EVALUATION OF THE PRINCIPAL RING-NECKED PHEASANT POPULATION INDICES IN MICHIGAN

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ABSTRACT

EVALUATION OF THE PRINCIPAL RING-NECKED PHEASANT POPULATION INDICES IN MICHIGAN

by Gale Charles Jamsen

The objective of the study was to evaluate whether the principal indices of pheasant abundance used by the Michigan Department of Conservation were providing useful information. For the time period 1956 to 1965, the crowing-cock and rural mail carrier brood survey were related to mail survey kill estimates by linear regression equations. Since information on fall pheasant populations is of most concern to game managers, prediction equations were constructed to provide kill estimates from the crowing-cock and rural mail carrier brood survey results.

As expected, the crowing-cock index was an imprecise tool in predicting the 1966 fall cock harvest. However, in four out of five study areas, predictions were possible with wide confidence limits. Approximately 20 per cent of the crowing-cock routes provided data suitable for use in the prediction equations.

The rural mail carrier brood survey results were highly correlated with the legal harvest. Linear regression equations predicted the 1966 kill with a high degree of accuracy.

Kill estimates for three of the five study areas deviated less than five per cent from the mail survey estimates. The rural mail carrier brood survey provides excellent information for making management decisions on regulation of the harvest.

Farm area as a basis for computing kill densities was not as satisfactory as the total study area when kill densities were correlated with the crowing-cock and brood indices.

Mail survey results appear to be precisely estimating the legal harvest of cocks. Considerable evidence exists that a constant proportion of cocks are being harvested in each study area. Thus, kill estimates are probably reflecting the magnitude of fall pheasant populations. This index is the most valuable because the results can be easily converted into density values.

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By

Gale Charles Jamsen

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INTRODUCTION

The ring-necked pheasant was introduced into Michigan in 1895 with the first season opening in 1925. Since that time, the pheasant has become the state's major game bird. The harvest peaked in 1944 when an estimated 1,401,076 cock pheasants were legally taken. The average annual bag for the state over the past 30 years has been just under one million cocks. During the period of this study 1956-1965, the pheasant season opened on October 20th and terminated on November 10th. The bag limits have been two cocks per day and eight for the season.

Management of upland game species such as the ring-necked pheasant requires periodic population assessments during key periods in the life cycle. The Michigan Department of Conservation does this by initiating numerous surveys throughout the Michigan pheasant range. The three most important surveys are conducted during the spring breeding season, in mid-summer when nearly all broods have been hatched, and after the hunting season for estimates of the harvest. In all three surveys only a segment of the total pheasant population is sampled.

In the spring an index to breeding male abundance is obtained from the crowing-cock survey. This survey is essentially the same as that developed by Kimball (1949). The mechanics of this survey entail the travel during early morning of twenty mile routes on rural roads. Male pheasant calls or crows are counted in a two-minute period at one mile intervals.

The summer survey enumerates broods. This results in an index that reflects the success of the breeding season. Approximately 600 rural mail carriers in Michigan's pheasant range cooperate with the Conservation Department by counting pheasant broods along their routes. Usually this is done during a two week period in early August.

The third major index of the pheasant population is the kill estimates obtained from a mail survey of approximately one per cent of Michigan's small game hunters. This sample survey is conducted early in the year following the hunting season (October 20th-November 10th).

The objectives of this thesis are to evaluate whether the indices are providing useful information concerning the pheasant population and whether the assumptions necessary for precision in each index are being satisfied.

METHODS

Data for this study were supplied by the Game and the Research and Development Divisions of the Michigan Department of Conservation. Original report forms completed by participants in the annual crowing-cock survey as well as Game Division reports summarizing this survey were made available. In addition, experimental data which had only been summarized were made available for analysis so various assumptions of the crowing-cock survey could be tested. The data from the rural mail carrier brood survey were primarily derived from Game Division Reports. The mail survey sample of small game hunters provided pheasant hunter numbers and pheasants killed in each county plus information on success and effort. Most of these data are from Research and Development Division reports and annual survey records.

The geographical areas (Fig. 1) used in this study are the same as those used by MacMullan (1960). They comprise approximately 72 per cent of Michigan's primary pheasant range (Table 1). These areas were selected primarily for convenience in analyzing a large amount of data. In many cases the data collected were only available on a geographical study unit basis since the original records were destroyed. Also, the study areas permitted contrasts between areas with

