Livestock Counts on Negative and Positive Transparencies

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By

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Abstract

Evaluation of photo interpreter counts on low altitude photography has shown that there is not a significant difference in the average number of livestock counted on the negative versus positive transparencies. In addition, there was not a significant difference between the averages for photos counted under different time restraints. A significant difference was found between interpreters which indicates use of interpreter adjustment factors may be necessary in an operational survey. The interpreters were not able to classify the animals by species very well. Further research needs be done to enable more reliable specie identification.

Background

Previous Research

Research sponsored by the Statistical Reporting Service and conducted by the School of Forestry of the University of California at Berkeley during the 1960's, indicated the feasibility of aerial photography as a means of estimating inventories of livestock. This research also indicated the scale, time of day, season, and overlap of stereographic coverage that collectively would yield an optimum result.[1/] These findings and other considerations fostered a project in Idaho counties of Jerome, Cassia, Twin Falls, and Minidoka during May and June of 1969. This report resolved that groups of livestock are hard to count, and high background cluster prevents reliable counts. The report also concluded that access to remote areas is easily accomplished, large areas of land are covered quickly, objectivity in livestock counting can be attained, and it is possible to reduce bias from imperfect communication between enumerator and respondent.[2/]

1/ For a detailed discussion of past remote sensing of livestock inventories see: "Use of Remote Sensing for Livestock Inventories," by H. F. Huddleston and E. H. Roberts, Fifth Annual Symposium on Remote Sensing, 1970.

2/ For results of this work see: "An Evaluation of Remote Sensing Data for Estimating Livestock Inventories," by Wendell W. Wilson, Donald H. Von Steen, and Paul V. Hurt, January, 1972.

Experiment Objectives

In all earlier aerial photography work, photo interpretation was completed on positive transparencies or positive prints. This allows the interpreter the normal gray-level interpretation where light is light and dark is dark as opposed to negative transparencies or negative prints where light is dark and dark is light. Since positive transparencies or positive prints cost more to produce than the corresponding negatives and negatives may possess greater detail than "copies" made from the negative, consdieration should be given to the interpretation of the negatives rather than the positive prints. Could the interpreter make the transition necessary to accurately count animals on the negative images? If he can make the adjustment, we would save the cost and time of producing the positive images.

In addition, the previous California and Idaho studies showed a marked difference in the ratio of photo counts to farmer responses. Possibly one reason for the difference may have been the differences in photo interpretation counting times. The California study allowed interpreters unlimited counting time, while the Idaho study was designed to simulate an operational program and the interpreter's counting time was restricted. Does this difference account for the difference in the ratio of photo counts to farmer responses?

To test these two questions, a sample of 90 photos was selected and the positive transparencies were made. The first hypothesis checked for a significant difference in the average number of livestock counted on the negative versus the positive transparencies. We have historically always used positive transparencies because it is easier for the interpreter to recognize objects in their normal contrast situations which we assume allowed quicker recognization and more livestock counted in a given time period. Our primary test objectives based on means were:

Primary Hypotheses:

a) $H_{01}: U_P \leq U_N$ where P = Positive Transparencies

$H_{11}: U_P \geq U_N$ N = Negative Transparencies

Rejection of H_{01} will show higher counts from positive transparencies for a given time period. The second hypothesis sought to determine if the average count of animals was the same for all time periods.

b) $H_{02}: U_{T_1} = U_{T_2} = U_{T_3}$ where T = Photo Count Time

H_{12}: There is at least one inequality in H_{02}.

Rejection of H_{02} will show there is a difference between counts by length of interpretation time. Generally, photo interpreters will count fewer livestock than ground enumeration methods.[3/] If this ratio (i.e. Photo interpreters count/ground enumeration) is not constant, a series of factors need be derived or a standard time and one factor need be computed to remove the downward bias of the photo interpreters counts.

A secondary hypothesis to be tested was to determine if all interpreters counted with a constant bias. Will all photo interpreters count the same ratio of livestock on the negative transparencies to the positive transparencies?

[3/] Ibid

a) H_{03}: $U_{PI_k} \geq U_{NI_k}$ or $U_{PI_k} \leq U_{NI_k}$

where I_k=Photo Interpreters

H_{13}: $U_{PI_k} < U_{NI_k}$ or $U_{PI_k} > U_{NI_k}$

(i.e. At least one case where the null hypothesis is incorrect).

Rejecting H_{03} will show lack of a significant count ratio. The other secondary hypothesis to be tested was whether specie identification on positive versus negative transparencies was the same. Projecting this hypothesis would indicate the inability of interpreters to consistantly identify the species from negative to positive photos. This test will be made by using quantitative valuables based on chi-square tests.

