manner, visibility bias information was collected while keeping the flights as similar to routine BLM census flights as possible.

Variables Affecting Accuracy

Snow and cloud conditions were noted on all flights. An estimate of the percent of the area covered with snow was made as well as the snow background for each band sighting. Background categories were no cover, scattered, and complete cover. Cloud condition was obtained from Federal Aviation Administration Flight Service Station reports. These conditions are broken into 4 categories: clear, scattered, broken and ceiling with an altitude given for each cloud layer. The effects of cloud and snow cover on total counts as well as on visibility bias of group sizes were examined.

Observer fatigue was evaluated using the Cook-Jacobson group size visibility bias model. Census flights were divided into a first half and second half and the probability of an observer sighting a group of a particular size in the first half of the flight was compared to the probability of observing that same group size in the second half.

The effect of observer experience was evaluated during the Beatys Butte census flights. Replicate flights were flown by an experienced BLM observer who had participated in censuses of the area yearly since 1971 and by inexperienced observers who either had flown the area only once or not at all.

Relationship of Band Sizes to Population Density

Band sizes were recorded on all flights. Mean band sizes were compared for flights prior to and following the gathering. Also examined were records for census flights conducted on Beatys Butte between 1971 and 1980. The relationship of mean band size to population density as indicated by fall total count data was examined.

Strip-Transect Estimation

An initial evaluation of strip transects was made to determine the sampling intensity needed to provide reliable population estimates. Computer simulation of strip-transect sampling of a population distribution of 623 horses on the Pah Rah Mustang Area was conducted at various levels of sampling intensity. Horse locations and numbers were those from the 5 May 1981 helicopter census of the Pah Rahs. Sampling intensity was based on the percentage of the area covered using randomly selected 1/2 mile wide strips. Observability was assumed to be 100% for the evaluation. One thousand simulations were made, and coefficients of variation were calculated for flights at each level of sampling intensity.

Burro Census

A typical BLM burro census was observed during late May in the Black Mountains, Phoenix District, Arizona. Burros on a portion of this area had been censused during a previous research project by Walker and Ohmart (1978). Paint marking was utilized to provide a Lincoln-Peterson estimate of the population size and sighting rates were compared between the two censuses. Also evaluated was the new paint delivery system being developed by the 3M Company of St. Paul, Minnesota.

RESULTS

Accuracy of Total Counts

Total counts obtained before and after the gathering on Beatys Butte are listed in Table 2. Counts before the gathering, including both experienced and inexperienced observers, had a mean of 397 with a 95% confidence interval of ± 23 horses (6%). Counts following the gathering had a mean of 145 horses with a 95% confidence interval of ± 7 horses (5%).

Table 3 utilizes the various combinations of minimum and maximum counts obtained before and after the gathering to derive the range of population estimates possible using the calibration of an index by removal method. Means of counts before and after gathering, indicated that, on the average, 93% of the horses on the area were being counted.

Table 2. Total count results for flights on Beatys Butte HMA, Oregon, before and after a gathering of 272 horses in February 1981.

BEFORE		AFTER	
DATE	COUNT	DATE	COUNT
14 Aug 80	419	2 Mar 81	141
14 Jan 81	437	3 Mar 81	153
24 Jan 81	408	6 Mar 81	136
25 Jan 81	350	12 Mar 81	146
1 Feb 81	374	13 Mar 81	132
2 Feb 81	384	14 Mar 81	150
3 Feb 81	407	10 Apr 81	150
4 Feb 81	393	8 May 81	153
$\bar{x} = 397$		$\bar{x} = 145$	
$ts_x = \pm 23$		$ts_x = \pm 7$	

Table 3. Population estimates using the calibration of an index by removal method for combinations of minimum and maximum counts obtained before and after removal, Beatys Butte, HMA, Oregon.

RANGE OF COUNTS

BEFORE	AFTER
437 - 350	153 - 132

REMOVAL METHOD

BEFORE		AFTER	ESTIMATE
437	-	132	390
350	-	132	436
437	-	153	418
350	-	153	483
			$\overline{x}$ = 432

Total counts and Lincoln-Peterson estimates for census flights on the Pah Rah Area are listed in Table 4. These flights were conducted during the peak of foaling time; however, the counts and estimates presented in Table 4 are for adult animals only. The mean for the 5 Supercub total counts was 412 with a 95% confidence interval of ± 70 animals (17%). The helicopter flight resulted in a total count of 519 animals.

Collar counts indicated 55% (range of percent counted was 53-58%) of the animals were being counted on the average during the Supercub flights. On the helicopter flight, 68% of the collars were observed. The Lincoln-Peterson estimates for these flights are presented graphically in Figure 1 for the Supercub flights.

The B-2 helicopter flight on the Pine Nuts resulted in a total count of 344 horses. Only 44% of the collars available were observed during the flight resulting in a Lincoln-Peterson estimate of 786 horses for the this area (Table 5).

Tag loss for the collared animals appeared to be minimal. Although 3 out of 9 collars were lost on the south end of the Pine Nuts, loss was, less than 3% on the other collaring areas. This difference in tag loss can be attributed to the method of restraining the animals. Horses on the Pah Rah Area and north end of the Pine Nuts were collared using a squeeze chute. Horses on the south end of the Pine Nuts were roped and placed on their sides for collaring and evidently accurate fitting of the collar was more difficult under these conditions.

Collaring did not appear to affect behavior of horses. Observations were made to determine if horse bands were moving or standing still when first observed for flights on the Pah Rahs. There was no significant

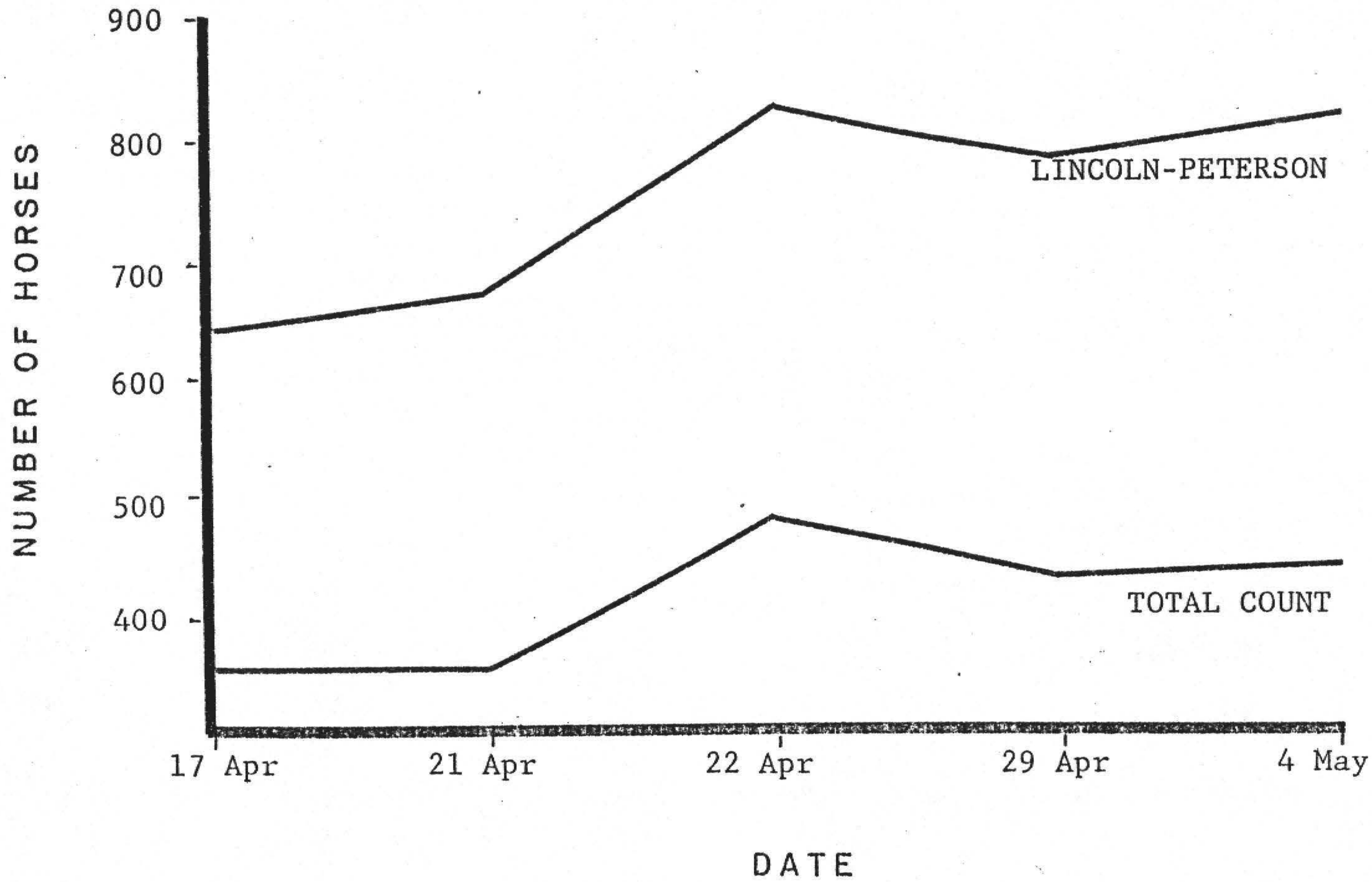
Table 4. Total count and Lincoln-Peterson estimates for flights conducted on Pah Rah Mustang Area, Nevada. Counts and estimates are for adult animals only.

DATE	TOTAL COUNT	COLLARS AVAILABLE	COLLARS OBSERVED	LINCOLN-PETERSON ESTIMATE
PIPER SUPER CUB				
17 Apr 81	353	74	41	637
21 Apr 81	353	74	39	670
22 Apr 81	480	74	43	826
29 Apr 81	432	74	41	780
4 May 81	442	74	40	818
B2 HELICOPTER				
5 May 81	519	74	50	768

Table 5. Total count and Lincoln-Peterson estimate for B-2 helicopter census of Pine Nut Mountains, Nevada.

DATE	TOTAL COUNT	COLLARS AVAILABLE	COLLARS OBSERVED	LINCOLN-PETERSON ESTIMATE
B2 HELICOPTER				
18-20 Feb 81	344	64	28	786

Figure 1. Total counts and Lincoln-Peterson estimates for supercub flights conducted on Pah Rah Mustang Area, Nevada.



difference ($p > 0.05$) between the reaction of bands with collared horses and bands without collared horses. This was true for both the Supercub and helicopter flights (Figure 2).