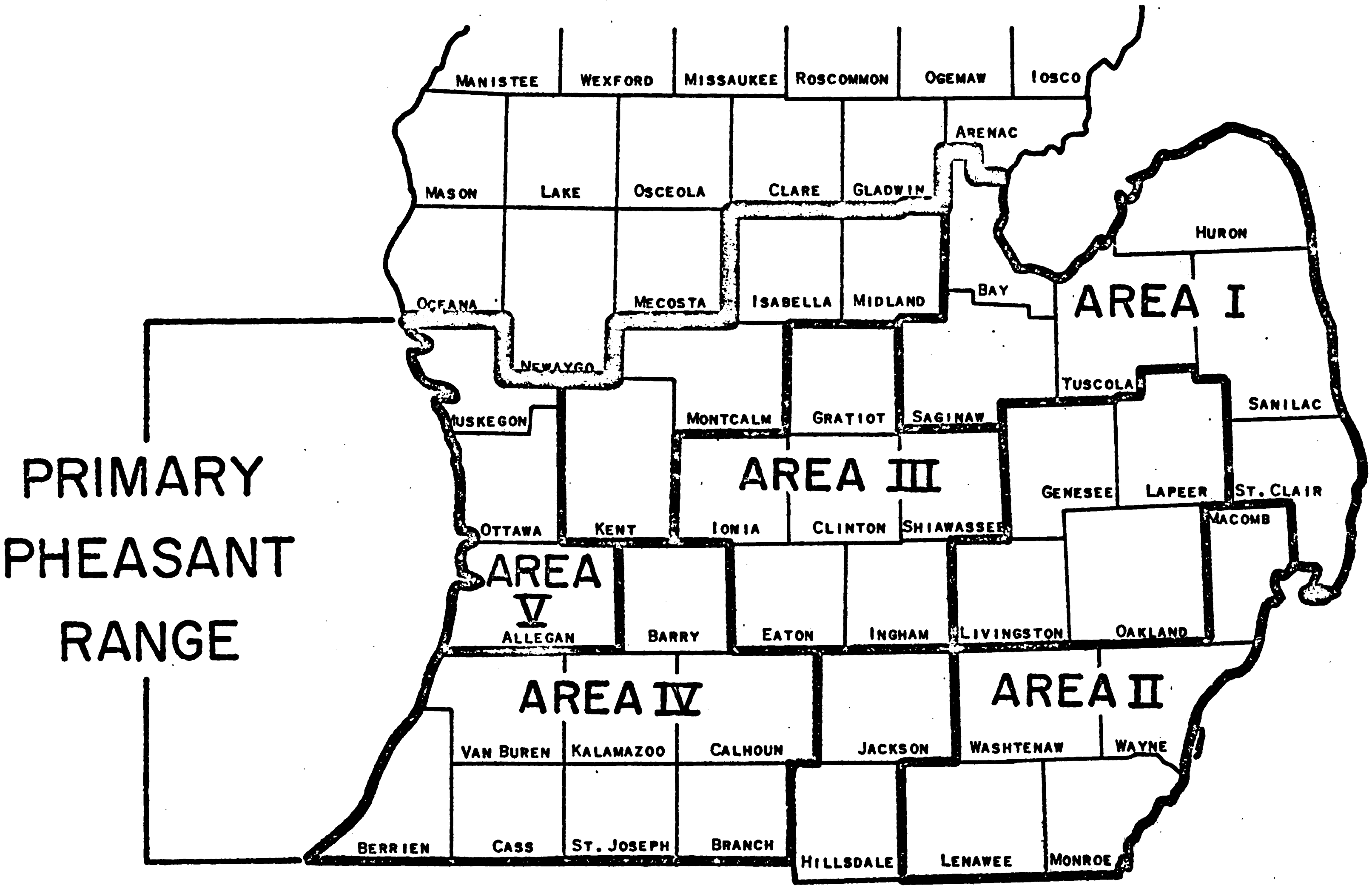


Figure 1. Study areas in Michigan's primary pheasant range.

Table 1. Characteristics of study areas and surveys in the primary pheasant range of Michigan.

Area	Square miles	Number of counties	Number of crowing routes	Number[a] of mail carriers	Miles driven[a] by mail carriers
I (Thumb)	4,597	6	7	107	76,590
II (Southeast)	3,120	5	5	80	53,584
III (Central)	3,378	6	5	100	68,856
IV (Southwest)	4,514	8	6	120	80,515
V (West)	1,897	3	2	48	33,673
Total	17,506	28	25	455	313,218
Primary Range	24,316	38	44	588	404,713

[a]1965 data.

relatively high densities and those with medium and low densities.

Reasonably complete records in the ten year period, 1956-1965, were available for analysis. About 70 per cent of the 36 crowing-cock routes were run continuously during the entire period and were suitable for analysis.

In the following analyses the mail survey kill estimates serve as the standard for testing the other two indices. Pheasant populations available to the hunter are of the most interest and importance to the managers of this game species. Further, it is assumed the mail survey results are unbiased estimates of a constant proportion of the fall cock population. The indices of male breeders and broods produced were then analyzed to determine their relative value in predicting the size of this fall population.

The three indices will be evaluated in the order they appear chronologically in the pheasant life cycle. A discussion of the assumptions underlying the results of each survey will be followed by remarks on how well it is meeting its objectives.

DISCUSSION AND RESULTS

Crowing-cock survey

The crowing-cock survey has been widely used as an index to breeding pheasant males. However, this segment of the spring breeding population is of little importance due to the polygamous nature of the species. An index of breeding pheasant hens would be more desirable as a clue to potential productivity for a given year. Accurate estimates of sex ratios would provide an adjustment factor for transforming the crowing-cock index into an index of breeding hens. Since accurate spring sex ratios are difficult to obtain (Stokes, 1954:82-88), in many cases the crowing-cock index becomes the breeding index. If the sex ratio is relatively constant over the portion of the pheasant range that is of interest, the crowing-cock index might suffice as an indicator of spring breeder abundance. An even better use of the crowing-cock index would be as a predictor of the fall population through its correlation with the legal harvest. The chain of events required for this to happen appear quite remote, since adult cocks usually compose only 10 per cent or less of the fall harvest.

For the spring crowing-cock index to serve as a good predictor of the fall population, certain assumptions must be met. They are:

1. Crowing is directly related to cock population size.

2. Crowing-cock survey results produce unbiased indices of breeding cock populations.

3. The ratio of hens to cocks in the spring pheasant population is constant.

4. A constant percentage of hens hatch broods of a constant size.

5. Spring-to-fall adult and juvenile mortality remains fairly static over the years.

6. Hunting kill is a constant percentage of the fall cock population and the kill estimates have rather narrow confidence limits.

The only assumptions where sufficient data are available for analysis are the first three and the last. The last one will be considered under the discussion of kill estimates; the intermediate assumptions will be tested by correlating the crowing index and the legal harvest. A discussion of the first three assumptions follows.

Relation of crowing to cock abundance -- Research in Illinois in 1947 and 1949 (Robertson, 1958:39) suggests that there is a linear relation between the number of calls per two-minute listening period and known cock populations. Gates (1966) also found a linear relation (r=0.96) between his crowing intensity index and known cock populations in Wisconsin. After carefully examining the data of Gates (1966), the correlation of calls per two-minute period and the square of the known cock population appeared to be the more meaningful comparison. This yielded a correlation coefficient (r) of 0.99.

A correlation this high is open to suspicion as being too good. More information is needed before the nature of the relation is adequately described. However, it does lend support to the logical assumption that crowing and cock numbers are related.

Causes of variation in crowing results -- Kimball (1949) who developed the crowing-cock survey states, "The accuracy of the crowing count and the success with which it can be used are dependent largely upon the following factors:

1. Variation in ability of the individuals conducting the survey to hear cock calls.
2. Daily trend and duration of maximum cock crowing.
3. Seasonal trend and duration of maximum cock crowing.
4. Uniformity of results.
5. Effect of variable factors, such as weather and cover, upon the count."

Carney and Petrides (1957) found close agreement among experienced participants in a crowing-cock survey. Participants without previous experience failed to agree with each other or with experienced participants. The Michigan Department of Conservation in 1961 conducted an experimental crowing-cock survey in Sanilac County with experienced biologists. The data were only superficially examined at that time. The replicated counts suggested a two-way analysis of variance as being the best means of testing the null hypothesis that there were no differences between individuals in their ability to count crowing pheasants (Table 2). These experienced

Table 2. Analysis of variance for counts by experienced participants in a crowing-cock survey (random model), Sanilac County, Michigan, June 1, 1961.