Experimental Design

Source of Photos

The photos used in this experiment were a subset of the 9x9 transparencies taken over Southern Idaho and used in completing the January 1972 "Evaluation of Remote Sensing Data for Estimating Livestock Inventories." Since it was known that many of the photos used in this earlier report contained no livestock, a subset of photos was selected corresponing to a stratified subsample. The stratified subsample used for this study came from the photos which had some livestock present based on previous work at Berkeley.

Photo Assignment

The project supervisor used Richards Light Table to trace common boundaries on the identical negative and positive transparencies. Additionally, at this time each photo was inspected and a determination made whether livestock were present or not. This determination was compared with prior counts from Berkeley and six groups formed. The groups follow:

<u>Livestock Present?</u>

	Berkeley Analyst	SRS Analyst	Photos
Group A	no	no	32
B	yes	yes	22
C	no	yes	2
D	yes	no	13
E	-	no	15
F	-	yes	6
TOTAL			90

The Photos from each group (A, B, C, D, E, &F) were portioned into 9 cells (3x3 factorial) with the restriction that each cell have 10 photos ($a_c + b_c + c_c + d_c + e_c + f_c = 10$, where $\sum_{c=1}^{9} a_c = A$, etc., and c = the cell number). At attempt was made to evenly distribute the number of photos in each group as numbers permitted. The group divisions were as follows:

A	4	3	4
	3	4	3
	4	3	4

B	2	3	2
	3	2	3
	2	3	2

C	0	0	0
	1	0	1
	0	0	0

D	2	2	1
	1	2	1
	1	2	1

E	2	2	2
	2	1	1
	2	1	2

F	0	0	1
	0	1	1
	1	1	1

Total	10	10	10
	10	10	10
	10	10	10

Photos within a certain group were assigned randomly as follows:

1. The group of photos was put in random order.

2. The cell to receive photos were numbered where $T_1I_1 = cell_1$; $T_2I_1 = cell_2$; $T_3I_1 = cell_3$; $T_1T_2 = cell_4$;...$T_3I_3 = cell_9$, and

run in random order.

3. The random ordered photos were assigned systematically to the cells.

After assigning the photos for each group to the appropriate cells, the cells were systematically ordered with 3 positive sittings following 3 negative sittings. Interpreters were assigned in a systematic random fashion so that no interpreter would know, in advance, a) what time restriction he would be working under, nor b) when he would see the corresponding negative transparencies or positive transparencies. The interpreters, therefore, did not know whether they would see a cell as positives or negatives first. In addition, the interpreter would not know what time limit he could expect until just prior to his count period. This was all done to balance the carryover affects of training resulting from viewing all negatives first or all positives first under a given time constraint.

Photo Interpretation

Three photo interpreters were available for final photo counts. They were tested under three time limits. Each set of photos for a given cell was counted twice. This gave 2x3x3 factorial with two repetitions per cell where the comparison was negative versus positive photos. Each interpreter counted 6 sets of 10 photos each, both on the negative and positive transparency prints. (120 counts/interpreter). The photos were interpreted on a Itek machine using 6x magnification. Three time restrictions were imposed. Forty-five minutes, 1 hour and twenty minutes, and unrestricted. These times were settled upon after considering previous similar work. Forty-four similar photos counted by interpreters who recorded their counting times but were not under time restrictions, averaged 9.2 minutes. Using this as a base, the previously mentioned times resulted. Forty-five minutes (4.5 minutes/photo) would allow a fairly strong time restriction to be imposed, 1 hour 20 minutes, (8.0 minutes/photo) would be about equal to the average, and unrestricted time would allow an open end.

Through the use of a tape recorder, we advised the interpreter at 5 minute intervals how much time they had remaining. The instructions to the interpreters were to complete the counts quickly, then review their work. The interpreters could somewhat pace themselves to complete all photos for each cell in the alloted time.

Interpreter Instruction

Prior to the actual experimental counts, a short training session was to, 1) instruct the interpreters on count areas in question, 2) familiarize interpreters with operational controls of the Itek machine, 3) acquaint interpreters with objectives of the experiment, 4) instruct interpreters how to recognize the different species of animals, and 5) instruct interpreters on methods of completing the counts.

A "Photo Interpretation Form"[4/] was designed to allow interpreters to record observations for the group of 10 photos counted for each cell. The interpreters were instructed to, a) count all animals that appeared on the photos, b) determine the species, and c) determine the number of young animals present. Because of these instructions our final ANOVA table includes only the variable total livestock counted on the survey pictures. Only secondary comparisons made use of the species and age information. A final comparison of counts versus Berkekey counts was not made since the area of count was larger for this survey.

[4/] See Appendix A

The general interpretation instructions were as follows:

(1) Record the photo identification number (segment exposure number) on the "Photo Interpretation Form."