Variables Affecting Accuracy

Observer experience did not appear to be a significant factor affecting accuracy of the total counts on Beatys Butte. There was not a significant difference ($p > 0.05$) between the counts by experienced and inexperienced observers either before or after the gathering (Figure 3).

Further evidence for the lack of any experience difference is demonstrated in Figure 4. As the inexperienced observers conducted their replicate counts no progressive increase in the count totals was observed as one might have expected if experience was a major factor influencing the outcome of a count.

Snow cover proved to have a significant negative effect on the number of horses counted. An estimate was made of the percent of the area covered by snow for each count for the Beatys Butte censusing conducted before the gathering. A linear regression of snow cover versus total count (Figure 5) resulted in an r^2 value of 0.727 which was significant ($p < 0.05$). No snow cover was ever present on the Pah Rah or Pine Nut areas to allow for similar evaluations.

Cloud cover had a significant negative affect ($p < 0.05$) on the total counts conducted with the Supercub on the Pah Rahs. Linear regression resulted in an r^2 value of 0.844 (Figure 6). No significant influence by cloud cover was demonstrated for the Beatys Butte censusing.

The extent of double counting was evaluated during the helicopter

Figure 2. Effect of collars on reaction to aircraft for bands on the Pah Rah Mustang Area, Nevada. Bands were classified as either moving or not moving when first spotted. No significant difference ($p>0.05$) in movement was found between bands with collared horses and bands without collared horses.

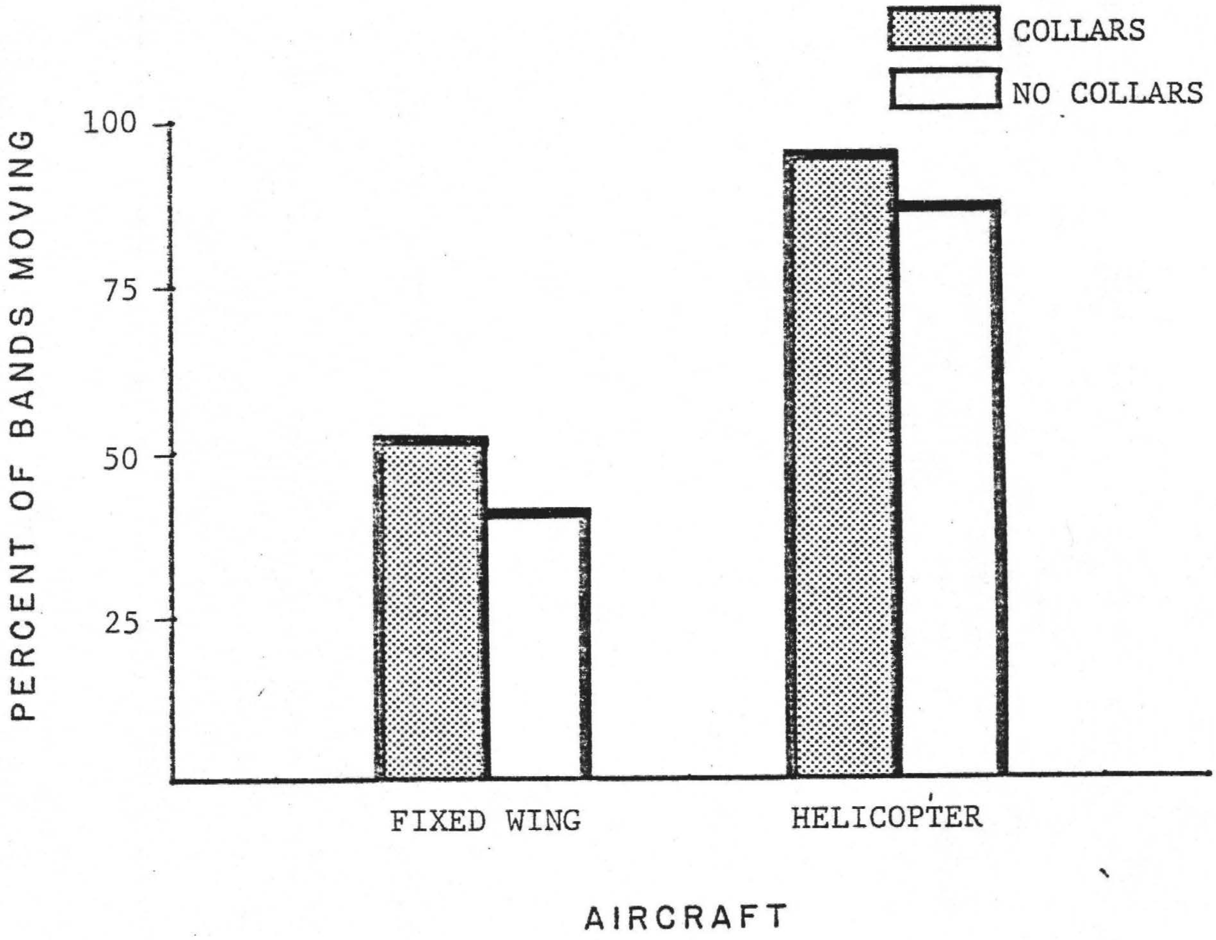


Figure 3. Means of counts for inexperienced and experienced observers before and after a gathering on Beatys Butte HMA, Oregon. No significant difference (p>0.05) was found between experienced and inexperienced observers.

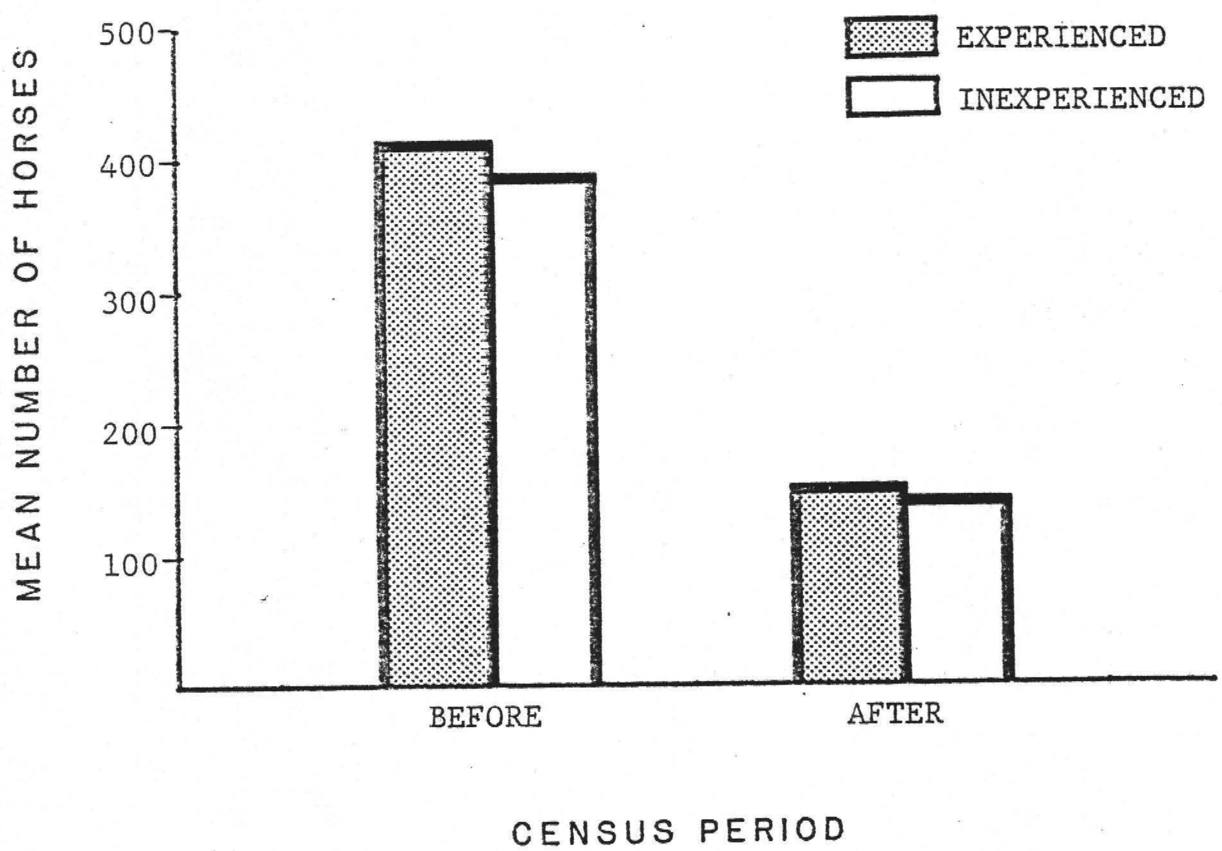


Figure 4. Total counts by inexperienced observers before and after a gathering of 272 horses on Beatys Butte HMA, Oregon.