Source	Degrees of freedom	Sum of squares	Mean square	F
Participants	6	321.000	53.500	1.681
Stations	3	1324.857	441.619	
Interaction	18	572.810	31.823	3.808*
Error	56	468.000	8.357	
Total	83	2686.667		

*Significant ($P < 0.05$)

workers, evidently, also do not differ significantly in their ability to record calls. Since Michigan has primarily used experienced personnel during the time period of this study, changes in participants have probably contributed little to the variation in results.

There is little disagreement that cocks begin crowing at a high level from 40 to 50 minutes before sunrise and continue crowing intensely until some time after sunrise. Kimball (1949) suggested that the daily intensity of crowing was fairly constant from 40 minutes before sunrise to 50 minutes after sunrise. Gates (1966) reviewed this matter, however, and demonstrated that in Iowa and South Dakota crowing reached a peak shortly after counting began and declined rapidly within one hour thereafter. In Wisconsin he found that the decline was moderate and that low-density stations had a significantly greater average rate of decrease than did high-density stations. Kozicky (1952) used a circular crowing route of ten miles where stops one and two also served as nine and ten, respectively. His comparison of the same stations at different times also yielded a significant difference.

Analysis (Table 3) by the "t" test of two-minute counts collected in 1961 and 1962 from Ingham County indicated that crowing declined significantly ($P < 0.05$) in three out of four cases when 40-minute periods before and after sunrise were compared. To learn how this bias might affect field data, random selection and analysis (Table 4) of five crowing routes was accomplished for both 1961 and 1963 to discover if the daily time period of the survey influenced the results. These routes had been cruised forward on one day and in reverse order a day or so later. Two out of five crowing routes each year had mean counts per stop that were significantly different from each other. The data were tested by the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956:75-83). Two routes, close to being significant, were tested further by the more powerful paired "t" test and were then found to be significantly different. The results of this analysis are not conclusive. The effect of day-to-day variation may be accounting for the differences. This effect could be eliminated by performing a similar trial with equally skilled participants on the same day.

Table 3. Single station counts of cock pheasant calls comparing the 40-minute period before sunrise with the 40-minute period after sunrise, Ingham County, Michigan.

Date	Mean number of cock-calls per two-minute period		Degrees of freedom	t
	Before sunrise	After sunrise		
4-15-61	14.1	7.8	14	5.24*
5-4-61	12.2	10.0	16	1.33
5-13-61	20.6	11.8	17	6.57*
5-21-62**	7.9	5.4	--	--

*Significant ($P < 0.05$)

**The Mann-Whitney U test (n_1=8, n_2=9, U=1.5) was used because the variances of the samples were not homogeneous [$P(U=1.5) < 0.05$].

Table 4. Effect of daily timing of the crowing-cock survey on the results, Michigan primary pheasant range.

	Crowing-cock route	Mean number of calls per stop	
		Forward	Backward
1961	Clinton*	5.35	3.55
	Eaton	13.85	14.45
	Huron W	9.30	10.15
	Lenawee NE*	10.50	14.15
	Washtenaw	5.40	7.20
1963	Clinton*	9.00	8.80
	Hillsdale	5.70	4.15
	St. Clair N	14.80	15.75
	Lenawee W*	13.25	7.40
	Tuscola NW	5.75	6.55

*Mean values significantly different ($P < 0.05$).

In Wisconsin, seasonal peaks of crowing occurred approximately the same time (April 25-May 15) during 1959 to 1964 (Gates, 1966). Differences in spring weather failed to influence the peak period. Michigan's peak period in 1951 and 1952 occurred during the month of May (Blouch, 1952). The crowing-cock survey has been conducted during this month since 1952 and the Wisconsin results lend support to the validity of this practice.

Gates (1966) suggests that the chief problem in using the crowing count as a population index is the day-to-day variability of the results. Counts varying from 7.5 to 20 per cent of the mean have been reported. Under restrictive weather conditions, Gates (1966) obtained results that varied less than 10 per cent from the mean at the peak of crowing. No similar data on this topic exists for Michigan. A way of testing whether the variability from day-to-day is significant would be by means of a two-way analysis of variance. Replicated counts at each station of a segment of a crowing route could be recorded over a number of days. Comparisons could be made between days and if careful weather data are collected, their effect on the results could be analyzed.

Kimball (1949) dismisses cover and weather as factors influencing the counting of calls when restrictions on wind velocity are met. Wind velocity and cloud cover were variables considered especially important by Gates (1966). He suggested that crowing counts be made only on calm and clear mornings.

Other factors such as the effect of the spring sex ratio on crowing behavior, the relation of crowing intensity to population density, the adequacy of the two-minute counting period, and the proportion of non-crowing cocks could be sources of variation. From Gates (1966) one can deduce that none of these factors has a significant influence on most crowing tallies. He found that crowing counts in areas of high pheasant density could lead to population overestimates because of mutual stimulation. Assessing this effect outside of an intensive study area would be extremely difficult. The two-minute count is long enough for some cocks to be recorded twice, but from evidence collected by Nelson et al. (1962) and Gates (1966) it should only be important at densities higher than those found in Michigan. Burger (1966) discovered from 5 to 8 minute counts that 71 to 92 per cent of the cocks he detected would have been recorded during a two-minute count. For this study it is assumed that the percentage of cocks calling in a two-minute period is constant.

In summary, one can see that the accuracy of the final result of a crowing-cock survey is affected by many sources of variation. The most serious appears to be day-to-day variation due to the fact that the routes are run only once. Assuming all the sources of variation could be eliminated or accurately measured, one would still have an index that would be difficult to interpret for there is no standard or gauge that it can be measured against. Unfortunately, most of the sources of variation cannot be easily measured. Therefore, the data analyzed here are assumed to be providing an unbiased estimate of cock abundance for each study area. Its acceptance or rejection as useful information occurs when it is judged against some acceptable standard established at an earlier or later time.

Relation of crowing-cock index to kill estimates -- Since the pheasant is a polygamous species, the spring sex ratio should be constant over the years for each study area or it should be precisely determined so the crowing-cock index can be adjusted to represent the spring breeding population of females. Smith and Gallizioli (1965) discovered a linear relationship between spring call counts and hunting success of the monogomous Gambel quail. This permitted them to make good predictions of hunting success by means of linear regression equations for three study areas in Arizona.