(2) Scan the area inside the blue boundaries for livestock. If animals are not present enter zero (0), return to (1) and continue until all photos are viewed. If animals are present, proceed to (3).

(3) For each photo with livestock present:

A: Count the total number of livestock present.

B: Determine species present.

C: Count the number of young animals of each species.

D: Repeat this procedure for all groups in the boundaries and enter the results on the interpretation form.

E: Return to (1) until all photos are viewed.

A key was presented to the interpreters to aid in their interpretation of species and age of animals. This key follows:

Horse - Mature

Shoulders and back are nearly the same width while the rump is slightly wider. The shadow shows a long neck, long spindly legs, slender body, and a full tail. If the shadows are moderately long, a dark area should be visible between the shadow of the legs.

Horse - Young

Area is 1/4 or less of Horse. The neck is long and thin and the body is long and slender.

Cattle - Mature

Generally appears slightly smaller than a horse. The neck is short and thin, back appears slightly broader than the shoulders, and the body has a slightly rounded appearance. The shadow indicates a heavy rounded abdomen with short stocky legs and thin tail. A bull has a short thick neck and heavy body.

Cattle - Young

Occupies about 3/10 the area of a cow. Generally observed with cows.

Swine - Mature

Approximately 2/3 the size of a mature cow. Generally found in or near small enclosures. Body is sausage shaped with a small head and no visible neck. The shadow indicates short, thick legs, and the belly underline is almost never seen in the shadow.

Swine - Young

The young pig is about 1/4 the area of a mature pig. The neck is short and the body is thick and relatively short.

Sheep - Mature

The body is a "teardrop" shape and about 1/2 as long as mature cattle. The head is small and the neck short (sometimes not noticeable). The shadow indicates short, spindly legs, and bulky body with the underline rarely visible.

Sheep - Young

Lambs cover about 6/10 the area of a mature ewe. Thinner than ewes, but still have a "teardrop" shape.

Experiment Results

Interpreter Counts

The enumerators counts of total livestock for all photos are shown in Table 1. The figures represent the sum of all horses, cattle, hogs, and sheep counted on each photo for the two repetitions.

TABLE 1

Total Livestock Counts by Photo

X_{111}	X_{112}	X_{113}	X_{211}	X_{212}	X_{213}
0-0	0-0	0-0	0-0	0-0	0-0
0-0	0-0	0-0	0-0	0-0	0-0
12-30	0-9	0-0	0-4	3-0	0-0
3-0	0-4	3-0	0-1	1-0	18-0
2-4	9-15	0-0	0-0	5-14	4-0
0-0	0-0	0-0	0-0	4-0	14-0
0-0	0-0	0-0	0-3	0-0	0-0
1-25	2-3	5-0	0-0	2-3	8-0
0-0	2-1	0-0	0-0	0-0	0-0
0-0	0-0	0-0	0-0	0-0	0-0

X_{121}	X_{122}	X_{123}	X_{221}	X_{222}	X_{223}
0-0	0-0	0-0	1-0	0-0	5-0
0-1	0-0	0-0	1-0	0-0	0-0
8-0	42-24	132-0	23-19	0-35	98-0
0-0	19-10	30-26	0-0	0-26	19-25
0-6	0-0	19-18	12-0	0-0	2-0
0-1	0-0	0-0	180-90	0-5	0-0
0-0	0-0	0-0	1-0	0-0	0-0
8-0	19-0	0-0	1-0	0-22	2-0
0-0	48-41	11-7	0-0	0-50	61-8
51-27	0-0	2-2	183-80	0-2	6-0

X_{131}	X_{132}	X_{133}	X_{231}	X_{232}	X_{233}
0-0	0-0	1-0	0-0	0-0	0-0
4-0	0-0	1-0	0-0	0-0	0-0
7-9	0-0	25-0	3-9	0-8	0-0
2-0	0-0	12-0	0-0	0-0	0-0
20-25	0-0	6-0	13-26	0-9	4-0
0-0	0-0	53-66	0-0	3-20	3-83
17-60	0-0	0-0	6-25	0-0	3-0
22-0	0-0	24-19	0-3	0-0	13-3
0-0	0-0	0-0	0-0	0-0	0-0
4-0	111-0	0-0	0-0	0-30	0-0

X_{ijk} i = 1,2 where 1 = negative transparencies
2 = positive transparencies
j = 1,2,3, where 1 = Interpreter 1
2 = Interpreter 2
3 = Interpreter 3
k = 1,2,3, where 1 = :45 minutes time
2 = 1:20 minutes time
3 = unrestricted time

The ANOVA Table for All Photos

The ANOVA Table for the data from Table 1 is shown in Table 2. In Table 2 the two film types contribute 1 degree of freedom (df), the three time restrictions contribute 2 df, the three interpreters contribute 2 df, and interaction of film and time, film and interpreter, and time and interpreter contribute 2, 2, and 4 df respectively. Interaction of film, time, and interpreter contributes 4 df.