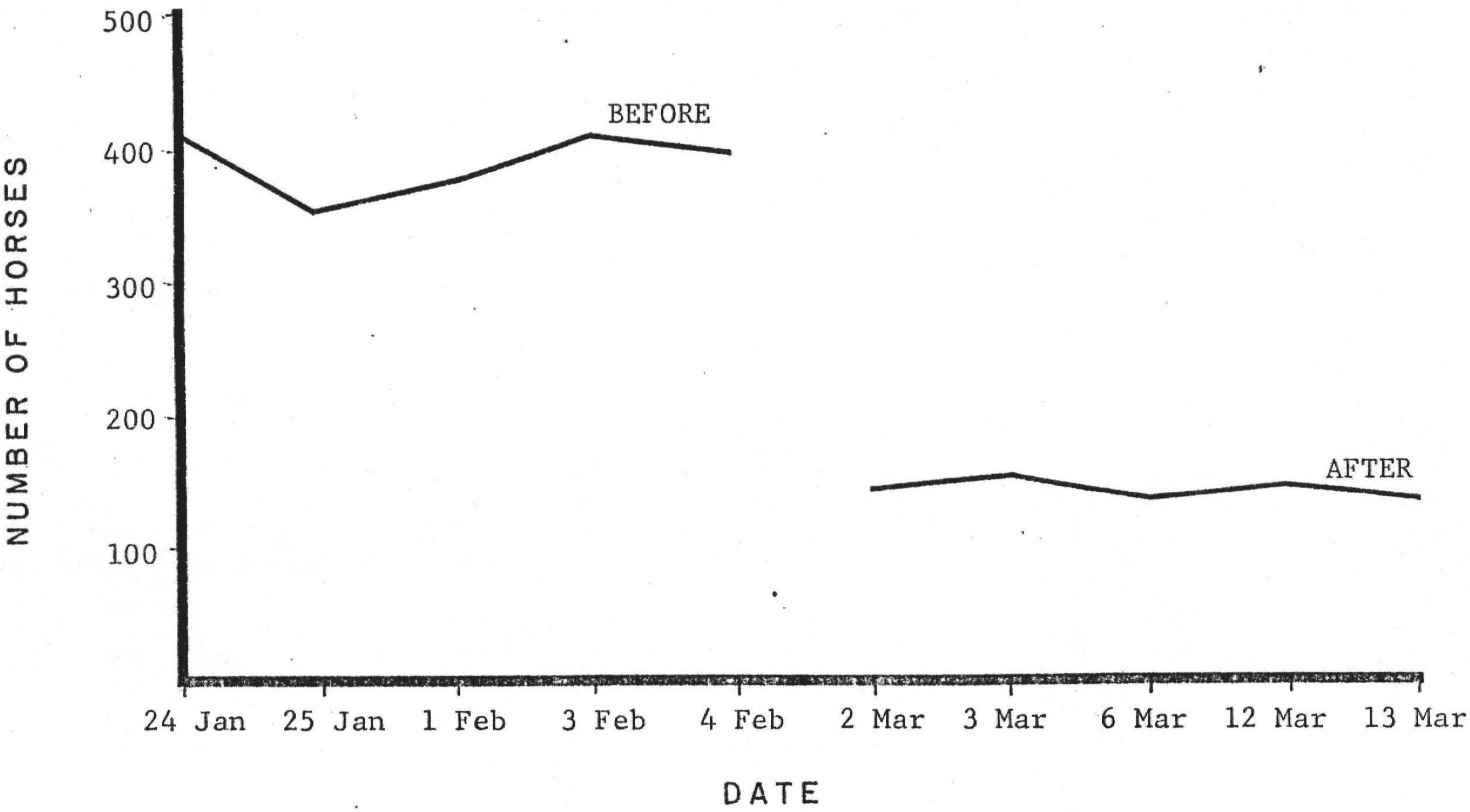


Figure 5. Linear regression of total counts on snow cover for census flights conducted prior to gathering, Beatys Butte HMA, Oregon. A significant ($p < 0.05$) negative relationship was found between total counts and snow cover.

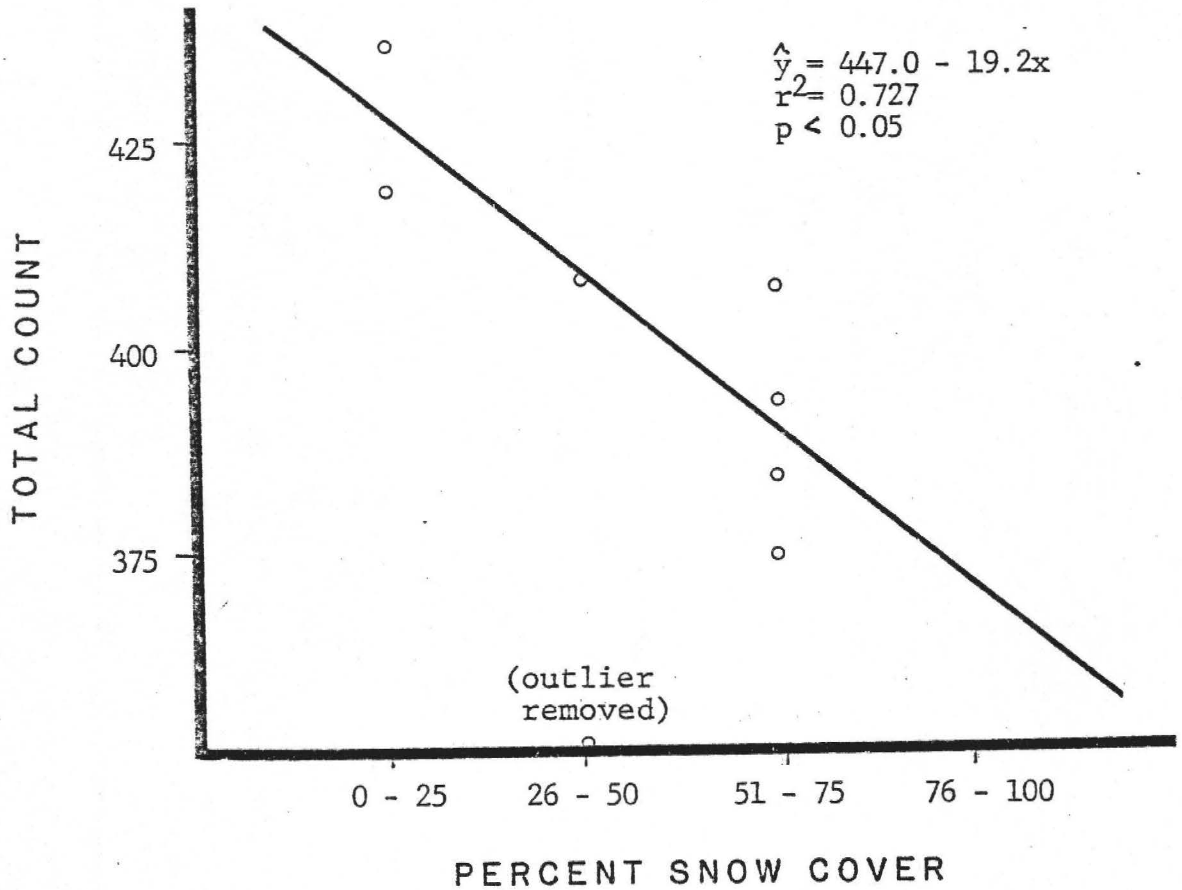
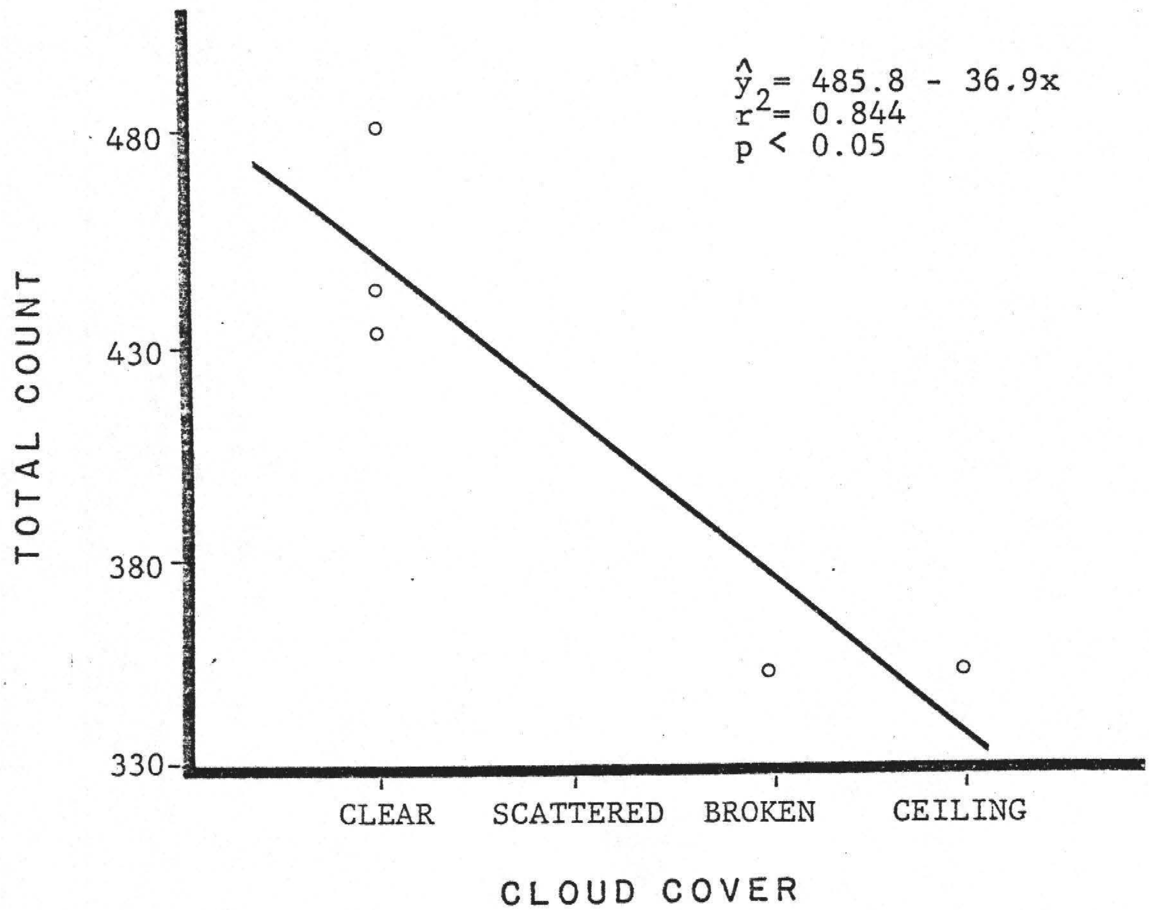


Figure 6. Linear regression of total counts on cloud cover for supercub census flights on Pah Rah Mustang Area, Nevada. A significant ($p < 0.05$) was found between total counts and cloud cover.



census of the Pah Rahs. Four out of 50 collars were counted twice during the survey - an 8% double count. Double counting appears to be more of a problem when using helicopters rather than fixed wing, and is probably related to group size. As can be seen in Figure 7, horses reacted more readily to helicopters than fixed wing aircraft on the Pah Rah area. Movement of a band was determined when sighting was first made.

Group Size Visibility Bias

The probabilities of observation of different size bands by a single observer on Beatys Butte are presented in Figure 8. The trend was for smaller bands, in particular bands of less than 5 horses, to be less observable than larger bands. This trend was more evident in Figure 9 where band sizes have been grouped. These results are taken from 9 flights by inexperienced observers using the Cook-Jacobson group size visibility bias model.

The effect of observer fatigue on the probability that an observer will sight a particular size band is presented in Figure 10. The census flights on Beatys Butte were divided into 2 periods, first half and second half. All sightings made before the midpoints of the flights were placed in the first half category while all sightings made after the midpoint were placed in the second half category. Figure 10 indicates that observers became more efficient at spotting small bands as the flight progressed. On the other hand, observers became less efficient at spotting larger bands.