Sex ratios of breeding pheasants are difficult to obtain due to their behavior. As cocks come into breeding condition in March and April, their conspicuous behavior strongly biases sex ratios determined by roadside counts (Wagner et al., 1965: 27). Thus, late winter sex ratios (Table 5) have been examined as the best substitute for spring sex ratios. Roadside surveys by Conservation Department personnel during February and March provide this data. Stokes (1954:82-88) in his Pelee Island study clearly points out the difficulties in obtaining meaningful sex ratios. Factors that bias the results

Table 5. Pheasant sex ratios from Conservation Department late winter roadside surveys, Michigan primary pheasant range.

	Sex ratio (hens per cock)													
	1959[a]		1960		1961		1962		1963		1964		1965	
Area	F[b]	M[c]	F	M	F	M	F	M	F	M	F	M	F	M
I	15.9	12.0	6.6	6.3	4.2	4.3	6.5	5.4	5.5	4.0	3.5	2.7	3.6	4.4
II	7.9	7.3	6.8	7.1	6.8	4.6	6.2	4.6	3.7	5.0	5.5	2.1	4.2	1.5
III	4.7	2.9	4.7	5.0	2.8	1.4	4.0	4.3	5.7	4.2	0.9	1.0	1.2	2.6
IV	2.2	2.3	1.4	1.0	1.0	0.9	1.8	1.9	1.3	1.0	0.2	1.0	1.9	1.7
V	10.0	6.9	6.8	8.7	9.7	1.7	19.2	2.6	20.3	9.0	0.9	0.1	3.4	13.9

[a]Data prior to 1959 unavailable or incomplete.

[b]F = February.

[c]M = March.

were investigated. They are method of observation, weather (snow cover), and the time of the winter when counts are made. Stokes' weekly estimates of the sex ratio of a given population were highly variable. The Rose Lake Wildlife Research Station in Central Michigan is another location where spring sex ratios have been carefully determined. The use of these sex ratios to estimate productivity available to the hunter yields values (Table 6) for 1961 and 1962 that appear to exceed biological potential (Stokes, 1954:87).

With this background, the data (Table 5) from the late winter survey were analyzed by short-cut multiple comparisons (Kurtz et al., 1965). The February and March data were treated separately. Differences between years for either month could not be detected. However, Area V had a significantly different mean sex ratio ($P < 0.05$) than Areas III and IV in February. In March, Areas I and V were significantly different from Area IV ($P < 0.05$). Next the February and March data were compared by means of the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956:75-83). It was believed the February results would yield sex ratios with a higher proportion of hens due to the effect of snow cover (MacMullan, 1960:129-143). This was the case, $P(z=1.70)=0.04$. It is not my intent to select one month or the other as the more representative of the "true" spring sex ratio. Rather, it is to show that there is a fair amount of variability in sex ratio determinations from roadside surveys. This is especially true

Table 6. **Pheasant sex and age ratios and mortality data, Rose Lake Wildlife Research Station, East Lansing, Michigan, 1956-1965.**

Year	Sex Ratio (hens per cock)			Per cent of juveniles in the kill	Young: adult females[b]	Crippling loss (per cent of total bag)
	Spring	First day of hunting				
		Observed[a]	Estimated[b]			
1956	4.2	.92	1.23	93	3.09:1	19
1957	3.8	1.10	1.20	91	2.68:1	19
1958	4.2	.98	1.21	93	3.10:1	21
1959	7.1	.93	1.46	92	1.55:1	18
1960	7.7	1.10	1.45	93	1.79:1	22
1961	4.3	1.05	1.16	95	4.58:1	17
1962	3.8	1.01	1.14	95	4.97:1	18
1963	5.0	1.12	1.22	94	3.02:1	18
1964	c	.98	--	94	--	20
1965	4.2	.85	1.30	91	2.33:1	21
Unweighted mean	4.9	1.00	1.27	93	2.71:1	19

[a]Computed from hunters reports.

[b]Computed by the method of Stokes (1954:87).

[c]Data unavailable.

in Area V where very small samples of birds are observed in some years.

From this analysis it was concluded that an assumption of a constant sex ratio for each study area from 1956 to 1965 would be reasonable and the crowing-cock index could be directly correlated with the kill. First, each crowing route was correlated with its respective county kill (Table 7). Biases in the kill estimates at the county level could be severe due to small sample size and an urban inflation factor (MacMullan, 1960:38). Approximately 25 per cent of the crowing route indices were significantly correlated ($P < 0.05$) with their county kill. Then the crowing route indices were correlated with the study area kill figures (Table 7) and similar results occurred.

Linear regression equations were prepared using the crowing-cock indices and area kills that were linearly related. Crowing-cock index values for 1966 were utilized in these equations and the predictions compared with mail survey estimates (Tables 8 and 9). In many of the cases the mail survey estimates were outside of the very wide confidence intervals of the regression estimates. Thus, they were not especially useful. Area I was difficult to interpret. A rapidly declining population in this area required predictions to be made from beyond the range of the data. Crowing-cock index values for 1966 and 1967 suggest that a logarithmic transformation of the crowing index might improve its relation

Table 7. Correlations of total crows per crowing-cock route (X_1) and their respective county (X_2) and area (X_3) kill per square mile, Michigan primary pheasant range, 1956-1965.

	Crowing route	$r_{X_1X_2}$	$r_{X_1X_3}$
Area I	Bay	0.88*	0.89*
	Huron W	0.59	0.80*
	Huron N	0.71*	0.77*
	Sanilac E	0.65	0.65
	Sanilac W	0.11	0.19
	St. Clair N	0.49	0.53
	Tuscola NW	0.68*	0.66
Area II	Lenawee SE	-0.13	0.34
	Lenawee W	0.09	-0.20
	Lenawee NE	0.34	0.55
	Monroe N	0.01	-0.05
	Monroe S	-0.38	0.21
Area III	Clinton	0.26	0.38
	Eaton	0.53	0.33
	Ingham	0.35	0.69*
	Ionia	0.69*	0.70*
	Shiawassee	0.25	0.21
Area IV	Barry	0.33	0.44
	Berrien	0.33	0.25
	Branch	0.17	0.24
	Calhoun	0.49	0.20
	Cass	0.88*	0.67*
	Kalamazoo	-0.29	0.15
Area V	Ottawa	0.89*	0.95*
	Allegan	0.38	0.43

*Significant ($P < 0.05$)

Table 8. Pheasant kill estimates in 1966 with 95% confidence limits, Michigan primary pheasant range.