The photo nested within film, time, and interpreter represents the difference between the average number of livestock counted on each photo within each photo cell. Since each photo cell contains 10 photos, there is 9 df by cell. There are 9 positive photo cells which contribute 81 df, and 9 negative photo cells which contribute 81 df for a total of 162 df.

The residual term in the analysis of variance represents the difference between the two counts on a photo for the same time and photo type. Since each photo is counted twice, there is 1 df for each photo. Within each photo cell there are 10 photos or 10 df. The 9 positive photo cells contribute 90 df and the 9 negative photo cells contribute 90 df for a total of 180 df attributable to residual.

TABLE 2

IDAHO LIVESTOCK COUNTS

ALL PHOTOS

ANALYSIS OF VARIANCE FOR ALL LIVESTOCK — MEAN 6.65 — C.V. 211.40%

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
FILM	1	8.40	8.40	.04
TIME	2	539.02	269.51	1.36
INTERP	2	6177.77	3088.89	15.62**
FILM*TIME	2	704.96	352.48	1.78
FILM*INTERP	2	1307.57	653.79	3.31*
TIME*INTERP	4	615.98	153.99	.78
FILM*TIME*INTERP	4	2889.74	722.43	3.65**
SEGEXP(FILM TIME INTERP)	162	84623.65	522.37	2.64**
RESIDUAL	180	35604.50	197.80	
CORRECTED TOTAL	359	132471.60	369.00	

* Significant at α = .05

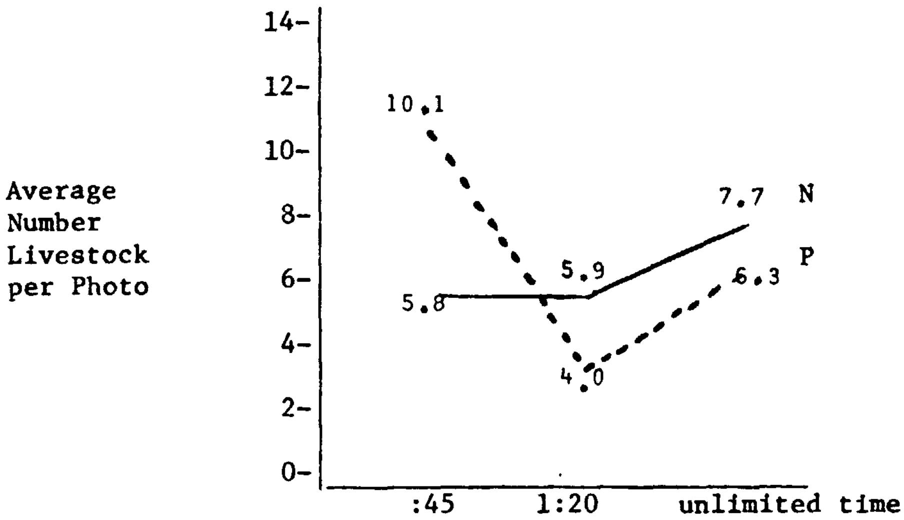
** Significant at α = .01

Analysis of Livestock Counts for All Photos

From the ANOVA in Table 2 we accept H_{01} that the negative transparnecies are at least as countable as the positive transparencies. Also, we accept H_{02} and conclude that the time restrictions do not account for a significant difference, and note that a significant amount of count variation is explained by individual interpreters. As would be expected by the combinations of groups of photos in each cell, a significant difference is explained by photo nested within Film, Time, and Interpreter.

On the following pages are graphic figures showing the relationships between the different variables for all photos counted.[5]

Figure 1



[5] See Appendix B for a discussion of treatment relationships.