Snow cover caused a general reduction in observation of all band sizes on Beatys Butte (Figure 11). Snow cover for this analysis was determined for the location where each band was spotted.

Figure 7. Reaction of horses to aircraft type for fixed wing and helicopter censuses of Pah Rah Mustang Area, Nevada. Bands were classified as moving or not moving when first spotted. This difference is significant ($p < 0.01$).

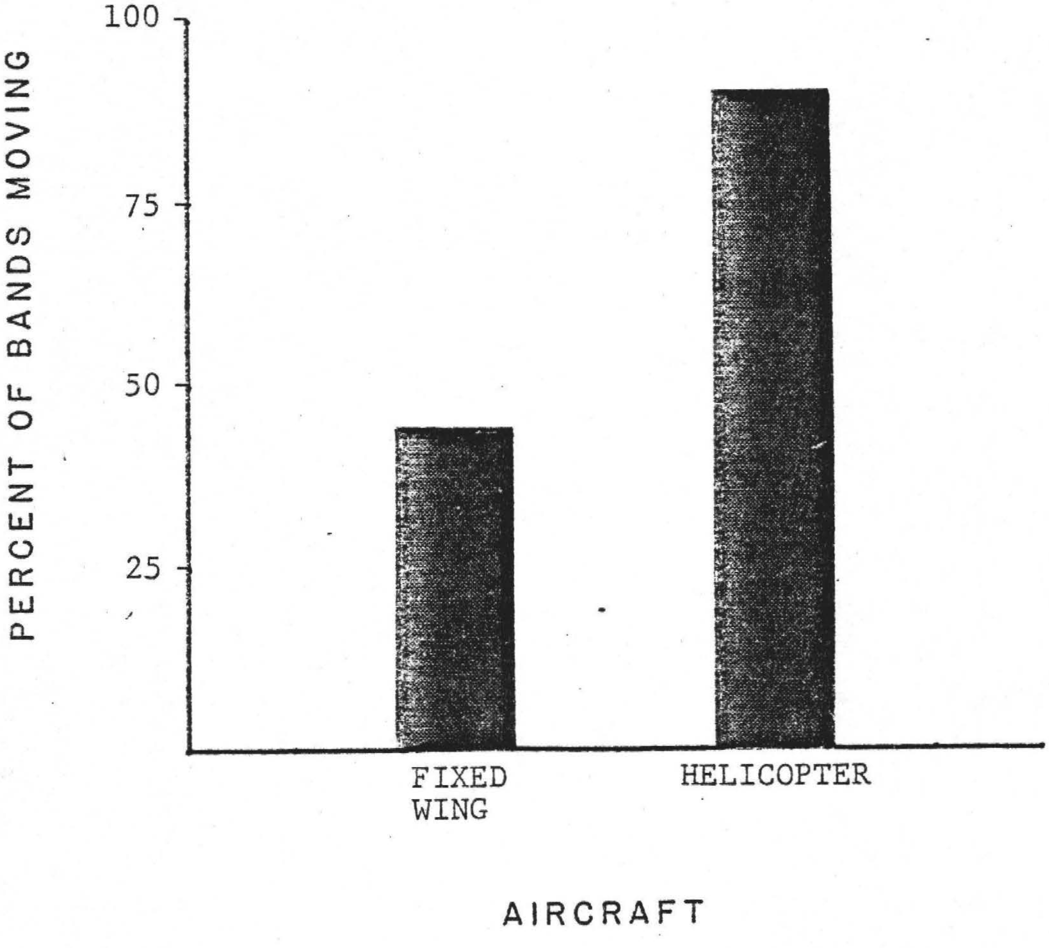


Figure 8. Group size visibility bias results for bands on Beatys Butte HMA, Oregon. Results are taken from 9 Cessna 180 flights by observers using the Cook-Jacobson group size visibility bias model. Bands of 15, 17, 18, 21, and 25+ were not observed.

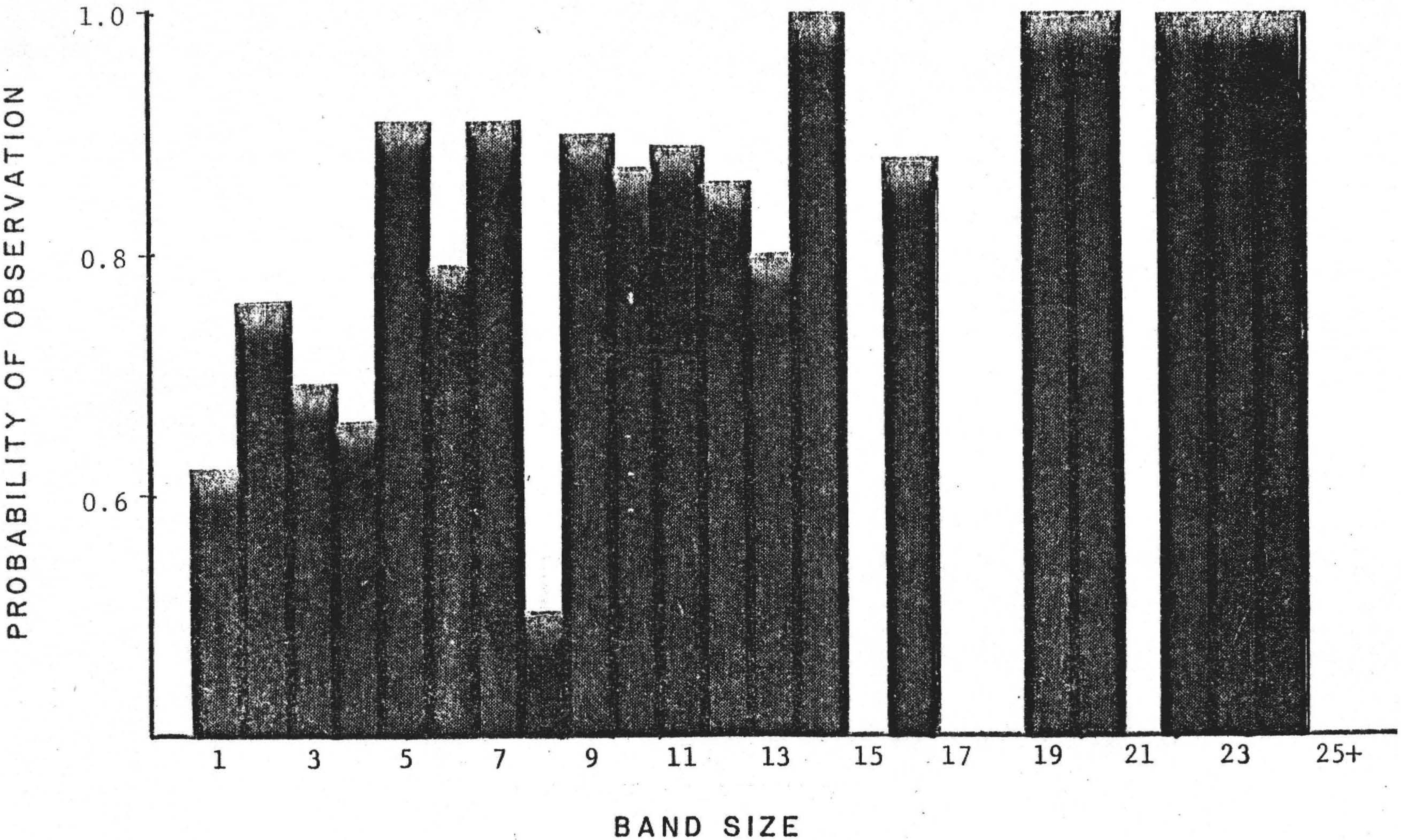


Figure 9 . Group size visibility bias results for bands on Beatys Butte HMA, Oregon. Band sizes are grouped. Results are taken from 9 Cessna 180 flights by observers using the Cook-Jacobson group size visibility bias model.

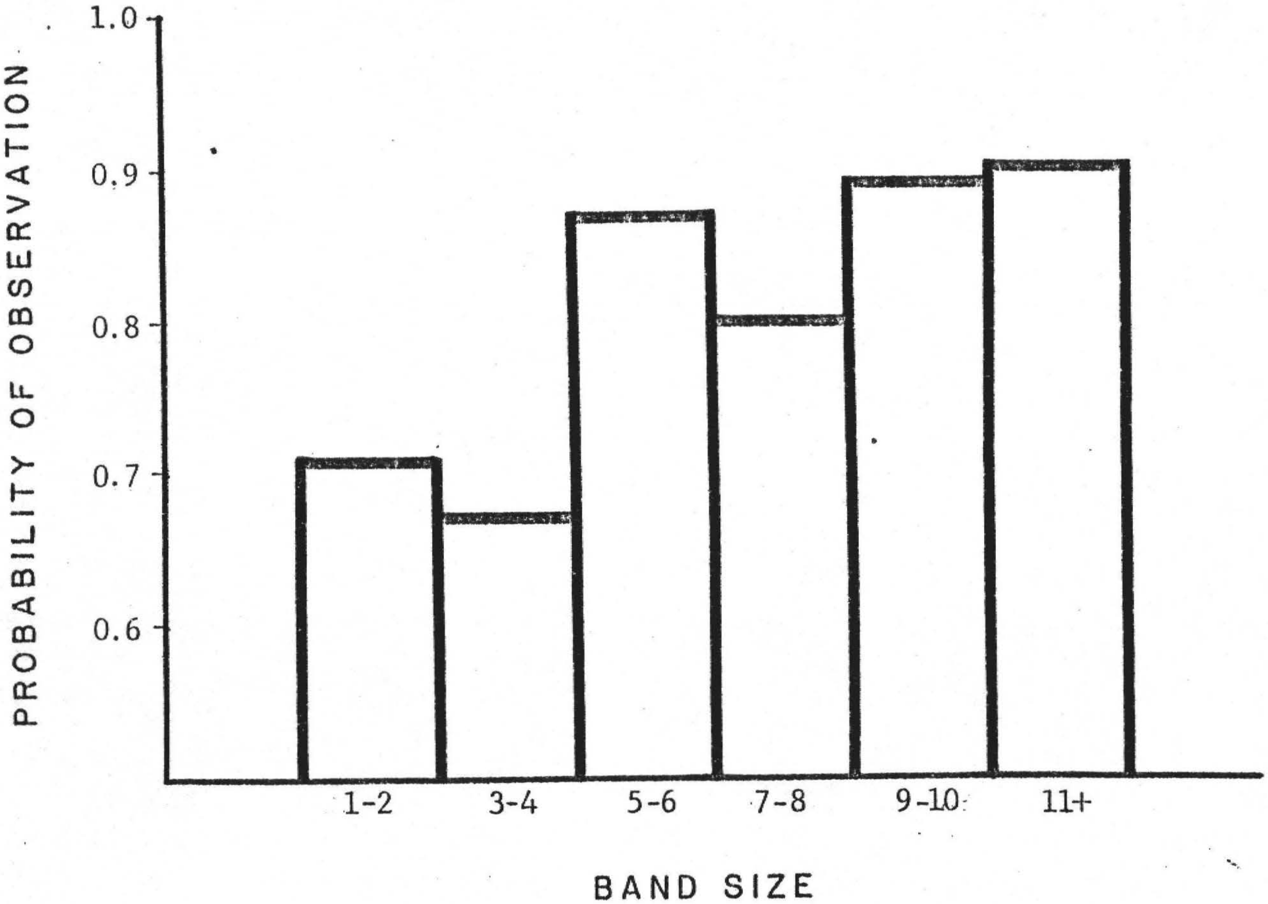


Figure 10. Effect of observer fatigue on group size visibility bias, Beatys Butte HMA, Oregon. Censuses were divided into observations made before the midpoint of the flight and those made after the midpoint.