Area	Crowing-cock survey	Brood survey: Broods per 1000 miles	Brood survey: Broods per 10 carrier days	Mail survey
I	190,400±20%[a] 173,600±38%[b] 151,900±49%[c]	87,300±67%	72,100±118%	89,250
II	d	176,600±9%	181,400±6%	142,080
III	80,100±27%[e] 88,700±18%[f]	68,900±23%	67,900±25%	67,760
IV	66,100±19%[g]	61,200±13%	63,700±14%	63,840
V	81,700±5%[h]	68,300±10%	72,000±10%	74,830

[a]Bay County crowing route.

[b]Huron County North crowing route.

[c]Huron County West crowing route.

[d]Crowing-cock survey results not significantly correlated with the kill.

[e]Ingham County crowing route.

[f]Ionia County crowing route.

[g]Cass County crowing route.

[h]Ottawa County crowing route.

Table 9. Per cent deviation of preseason estimates of 1966 pheasant kill from mail survey estimates, Michigan primary pheasant range.

Area	Crowing-cock survey	Brood survey: Broods per 1000 miles	Brood survey: Broods per 10 carrier days
I	+113.3%[a] + 94.5%[b] + 70.2%[c]	-2.2%	-23.8%
II	d	+19.5%	+21.7%
III	+18.2%[e] +30.9%[f]	+1.7%	+0.2%
IV	+3.5%[g]	-4.1%	-0.2%
V	+9.2%[h]	-9.6%	-3.9%

[a] Bay County crowing route.

[b] Huron County North crowing route.

[c] Huron County West crowing route.

[d] Crowing-cock survey results not significantly correlated with the kill.

[e] Ingham County crowing route.

[f] Ionia County crowing route.

[g] Cass County crowing route.

[h] Ottawa County crowing route.

with the kill density and be of some utility for making future predictions. The crowing index and area kill in study area II have very little relation to each other. A relatively stable kill for the period is matched by fluctuating cock populations. Cocks appear to be underharvested compared to Areas I and V. This is probably explained by the fact that much of the land in this area is unavailable to hunters because it includes large metropolitan areas (e.g. Detroit) and landowners are reluctant to permit hunters to use their land (Zorb, 1959). Klonglan and Kozicky (1953) found that crowing routes in areas of low pheasant population density produced data that was much more variable than in areas of high densities. This may be an explanation for the narrow confidence limits in 1966 kill predictions for the high pheasant density range (Area V) as opposed to the fairly wide confidence limits found in the low to medium pheasant density range represented by Areas III and IV (Table 8).

Rural mail carrier brood survey

The rural mail carrier brood survey usually is carried out during the first two weeks of August. Cooperating mailmen, around 600, travel approximately 400,000 miles throughout Michigan's primary pheasant range and enumerate pheasant broods, hens, and cocks. To evaluate this survey, broods were correlated with the hunting kill. MacMullan (1960) demonstrated that a high correlation existed between these two quantities. He also analyzed the factors that contributed to this situation prior to 1957. In investigating the relation during the time period covered in this study, kill figures on a density basis were used. Brood survey results were converted to broods per unit of distance traveled and per unit of time to test which set of data provides the best kill predictions.

Brood data for the analysis in this study were utilized as broods per thousand miles since this implies a sampling unit in terms of area. The Conservation Department presents its data as broods per ten carrier days in the belief that a unit of time in the field as a sample will yield as good an index as a unit of distance traveled (MacMullan, 1960). This point was tested by regressing kill per square mile of each study area upon the respective number of broods per thousand miles and ten carrier days. Two sets of regression equations were prepared. Data from the 1966 brood survey were introduced into the equations and the resulting kill estimates were compared with the 1966 mail survey results (Tables 8 and 9). Broods per ten carrier days yield closer estimates to the mail survey in Areas III to V, but for practical purposes the estimates provided by broods per thousand miles as the independent variable are satisfactory (Table 10). In Area I the 1966 brood index value was considerably lower than the range of the previous ten years. This causes one to be very hesitant in attempting to place much importance in the estimates, although they are surprisingly close to the mail survey estimate. In addition, it should be noted that a recent decline in pheasant numbers over the primary pheasant range requires that 1966 estimates be made from slightly beyond the range of data for Area II and III when using broods per 1000 miles as a base and in Area III when using broods per ten carrier days.

Table 10. Correlations of kill per square mile of pheasant range (X_1) with broods per 1000 miles (X_2) and broods per ten carrier days (X_3), Michigan primary pheasant range, 1956-1965.

Area	$r_{X_1X_2}$	$r_{X_1X_3}$
I	0.93*	0.88*
II	0.75*	0.80*
III	0.88*	0.88*
IV	0.68*	0.67*
V	0.90*	0.87*

*Significant ($P < 0.05$).

At this time it is appropriate to look into the reasons why such a good linear relation exists between the brood survey results and the kill density. It appears the most important factors contributing to an accurate brood index are large sample size, a random sample of broods appearing on highways, and the timing of the survey. With nearly 600 mailmen participating annually, the primary pheasant range is intensively surveyed. Also, although the time of day

(9:00 a.m. to 3:00 p.m.) is far from ideal for observing broods it is constant year after year. To optimize the survey to the time period when adult pheasants are most active would require beginning the survey at sunrise, which is obviously impractical. Dalke (1937) observed that adult pheasants are most active during the hour following sunrise and little feeding occurred during the middle of the day in either summer or winter. Experience through participation in the survey for many years also adds to its reliability. Annual turnover among rural mail carriers is only about five per cent. Finally, the weather and crop phenology are monitored via climatological reports and crop weather bulletins. This with the aid of hatching curves and the judgment of the pheasant specialist insure that the brood survey will be conducted each year at a time when a maximum number of broods are available for observation.

To learn if changes in the brood index caused uniform changes in the kill density throughout the range, slopes and levels of the individual area regressions were tested (Freese, 1964). The slopes were not significantly different but the levels were different (Table 11). Thus, the use of one regression equation utilizing all the data would probably err in predicting an average kill density for all the study areas.