Figure 2

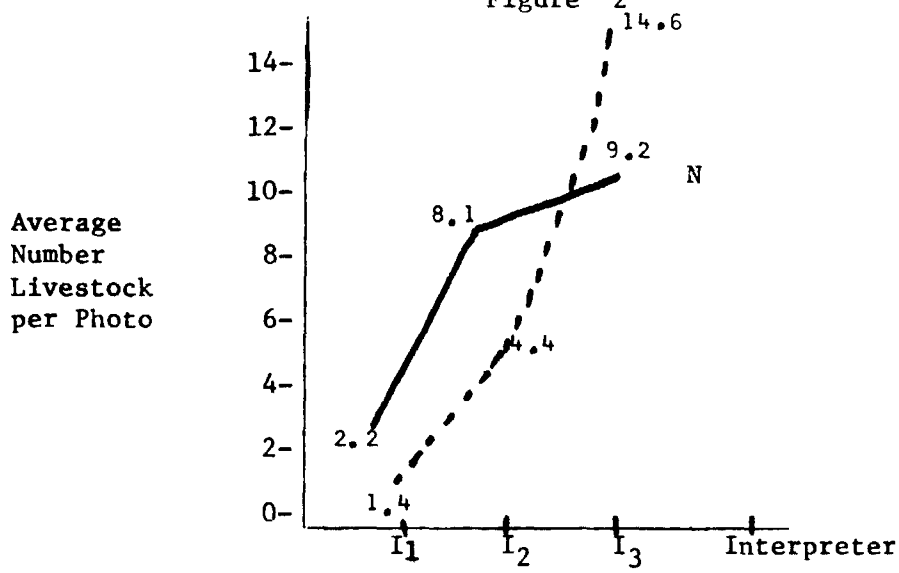
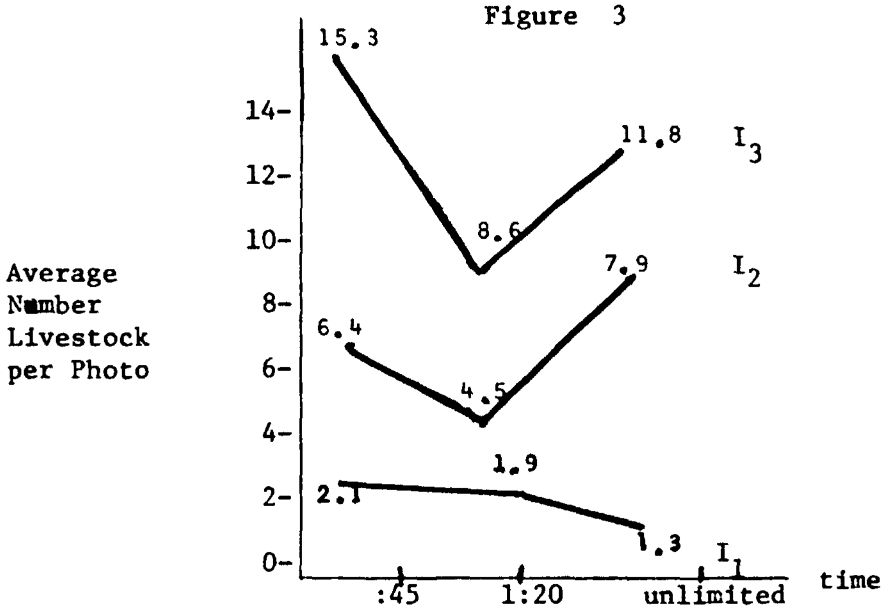


Figure 3



From Figure 1 we see there may be a significant difference between negative and positive transparencies, but it is masked in the ANOVA Table due to strong interaction of film type, and time. Figure 2 also shows an interaction between film type, and interpreter. This negates any constant relationship between negative and positive transparencies and livestock counted and we reject H_{03}. Figure 3 shows the expected (From ANOVA) difference between individual interpreters.

<u>The ANOVA Table for Group B Photos</u>

Recalling that the photographs were originally grouped by presence of livestock into 6 groups (A, B, C, D, E, & F), let us consider Group B. (This group separates those photos which two independent sources said had livestock present). The interpreters counts of all livestock on the photos in Group B follow in Table 3. The numbers represent the sum of all horses, cattle, hogs, and sheep counted on each photo for the two repetitions.

TABLE 3
Group B Livestock Counts by Photo

X_{111}	X_{112}	X_{113}	X_{211}	X_{212}	X_{213}
12-30	0-4	3-0	0-4	1-0	18-0
3-0	9-15	0-0	0-1	5-14	14-0
3-0	2-3			2-3	
X_{121}	X_{122}	X_{123}	X_{221}	X_{222}	X_{223}
8-0	42-24	132-0	23-19	0-35	98-0
0-1	19-10	30-26	180-90	0-26	19-25
	19-0			0-22	
X_{131}	X_{132}	X_{133}	X_{231}	X_{232}	X_{233}
7-9	0-0	53-66	3-9	0-9	3-83
17-60	0-0	24-19	6-25	3-20	13-3
22-0		0-0	0-3		0-0

X_{ijk} i = 1,2 where 1 = negative transparencies
2 = positive transparencies
j = 1,2,3 where 1 = Interpreter 1
2 = Interpreter 2
3 = Interpreter 3
k = 1, 2,3 where 1 = :45 minutes time
2 = 1:20 minutes time
3 = unrestricted time

The ANOVA table for the data from Table 3 is shown in Table 4. The degrees of freedom are the same as Table 2 down through the interaction of film, time, and interpreter. The photo nested within film, time, and interpreter represents the difference between the average number of livestock counted on each photo within each photo cell. Since each photo cell contains either 2 or 3 photos only 26 df are recorded here. The 9 positive photo cells contribute 13 df and the 9 negative photo cells contribute 13 df.