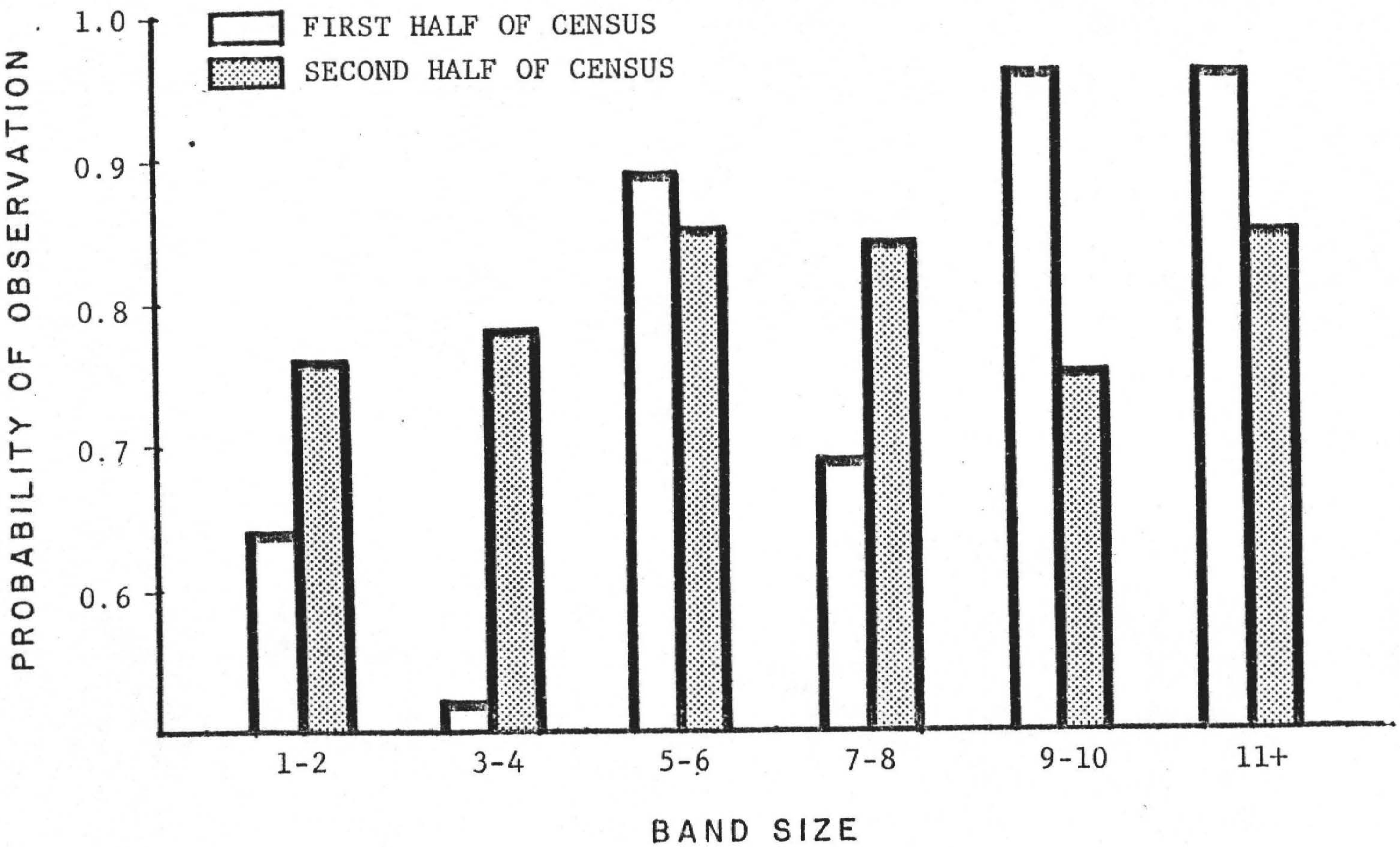
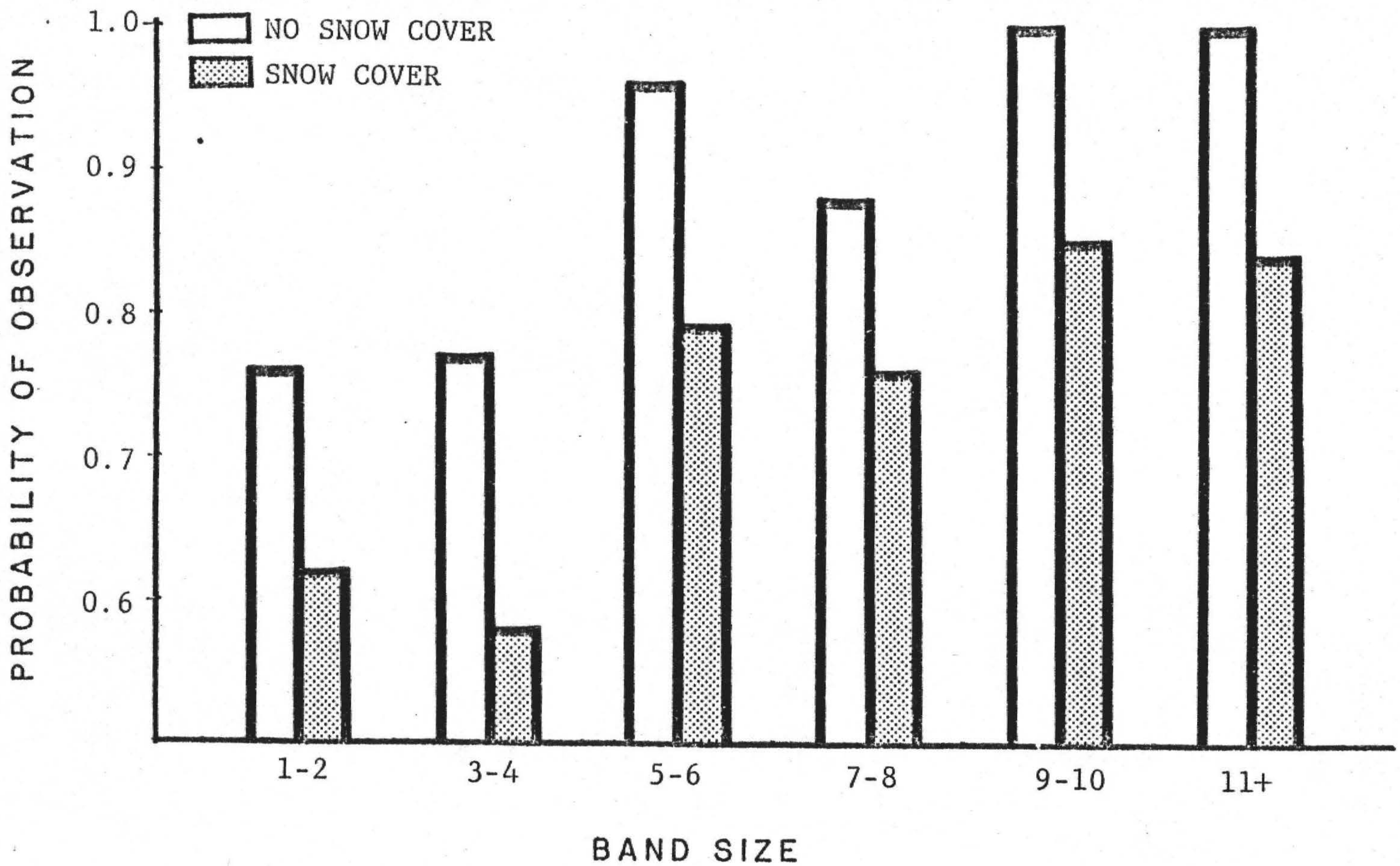


Figure 11. Effect of snow cover on group size visibility bias, Beatys Butte HMA, Oregon. Absence or presence of a snow background was noted for each band sighting and formed the basis for this comparison.



The effect of cloud cover on the observability of different band sizes was less clear (Figure 12). Observability of smaller bands was reduced with a cloud cover while it increased for some of the larger band sizes.

Relationship of Band Sizes to Population Density

A strong correlation was noted for observed mean band sizes and population density for past fall census on Beatys Butte. Figure 13 shows this relationship of increasing mean band size with increasing population density. The outlier was a year when it appeared that many bands were combined at the time the count was made.

Band sizes observed prior to and following the February 1981 gathering of horses on Beatys Butte also reflected this. Mean band size before the gathering was 7.1. Following the gathering, mean band size dropped to 4.4 (Figure 14). Although these values are both less than those predicted by the regression equation, it is possible that seasonal changes in band size may be responsible for this difference.

Strip-Transect Estimation

A graph of coefficients of variation for levels of sampling intensity ranging from 5% to 95% is shown in Figure 15. Coefficients ranged from 1.213 at a 5% level of intensity to 0.0649 at a 95% level of intensity.

Figure 12. Effect of cloud cover on group size visibility bias, Beatys Butte HMA, Oregon.