While working on this phase of the study and observing the difference in the precision of the kill estimates for the different study areas, the idea that the total land area

Table 11. Covariance analysis for homogeneity of regression concerning broods observed per 1000 miles and population level as cocks killed per square mile of study area, Michigan primary pheasant range, 1956-1965.

Source	Degrees of freedom	Sum of squares	Mean square	F
Area I	8	347.022		
Area II	8	151.088		
Area III	8	121.916		
Area IV	8	32.481		
Area V	8	129.627		
Total	40	782.134	19.553	
Difference (slopes)	4	110.499	27.625	1.413
Pooled regression	44	892.633	20.287	
Difference (levels)	4	3768.976	942.244	46.446*
Single regression	48	4661.609		

*Significant ($P < 0.01$).

was not suitable as pheasant habitat suggested itself. Since the pheasant is closely associated with farmland and has a diet composed mostly of corn and grains, it seems logical that farm area (U. S. Bureau of the Census, 1959 and 1964) rather than the total study area would be more suitable as the basis for computing pheasant denisities. This hypothesis was tested by correlating crowing-cock results and the kill per square mile of farmland. Correlations equal to or slightly lower than those obtained from the total area kill densities were computed except for Area IV where the correlation decreased to where it was not longer significant (Table 12). In testing the hypothesis by correlating broods per thousand miles with kill per square mile of farmland, only in Areas I and III were correlations as good as the correlations of broods per thousand miles and kill per square mile of study area (Table 13). It is not clear why farm area does not serve as well as the total area in defining pheasant habitat.

The good correlation between the brood index and kill densities for the study areas serve to strengthen the contention by MacMullan (1960) that:

1. Late summer mortality and brood size are relatively constant from year to year.
2. The brood survey has been appropriately timed.
3. The precision and accuracy of the brood survey and computed kill are quite high.

Table 12. Correlations of total crows per crowing-cock route (X_1) and kill per square mile of pheasant habitat as total area (X_2) and farmland (X_3), Michigan primary pheasant range, 1956-1965.

Area	Crowing route	$r_{X_1X_2}$	$r_{X_1X_3}$
I	Bay	0.89*	0.88*
I	Huron W	0.80*	0.80*
I	Huron N	0.77*	0.77*
III	Ingham	0.69*	0.67*
III	Ionia	0.70*	0.69*
IV	Cass	0.67*	0.56
V	Ottawa	0.95*	0.92*

*Significant ($P < 0.05$).

Table 13. Correlations of pheasant broods observed per 1000 miles (X_1) and kill per square mile of pheasant habitat as total area (X_2) and farmland (X_3), Michigan primary pheasant range, 1956-1965.

Area	$r_{X_1X_2}$	$r_{X_1X_3}$
I	0.93*	0.93*
II	0.75*	0.48
III	0.88*	0.87*
IV	0.68*	0.54
V	0.90*	0.80*

*Significant ($P < 0.05$).

Mail survey kill estimates

Advantages over previous surveys -- The mail survey of approximately a one per cent sample of Michigan small game hunters was initiated in 1953 to obtain a kill estimate for pheasants. Prior to that time, kill estimates were dependent upon an unenforced "compulsory" return (totaling only 10 per cent in 1950) of report forms provided with the hunting license. The sampling system described by Blouch (1956) and Eberhardt and Murray (1960) has the advantage of being representative of the hunting population. A nearly complete response, about 90 per cent, from a systematic sample with a random start avoids the possibility that unsuccessful hunters may be less inclined to report as may have been the case in the previous system. Also, all areas of the state appear in the sample. In the first sample survey it was found that neither failure to hunt nor poor success was a primary reason for neglecting to reply (Blouch, 1956).

Relation of fall populations to kill estimates -- The mail survey kill estimates are assumed to be unbiased estimates of the actual kill for the reasons cited above. Biases which are not practical to detect in a post season sampling method, however, could influence the estimate. They include:

1. Memory bias in which the hunter does not remember what he shot.

2. Prestige bias in which a hunter consciously or unconsciously exaggerates his kill.

3. Party bias in which two hunters report shooting the same game.

No tests have been made and no proof exists that these biases affected kill estimates in Michigan. Confidence limits for the kill estimates were computed (Cochran, 1963:26-27) for the 1956 to 1965 time period (Table 14). They are surprisingly uniform. The only thorough test of this sampling procedure is to run two random samples of the same size under the same conditions. In 1962 two sample surveys of approximately the same size were conducted for the purpose of detecting whether the length of time between the end of the season and the time of the survey had an effect on the estimates. The early survey produced the smaller kill estimate (Table 14). The total kill estimate from the later survey fell outside of the 95 per cent confidence limits of the early survey estimate. This indicates the samples were from different populations. This may be the case, but judgment should probably be reserved until the hypothesis of no difference in sample estimates can be tested. The confidence limits on the estimates are computed as if each mail survey was a simple random sample. The systematic samples appear to fit the model where the population is in "random" order (Cochran, 1962:225). The skewed frequency distribution of pheasants per hunter presented itself as a problem in determining confidence limits. However, Cochran (1963:26) states that it is sufficient for the means of sample estimates to be normally distributed if unbiased total

Table 14. Michigan pheasant hunting results from mail survey estimates.

Year	Kill with 95% confidence limits	Hunters	Days hunted	Small game licenses[b]
1956	1,125,680±4.2%	549,550	2,421,200	758,086
1957	1,257,570±4.0%	513,960	2,359,290	691,072
1958	1,181,340±4.0%	528,780	2,469,140	700,710
1959	914,600±4.8%	454,080	2,098,910	637,071
1960	974,490±4.5%	469,370	2,267,340	647,989
1961	846,470[a]	453,260	2,085,180	627,514
1962	956,660±4.5%	486,810	2,168,540	638,945
1963	720,150±4.4%	421,480	2,018,450	616,843
1964	837,590±4.2%	444,070	2,066,605	634,950
1965	683,770±4.6%	433,440	2,133,420	632,246

[a]Data unavailable for computing confidence limits.
[b]Tabulated from license dealer sales.

estimates with confidence limits are to be made. The data over the years indicate this condition is probably satisfied.

It has been hypothesized that the kill densities are good indices of fall pheasant populations. For this to be the case there must be some indication of the percentage of hens removed from the population by hunters and a constant percentage of cocks must be harvested annually for a given area.