The residual term in the analysis of variance represents the difference between the two counts on a photo for the same time and photo type. Since each photo is counted twice, there is 1 df for each photo. The 9 positive photo cells contribute 22 df and the 9 negative photo cells contribute 22 df for a total of 44 df attributable to residual.

TABLE 4

ANALYSIS OF VARIANCE FOR ALL LIVESTOCK		MEAN 17.	C.V.	136. %
SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
FLIM	1	52.55	52.55	.09
TIME	2	1709.66	854.83	1.48
INTERP	2	12057.73	6028.86	10.41**
FILM*TIME	2	1578.38	789.19	1.36
FILM*INTERP	2	1463.52	731.76	1.26
TIME*INTERP	4	1658.95	414.79	.72
FILM*TIME*INTERP	4	10225.47	2556.37	4.42**
SEGEXP(FILM TIME INTERP)	26	23956.33	921.40	1.59
RESIDUAL	44	25469.00	578.84	
CORRECTED TOTAL	87	78171.59	898.52	

* Significant at α = .05

** Significant at α = .01

Analysis of Livestock Counts for Group B

From the ANOVA in Table 4 we realize the expected. There is still a significant difference accounted for by the different interpreters and the interpretation of film, time, and interpreter. The difference between photos nested within film, time, and interpreter is shown non-significant. Again the graphic figures are presented and follow.