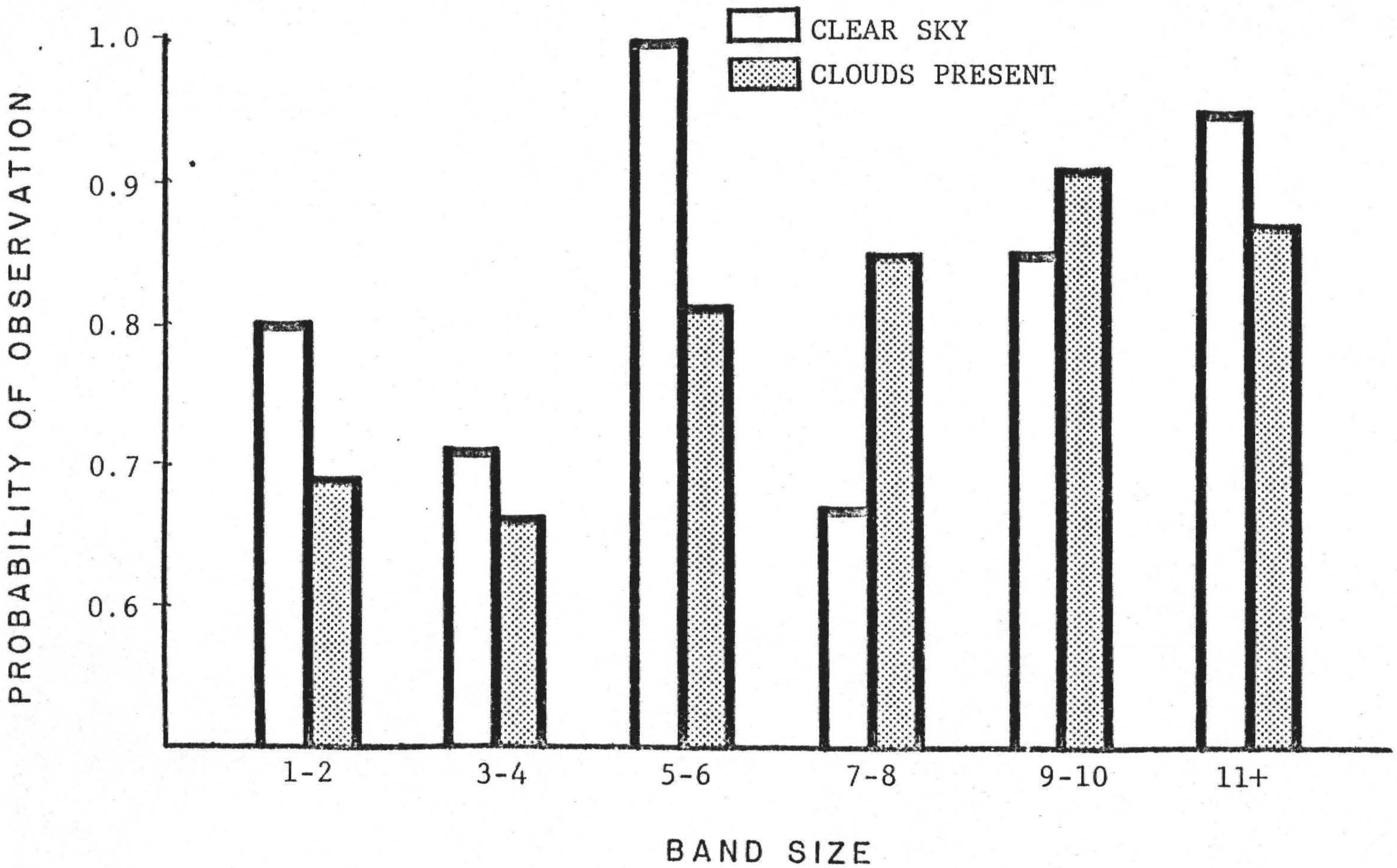


Figure 13. Linear regression of mean band size on population density for 1971-1980 census data for Beatys Butte HMA, Oregon. A significant positive relationship ($p < 0.01$) was found.

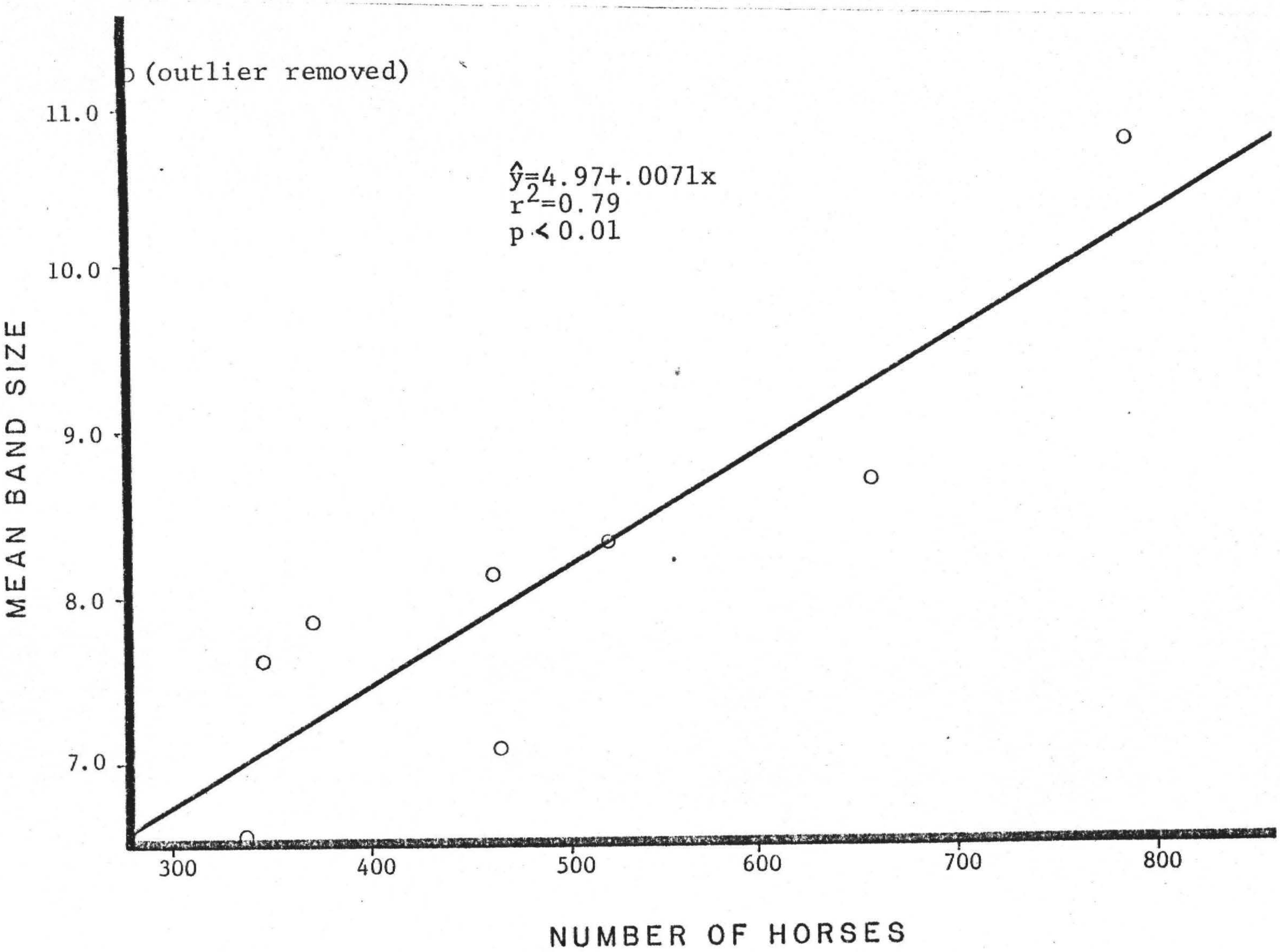
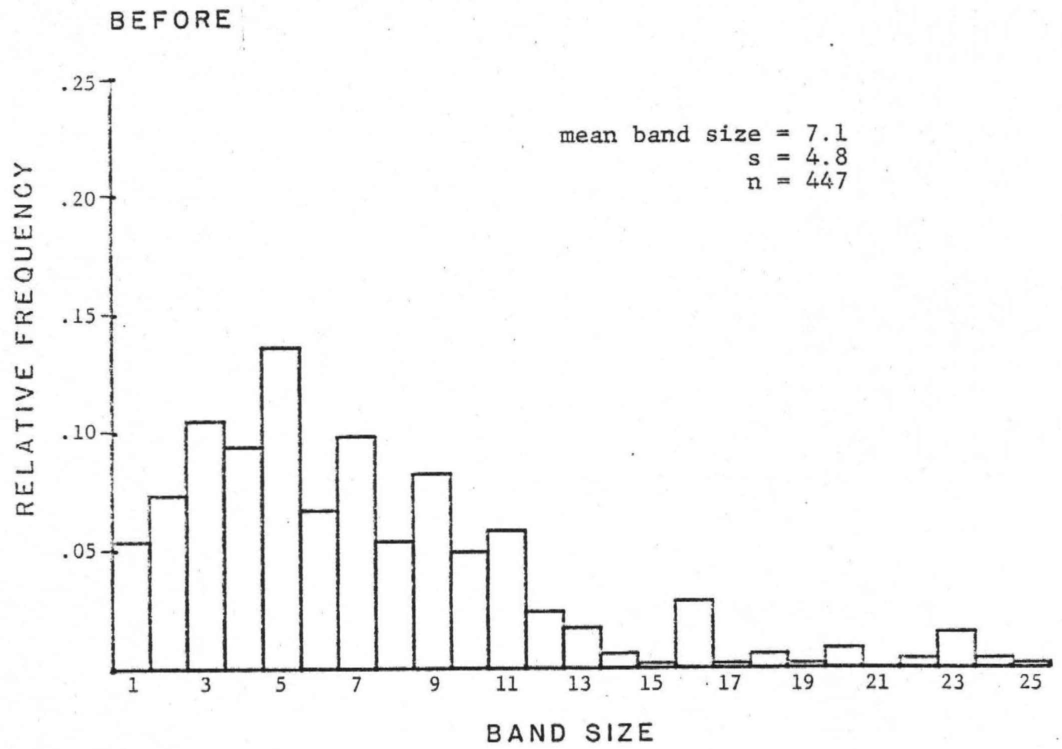


Figure 14. Band size distributions observed on census flights before and after a gathering of 272 horses during February 1981, Beatys Butte HMA, Oregon. Population was reduced from approximately 425 horses to 150 horses. Difference in means was significant ($p<0.01$).