No information is available on the illegal hen kill in Michigan. It is not thought to fluctuate widely or to be a limiting factor to the pheasant population (V. S. Janson, Personal communication).

The per cent of cocks harvested annually from each study area was computed (Table 15). The basis for the computations was the sex ratio data from the rural mail carrier post season survey. Also, a 1:1 preseason sex ratio and a negligible loss of hens during the hunting season was assumed. Small samples of pheasants as well as snowfall over parts of the range in early December are the chief weaknesses of the post season survey. Small samples often result in nearly equal numbers of hens and cocks being observed, while snow on the ground tends to inflate the ratio of hens to cocks actually present in the population. The results of such biases are poor estimates of the per cent harvest as evidenced in Area IV.

The data in Table 15 were analyzed by the short-cut method of Kurtz *et al.* (1965). Partial results follow:

Years	1965	1961	1963	1962	1960	1959	1957	1956	1964	1958
Means	42.9	49.0	53.8	53.9	56.0	61.3	62.0	62.1	65.1	74.2

The per cent harvest in 1958 appears inflated. Snow cover during the survey period might explain the unusually high percentage of cocks taken. The low percentage of cocks harvested in 1965 is probably due to the adverse weather conditions on the opening day. Further analysis determined that each study area had a per cent harvest of cocks significantly different

Table 15. Per cent of pheasant cocks harvested.[a] Based on a post season survey by rural mail carriers in Michigan's primary pheasant range.

Area	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	Mean
I	78.7	79.6	86.5	71.4	75.6	73.7	69.7	71.4	80.4	63.0	75.0
II	68.8	67.7	73.7	60.0	60.0	56.5	50.0	47.4	63.0	33.3	58.0
III	56.5	60.0	72.2	50.0	37.5	41.2	50.0	37.5	44.4	28.6	47.8
IV	23.1	16.7	54.5	33.3	23.1	0.0	28.6	33.3	50.0	23.1	28.6
V	83.6	85.9	83.9	91.6	83.6	73.7	71.4	79.6	87.7	66.7	80.1
Mean	62.1	62.0	74.2	61.3	56.0	49.0	53.9	53.8	65.1	42.9	

[a]1:1 preseason sex ratio assumed. Per cent harvest computed by method of Petrides (1954).

from the other areas. In conclusion, the per cent of cocks harvested in each study area appears to be relatively constant.

Age ratios in the kill also reflect the differences between low and high density areas (Table 16). These figures derived from wings and feet collected early in the season are probably biased towards a higher number of juveniles in the kill than appear in the population (Eberhardt and Blouch, 1955). Specifically, the age ratio data points to the contribution of broods to the fall kill. Thus, if the juveniles taken annually provide the bulk of the cocks harvested, the brood survey and the mail survey are essentially measuring the same quantity.

Table 16. Male pheasant age ratios derived from wings and feet collected by cooperating Michigan hunters.

Area	Juvenile males per adult male				Mean per cent of juveniles in kill
	1959	1961	1962[a]	Mean	
I	24.2	16.2	33.3	24.6	96
II	16.9	21.4	10.4	17.3	95
III	10.7	11.9	8.6	10.4	91
IV	6.7	10.7	b	8.7	90
V	19.5	19.7	10.7	16.6	94

[a]Collections on a statewide basis discontinued after 1962. Data for 1956-1958 and 1960 is unavailable.

[b]No adults in the sample.

A number of factors affect the proportion of cocks shot. They work chiefly on the effort (hunter-days) expended in hunting pheasants. If the population densities within a study area remain relatively stable, then constant annual effort should produce a fairly constant percentage of cocks harvested annually. Factors influencing effort are:

1. Hunting season length.
2. Changes in bag limits.
3. Variation in hunting conditions.
4. Changes in hunter numbers.

During the time period (1956-1965) studied, the season length remained constant at 22 days. Increasing the season length or decreasing it by a few days probably would not have had much of an effect on the total harvest. Most of the kill and effort occurs during the opening day and the first weekend of the season. During the 1953 Michigan season, 76 per cent of the cocks were harvested during the first week with 31 per cent taken on opening day (Blouch, 1956). Also 66 per cent of the total effort (gun-hours) was expended during the first week of that year.

The bag limits of two cocks per day and eight for the season have remained constant from 1956 to 1965 and would exert a stabilizing influence on the total kill.

Variations in hunting conditions are difficult to assess. The timing of corn-picking, weather, and conditions of natural vegetation influence the kill. Some of these factors are compensatory. Unfortunately, there is no good way of measuring their effect. MacMullan (1960) was not able to detect any measurable effect of these conditions on the kill. The opportunity does exist for assessing the effect of the weather on the opening day of the 1965 season. A heavy rain fell over most of the range on that day. The expected results of this occurrence would be a reduced harvest for 1965. Table 15 indicates that the per cent of cocks harvested was down appreciably for all the study areas in that year. Thus, unusual weather conditions during the first few days of the hunting season should be considered by anyone concerned with pheasant population changes.

MacMullan (1960) in his study of Michigan pheasant populations uses small game licenses to indicate there was little change in pheasant hunter numbers through 1956. Better data are now available (Table 14). Small game licenses, pheasant hunters, and days hunted by pheasant hunters in the state indicate that annual changes as high as 10 per cent are unusual. In the study areas (Table 17) this was also true. In examining the mail survey sample data it was noted that close to 40 per cent of the pheasant hunters did not kill any pheasants. Also, approximately 30 per cent of the pheasant hunters harvested about 75 per cent of the pheasants. So, losses of pheasant hunters as high as 50 per cent from one year to the next would probably not have an appreciable effect on the total harvest if it can be assumed that the

Table 17. Pheasant hunter numbers in Michigan's primary pheasant range, 1956-1965.

Area	Range	Mean	Mean hunters per square mile	Coefficient of variation
I	86,622-123,600	103,704	22.6	13.5%
II	87,531-102,465	96,029	30.8	5.3%
III	41,905-57,909	49,400	14.6	11.3%
IV	32,509-45,497	38,674	8.6	10.8%
V	32,332-45,874	37,288	19.7	12.7%

majority of the unsuccessful and probably the least skillful of the hunters would drop from the hunting ranks in such a situation. Since the changes in hunter numbers or effort from 1956 to 1965 has been slight, the assumption of a relatively constant effort in this time period seems warranted.