Figure 4

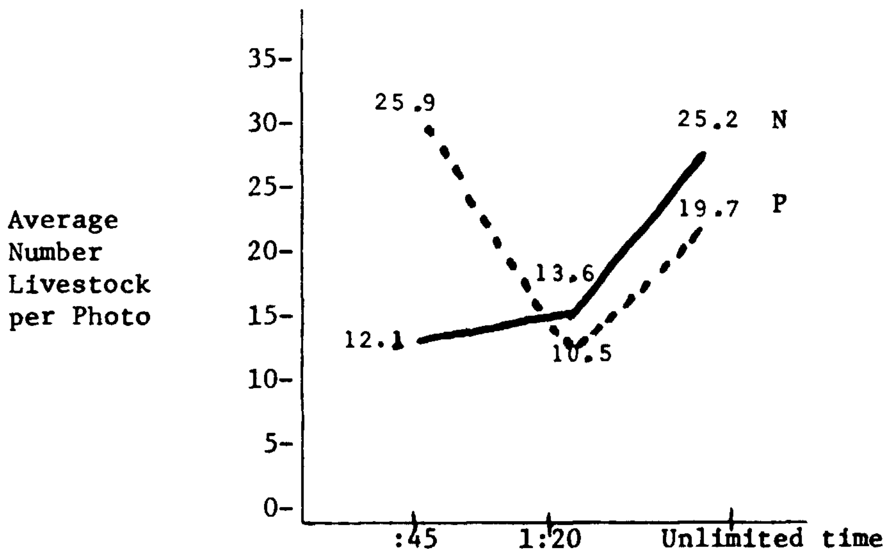


Figure 5

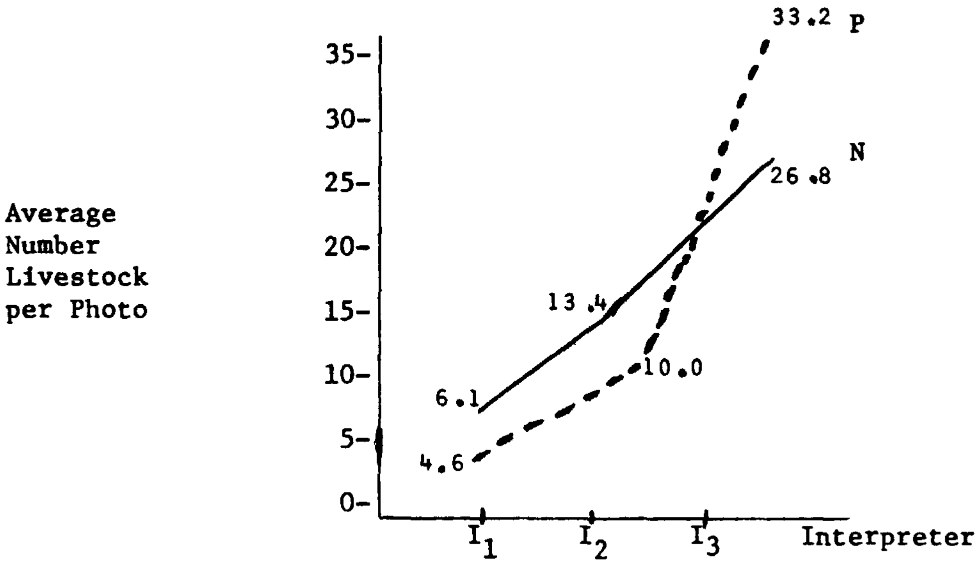
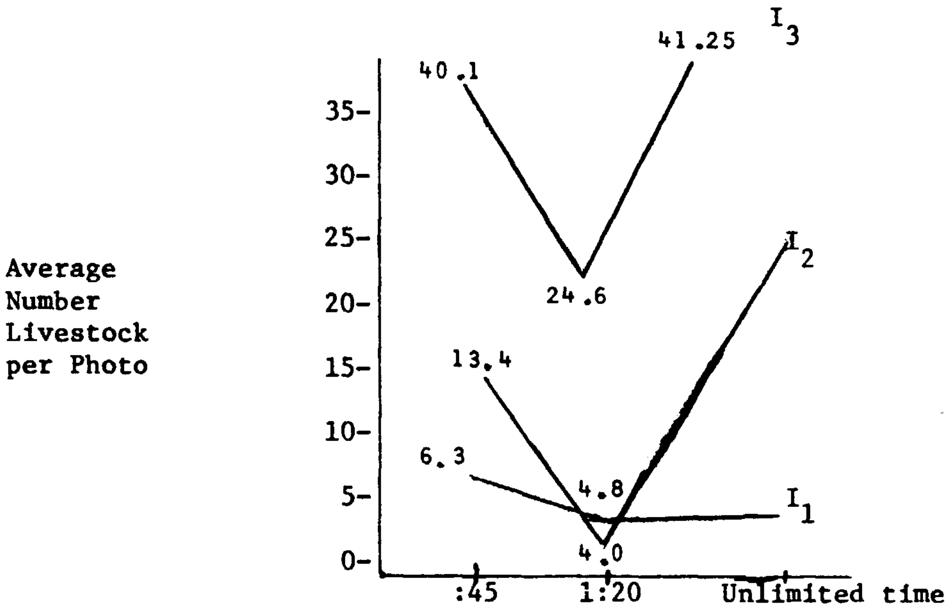


Figure 6



We see that the corresponding figures (Figures 1 vs 4, 2 vs 5, and 3 vs 6) are quite similar since group B accounts for most of the livestock counted. The 88 separate counts on the 22 photos included in the B group have 81 non-zero counts indicating livestock present. The remaining 272 separate counts on the other 68 photos (Group A, C, D, E, and F combined) produced only 62 non-zero counts. Of these 62 counts, 29 had 5 or less livestock of any type present.

Analysis of Species Determinations

The interpreters were instructed to count all livestock present then determine the animal species and record the number of each species in the appropriate answer space on the form. The tables that follow relate only to those photos which had at least one animal of any species on the recording form. This analysis assigns the value 1 to any positive livestock counts on a photo and a zero where no livestock were observed. The results of these comparisons are recorded in Table 5 and 6. In both tables common species refers to interpreter identification of at least one specie which was the same on both counts of the same transparency and a second specie which was different. Identical species refers to identification of the exact same species on both counts of the same transparency.

Table 5--Comparison of Species Determination on Identical Positive or Negative Transparencies.

Interpretation	Photos	
	Negative	Positive
1) Total photo comparisons	90	90
2) Livestock detected by at least one interpreter	41	45
3) Livestock detected by both interpreters	19	13
4) Detection of common species	14	7
5) Detection of identical species 1/	12	5

1/ Each line is a subset of the line immediately above it.

Table 6--Comparison of Species Determination by Photo Interpreter on Negative versus Positive Transparencies.

Negative vs Positive Transparencies	Interpreters					
	1vs1	2vs2	3vs3	1vs2	1vs3	2vs3
1) Total interpreter comparisons	30	30	30	90	90	90
2) Livestock detected on at least one transparency	10	21	8	54	26	49
3) Livestock detected on both	2	13	5	19	19	11
4) Common species on both	0	9	4	10	6	5
5) Identical species on both[1/]	0	6	1	3	5	3

1/ Each line is a subset of the line immediately above it.

From Tables 5 and 6 three additional tables were constructed to determine the following: (1) Do interpreters identify the same species on the same type of film? (2) Does the interpreter identify the same species on positive and negative transparencies? (3) Do the interpreters identify the same specie?

Table 7--Agreement of specie identification for Same Types of Transparencies.