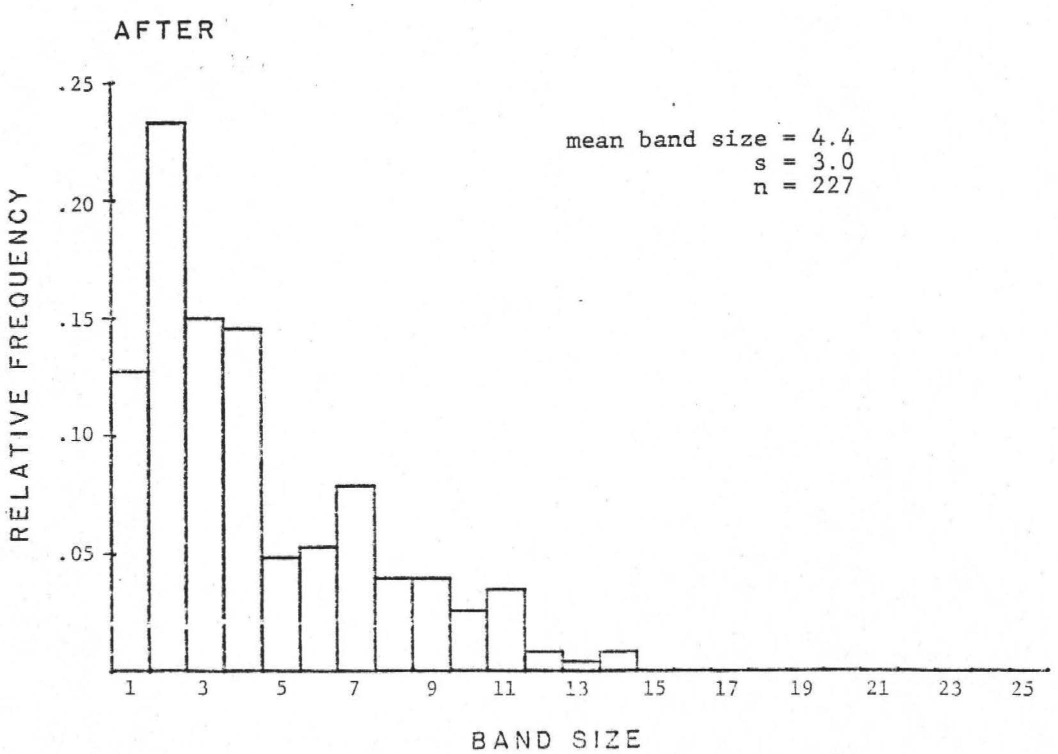
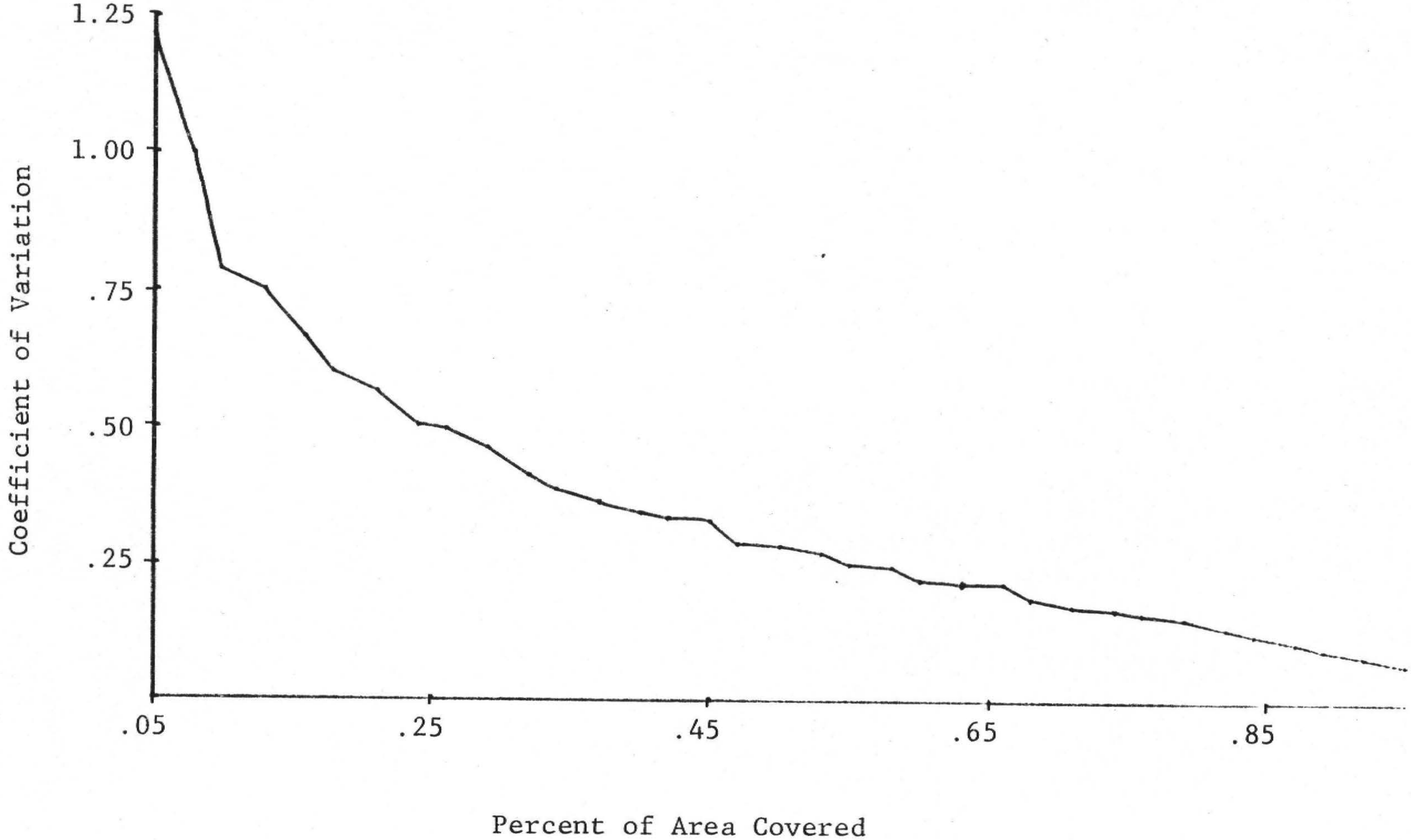


Figure 15. Graph of coefficient of variation for various levels of sampling intensity for simulated strip-census flights of Pah Rah Mustang Area. Sampling intensity is represented by the proportion of area covered during census flight. Coefficents were determined from 1000 simulated flights at each level of intensity. Wild horse population and distribution data from 5 May 1981 helicopter census provided theoretical population.



Burro Census

The resight rate for paint marked burros during the May 1981 census on the portion of the Black Mountains from Oatman to I-40 was 54%. Walker and Ohmart (1978) found a resight rate of 51% for this same area in September 1977.

DISCUSSION

Accuracy of Total Counts

The fact that, on the average, 93% of the horses were tallied on census flights on Beatys Butte indicates that fixed wing censusing in this type of habitat is probably adequate for obtaining population estimates on which to base management decisions. Any increase in accuracy that might be provided by using a helicopter would be slight at a much greater cost. A helicopter census could even conceivably be less accurate given the increased likelihood of double counting. The calibration of an index by removal method appears to be a relatively inexpensive method by which further check on the accuracy of census counts for different topographic and vegetation conditions can be obtained.

Topography and vegetation are significant factors affecting the accuracy of total counts as demonstrated by the flights on the Pah Rah and Pine Nut Areas. The 68% and 44% observation rates on the Pah Rah and Pine Nut areas, respectively, need further evaluation. However, they indicate that a substantial number of horses can be missed on total count surveys of areas with rough topography and/or tree cover. An overall comparison of the accuracy of total counts on the 3 study areas is presented in Figure 16.

Some questions were raised initially that our collaring activities would alter the behavior of the collared horses. The movement observed during censusing on the Pah Rahs demonstrates that collaring has had no significant effect on behavior in reacting to aircraft (p 0.05).

The Cook-Jacobson 2 observer model will be further utilized to determine if there are any problems in determining whether or not an animal has a collar as it is possible that animals with collars are being noted but the collars missed. Use of this model will quantify this bias, if it exists.

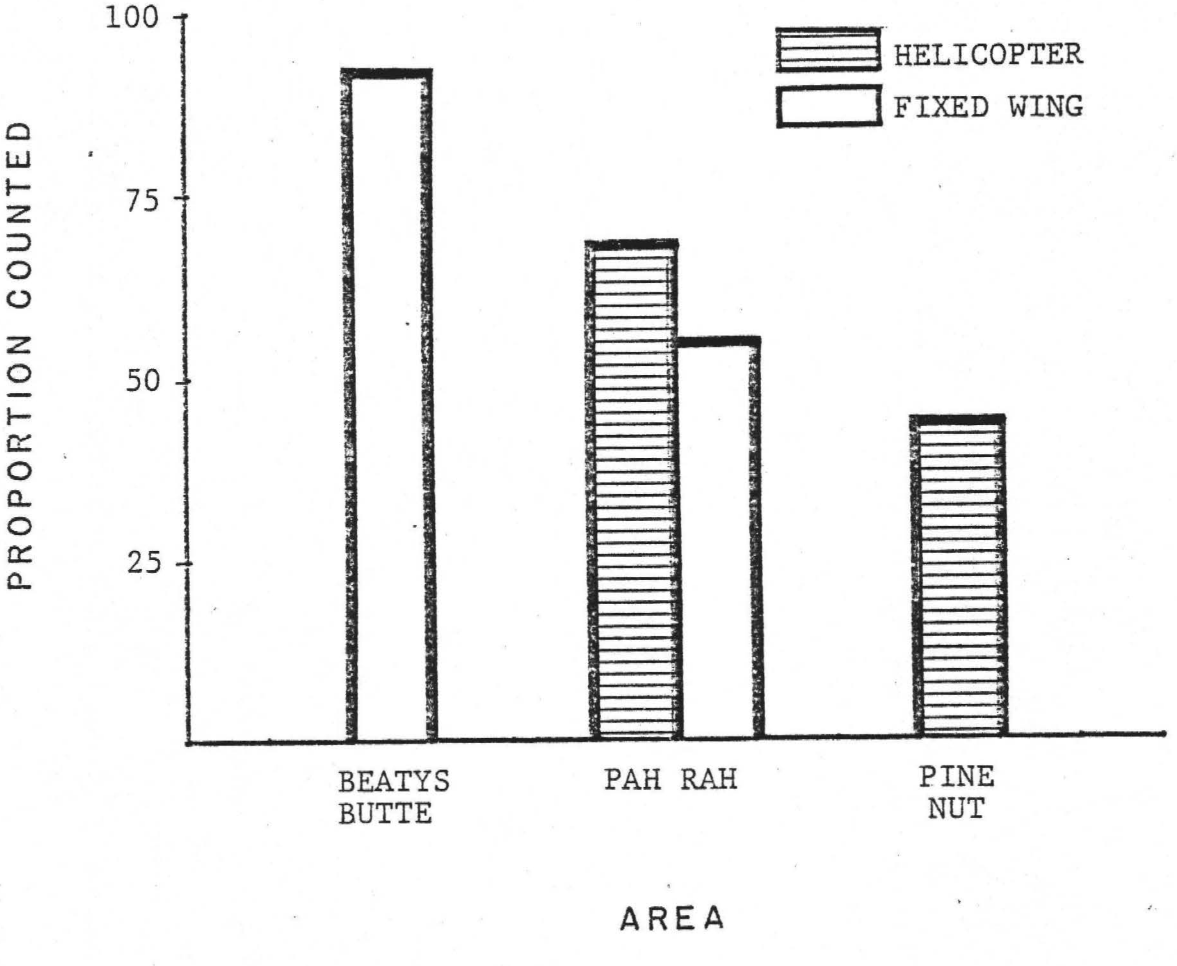
Variables Affecting Accuracy

Snow cover and cloud cover can significantly influence the outcome of a total count. Further research is planned to evaluate snow and cloud cover effects under different topography and vegetation conditions, but it now appears that censuses should be conducted only under clear skies and snow free conditions. At the very least, accurate recording of snow and cloud cover conditions is an absolute necessity.

Observer experience has not been demonstrated to play a major role in influencing total counts. Further research is planned to explore any experience affects that may enter into total count censusing.

Double-counting has the potential to influence the outcome of a total count also. The work we have done to date in this area is preliminary and more studies are planned to check the consistency of existing data.

Figure 16. Estimated proportion of population counted during total counts of Beatys Butte HMA (Oregon), Pah Rah Mustang Area (Nevada), and Pine Nut Mountains (Nevada). Estimates are based on the calibration of an index by removal method for Beatys Butte and resighting of collared animals on the Pah Rah and Pine Nut areas.



Group Size Visibility Bias

The fact that smaller bands are less likely to be seen than larger bands is hardly surprising. It does however, emphasize the point that the probability of counting all horses during a total count census is extremely remote.

The fact that there was no fatigue effect in spotting smaller bands was surprising. The flights on Beatys Butte were long in duration, lasting from 4 to 6 hours without any breaks. We expected fatigue to show up in the second half of the flight with decreased probabilities of observation for all band sizes. This turned out to be true only for larger bands. It appears that practice in spotting small bands contributed more to the overall observability for small bands than did fatigue. This was not the case for larger bands where practice evidently contributed little.

The fact that snow cover reduced observability for all band sizes was expected. The snow that was present on Beatys Butte was not very deep. It left sagebrush very visible creating a mottled or splotchy background from which it was hard to distinguish horses.

Cloud cover effects were not clear cut. Direct sunlight appears to aid in spotting smaller sized bands. For larger sized bands it evidently is not as critical.

The Cook-Jacobson group size visibility bias model is an important tool in understanding variables that affect the accuracy of total counts. We plan to use this model on future flights on the Pah Rah and Pine Nut HMA. We are also planning to use the model to look at collar visibility bias as noted earlier and to establish a sighting curve for bands at different distances from the airplane. This second trial will provide information useful in evaluating strip and line transects.

Relationship of Band Sizes to Population Density

The relationship of mean band size to population density was examined to determine if mean band size could be useful as an index for population density. Although a strong relationship was evident in past census data for Beatys Butte, the magnitude of change in mean band size compared to population density makes it doubtful that mean band size would be a practical index. A very large number of band sightings would have to be made to obtain reliable results from the predictions made by the regression line. Also, seasonal differences in mean band size must be further explored to account for changes unrelated to population density.

Strip-Transect Estimation

This initial evaluation of strip-transect censusing indicates that over 55% of the Pah Rah Area would have to be covered using strip-transects to provide reliable estimates. Because of the clumped distribution of the horse population, levels of sampling intensity less than this provide estimates that vary considerably from census to census.

At an intensity of sampling greater than 55%, any savings in aircraft censusing time over total counts would be greatly diminished. Also, the model used assumes 100% observability. Deviation from 100% will further reduce the utility of strip-transects.

Further simulation evaluations are planned using population distribution data from other areas. However, no field evaluations are planned unless simulation evaluations show some potential for reliable estimates from strip-transects.

Burro Censusing

It was interesting that resight rates were so similar between Walker and Ohmart's 1977 census and the recent census; 51% and 54%, respectively. If the resight rate for a given area remains relatively constant, marking could be dispensed with once a correction factor had been established. Then subsequent counts could simply be total counts adjusted by the correction factor. The savings in helicopter time and man-hours would be substantial.

Correction factors may vary seasonally due to changing probabilities of observation related to changes in background vegetation. Cloud cover, flight altitude and search intensity are additional variables that need to be considered.

Several potential sources of error associated with the paint mark-resight method commonly used by BLM personnel need to be investigated. Paint marks need to be evaluated for observability. Marks lost to grooming and dusting behaviors need to be quantified. Effects of the initial marking on subsequent animal behavior need to be evaluated. The reaction of marked and unmarked animals to aircraft on the resight flight must be determined. If these reactions differ, the effect on observability must be evaluated. Sighting rates may be different for different color burros which may be biasing mark resight estimates. The lack of a sampling scheme when marking may also be affecting the accuracy of the mark resight estimates. These sources of error and how they might influence a mark resight estimate are summarized in Table 6.

Table 6. Potential scources of error and their effects on resulting population estimate for paint marking mark-resight estimates of burro populations (after Begon 1979).

OVERESTIMATE

1. marks lost to grooming and dusting behaviors
2. observer fails to note mark
3. animal behavior altered - home range
4. immigration and emmigration occurs

UNDERESTIMATE

1. animal behavior altered - reaction to aircraft
2. lack of sampling scheme
3. sighting rates different for different color burros

If paint marking continues to be the most viable method of marking burros for mark-resight estimates, consideration should be given to obtaining a delivery system similar to 3M's prototype drug implant - paint marking gun. The paint pistols now commonly used utilize CO_2 for propulsion of the paint ball and have an effective range of 10 yards or less. 3M's prototype is a long barrel gun that utilizes compressed air and has a much greater range. This not only provides for more accurate placement of the marks, it is also very desirable in terms of safety. Many burro areas are just too rugged for safely getting as close as one has to to mark a burro with the pistols. Comments on 3M's gun by Kelly Grisson, BLM Burro Specialist for the Kingman Resource Area, are included in Appendix II.

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Appendix I. Foaling information collected during helicopter censusing of Pah Rah Mustang Area and Pine Nut Mountains, Nevada during 5-7 May 1981.

FOALING OF COLLARED MARES
PINE NUT AND PAH RAH AREAS, NEVADA
5-7 MAY 1981

	PAH RAHS		PINE NUTS	
AGE CLASS	NUMBER OBSERVED	FOALS	NUMBER OBSERVED	FOALS
2	-	-	-	-
3	5	1	4	-
4	5	-	5	3
5	3	3	2	1
6	2	-	2	2
7	-	-	2	-
8	6	2	1	1
9	5	1	3	2
10	3	-	1	1
11	2	-	-	-
12+	1	-	3	-
Totals	32	7	23	10
	22% mares with foals		44% mares with foals	

Appendix II. Comments by Kelly Grissom, Burro Specialist, Kingman Resource Area, on paint marking delivery systems.

IN REPLY REFER TO
4700 KRA

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Kingman Resource Area
2475 Beverly Avenue
Kingman, Arizona 86401

June 11, 1981

Memorandum

To: Greg McMahon

From: Kelly Grissom, Burro Specialist

Subject: Comments on the Marking Gun Developed by 3-M Company

The gun was used to mark wild burros in the Black Mountains of Western Arizona. A helicopter was used to locate the animals, then close in while a shooter attempted to mark the animal with an orange paint spot. The 3-M rifle was used in conjunction with air pistols developed by Nel Spot. During the inventory, 620 animals were marked and about 500 of those were marked with the 3-M rifle.

A. Problems with the 3-M Rifle

1. The air bottle used with the rifle was too small. After a full day of shooting, the air pressure would begin to drop off. A bottle twice the size would ensure enough air.

2. The plug holding the paint balls in the magazine needs to be constructed of a heavier material. It now can be crimped very easily, not allowing the paint balls to flow into the firing chamber.

3. The rifle needs to have a bigger magazine. The pistols hold more paint balls than does the rifle. A magazine could be developed to hold 15 to 20 shots.

4. Paint balls explode easily in the barrel. Different air pressure should be tried. Range isn't that important because when fired at to great of distance, the prop wash from the helicopter will effect the projectiles path. If the air pressure could be lowered a bit, the exploding paint balls in the barrel might be reduced.

B. 3-M Rifle vs. Nel Spot Marking Pistols

1. The rifle would be steadied easier when pointed at a target animal. Having a more stable firing platform, accuracy was increased when using the rifle.

B. 2. The small scope increased the shooters accuracy. It was easier to keep the crosshairs of the scope lined up on the targetanimal then it was the open sights of the marking pistols.

3. The pump action of the 3-M rifle was easier to operate than the stiff bolt action of the marking pistols. The rifle could be cocked and refired without taking your eye or the rifle off the target animal. This was not possible with the marking pistols.

C. Conclusion

The rifle with the scope increased accuracy and range over the previous method of using the Nel Spot marking pistols. This is a major safety consideration for the helicopter and crew. With the increased accuracy, the pilot didn't have to fly as low or stay as close to the running burros for as long of a time. This also caused less stress to the burros. The rifle is a needed improvement necessary for marking wild burros.

Kelly Grissom