Film / Interpretation	Negative	Positive	Total
Agree	12	5	17
Disagree	7	8	15
Total	19	13	32

Table 8--Agreement of Specie identification on Different Types of Transparencies.

Interpretation	Interpreter			Total
	1	2	3	
Agree	0	6	1	7
Disagree	2	7	4	13
Total	2	13	5	20

Table 9--Agreement of Specie identification on Identical & Different Transparencies

Interpretation	Same Film	Different Film	Total
Agree	17	7	24
Disagree	15	13	28
Total	32	20	52

Chi Square tests were computed for all three tables none were significant which indicates that species identification was not different by interpreters or by type of transparency. However, it does not answer the question which was correct or the best. In all three tables interpreters only agreed about half the time which indicates their agreement was not to much better than chance.

There does appear to be more problems in common identification from positive-negative comparisons that negative-negative or positive-positive comparisons. Apparently the species look different on the negative transparencies than they do on the positive transparencies. Another factor may have been the length of time from interpreter training until completion of the counts. There was an extended period during the experiment that equipment difficulties stopped the counts. Other considerations might be interpreter motivation and experience.

Analysis of Age Determinations

No age analysis is presented since the species comparisons were not reliable. Consequently, a comparison of adult animals versus young animals within species was not attempted.

Conclusions and Recommendations

From the study, we accept H_{01} and conclude that negative transparencies are as countable as the positive photos. Rejection of H_{03} indicates our counts will not be significantly biased to a large count. In future operational surveys of this type, there is a potential time and cost savings realizable since the negative transparencies take less time to produce and cost less than positive transparencies.

A qualified acceptance of H_{02} is made. Although the ANOVA shows no significant difference between counting times, there is a caution that serious overcounting may result where the interpreter is not allowed adequate counting time. Doubtful objects may be counted as animals in this case. Eight minutes per photo should be adequate time during operational survey work. Lead time for publishing survey results may dictate that this would be an upper time limit.

The ANOVA table shows significant interpreter differences. Although this was not one of the original hypotheses to be tested, it should be incorporated into future surveys since it should be anticipating. Thorough training incorporating practice counts needs to be a part of any operational survey. Practice counts would then be a basis for establishing interpreter adjustment factors or covariates for use in the current survey.

The minimal species identification ability indicates that different species appear different to the interpreters. This may be due to lack of adequate training or scale of photography. Improved techniques should be used in training and selection of scale to enable species identification with more reliability.

Appendix A

PHOTO INTERPRETATION FORM

Positive and Negative
9-inch Black and White Transparency

Film	____________	1
Interpreter	____________	2
Time	____________	3
Date	____________	4-6

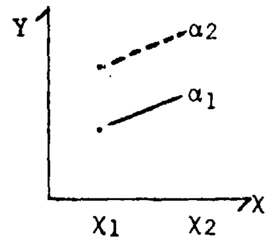
SEG	7-10									
EXP	11-12									
Tot Horses	13-15									
Colts	16-18									
Tot Cattle	19-21									
Calves	22-24									
Tot Sheep	25-27									
Lambs	28-30									
Tot Swine	31-33									
Pigs	34-36									

Appendix B[6/]

Graphic Representation of Interaction

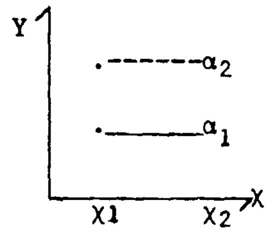
A graphic representation of the results of a given experiment uses the horizontal axis as the independent variable. The dependent variable is then measured on the vertical axis. In each case, we compare different levels of different treatments. Several different occurrence are considered here:

Case 1:



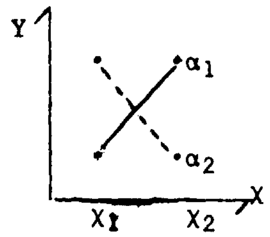
Treatment x has a significant effect upon the treatment levels a_1 and a_2.

Case 2:



Treatment x has no significant effect upon the treatment levels a_1 and a_2.

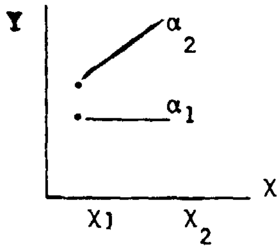
Case 3:



Treatment is interacting with the treatment levels a_1 and a_2.

6/ Kirk, Roger E., Experimental Design: Procedures for the Behavioral Sciences, (1968) Brooks/Cole Publishing Company.

Case 4:



Treatment x is interacting with the treatment levels a_1 and a_2.

With significant interaction illustrated by Case 3 and 4, there is usually little interest in tests of the main effects since these differences will be masked by the interaction. The experimenter will normally proceed to tests of simple main effects.