In summary, the kill estimates are providing precise estimates of the legal harvest. They are also indicating fall population levels when the above mentioned assumptions are satisfied. Considerable evidence exists that these assumptions are being met. This permits estimates to be made of the total fall population. This is the only time in the pheasant life cycle when relatively good estimates of total numbers are possible. Finally, the kill estimates serve as a standard for evaluating the other indices of abundance.

CONCLUSIONS

1. The crowing-cock index is a very imprecise indicator of the fall cock pheasant population in Michigan. Only 20 per cent of the crowing-cock routes in the study areas provided data useful in generating linear regression equations for predicting the fall kill. A logical action would be to abandon this survey or to limit it to an experimental basis in the hope that it can be refined to yield better information.

2. The rural mail carrier brood survey is serving as an excellent source of information for management decisions concerning utilization of the species. Its chief importance appears to be in the area of public relations. When pheasant numbers are low, reports on brood abundance and its relation to the fall harvest enable the casual hunter to decide whether he will participate. These reports also ease the disappointment of hunters who are not very successful. Since the cost of this survey is minimal, its continued existence appears justified.

3. The mail survey kill figures are the only precise estimates of cock pheasant populations and certainly the most valuable in recording historical trends. Experimentation

with sampling methods could possibly yield more precise estimates.

4. The extensive surveys (late winter, hunter success, and the rural mail carrier postseason survey) complementing the three major surveys are supplying essentially the same information about pheasant population levels and appear to be of marginal value. All the surveys presently indicate that the southeast (Area II) and west (Area V) portions of the primary pheasant range are areas of high density. The "thumb" (Area I) and central (Area III) portion are of medium density while the southwest (Area IV) has a low pheasant density. Why this distribution occurs is still unknown although high pheasant densities appear to be associated with lake-bed clay soils (MacMullan, 1960:154).

5. Surveys of pheasant populations are noted for their imprecision. Carefully thought out experimental designs using aids such as the digital computer appear to be an approach most likely to produce the precision necessary to a better understanding of pheasant population dynamics.

6. Management of a species implies manipulation of the species for the benefit of man. Planning for optimum utilization of a game species requires changing of the daily and season bag limits when evidence for a change is present.

Also, it may mean harvesting both sexes of a game species. Game birds that are not readily identified by sex do not appear to be harmed in maintaining their population level when they are hunted. Since the biology of the pheasant is probably known better than any other game bird and is nearly as well understood as that of the white-tailed deer, experimental hen seasons should play the same role as the antlerless deer harvest in utilizing this valuable wildlife resource. Thus, extensive and intensive surveys can become valuable in detecting changes in the population due to management decisions. Direct management of the type mentioned above has not been practiced in Michigan. This is probably because the Conservation Department lacks discretionary authority to manage game species. Convincing state legislators of the soundness of biological principles is difficult. This leads to a conservative stance in direct manipulation of species such as the pheasant whose population size fluctuates quite widely.

SUMMARY

The three principal indices of pheasant abundance in Michigan's primary pheasant range were evaluated for the 1956 to 1965 time period. The mail survey kill estimates were established as the standard in evaluating the crowing-cock and the rural mail carrier brood survey.

As expected, the crowing-cock index was an imprecise tool in predicting the 1966 fall cock harvest with linear regression equations. However, in four out of five study areas, predictions were possible with wide confidence limits. Approximately 20 per cent of the crowing-cock routes provided data suitable for use in the prediction equations.

The rural mail carrier brood survey results were highly correlated with the legal harvest. Linear regression equations predicted the 1966 kill with a high degree of accuracy. Kill estimates for three of the five study areas deviated less than five per cent from the mail survey estimate. The remaining two deviated 10 and 20 per cent from the mail survey estimates. The brood index is equally valuable in terms of broods per unit of time or broods per unit of distance traveled by mailmen. The rural mail carrier brood survey provides excellent information for making management decisions on regulation of the harvest.

Farm area as a basis for computing kill densities was not as satisfactory as the total study area when kill densities were correlated with the crowing-cock and brood indices.

Mail surveys of small game hunters appear to estimate closely the legal harvest of cocks. Considerable evidence exists that a constant proportion of cocks are being harvested in each study area. Thus, kill estimates are probably reflecting the magnitude of fall pheasant populations. This index is the most valuable because the results can be easily converted into density values.

LITERATURE CITED

Blouch, Ralph I. 1952. The 1952 Pheasant breeding season. Michigan Dept. Conserv., Game Div. Rept. 1165. 9 pp.

________. 1956. Results of a survey of pheasant hunters by mail. Papers Michigan Acad. Sci., Arts, and Letters 41:99-107.

Burger, George V. 1966. Observations on aggressive behavior of male ring-necked pheasants in Wisconsin. J. Wildl. Mgmt. 30(1):57-64.

Carney, Samuel M., and George A. Petrides. 1957. Analysis of variation among participants in pheasant cock-crowing censuses. J. Wildl. Mgmt. 21(4):392-397.

Cochran, William G. 1963. Sampling techniques. John Wiley & Sons, Inc., New York and London. xvii + 413 pp.

Dalke, Paul L. 1937. Food habits of adult pheasants in Michigan based on crop analysis method. Ecology. 18(2):199-213.

Eberhardt, Lee, and Ralph I. Blouch. 1955. Analysis of pheasant age ratios. Trans. N. Am. Wildl. Conf. 20:357-367.

________, and R. M. Murray. 1960. Estimating the kill of game animals by licensed hunters. Proc. Soc. Statist. Sect., 120th Annual Meeting Am. Statist. Assoc. pp. 182-188.

Freese, Frank. 1964. Linear regression methods for forest research. U. S. Dept. Agriculture, U. S. Forest Service Research Paper FPL 17. 136 pp.

Gates, John M. 1966. Crowing counts as indices to cock pheasant populations in Wisconsin. J. Wildl. Mgmt. 30(4):735-744.

Kimball, James W. 1949. The crowing count pheasant census. J. Wildl. Mgmt. 13(1):101-120.

Kozicky, Edward L. 1952. Variations in two spring indices of male ring-necked pheasant populations. J. Wildl. Mgmt. 16(4):429-437.

Kurtz, T. E., R. F. Link, J. W. Tukey, and D. L. Wallace. 1965. Shortcut multiple comparisons for balanced single and double classifications: part 1, results. Technometrics 7(2):95-161.

MacMullan, Ralph A. 1960. Michigan pheasant populations. Michigan Dept. Conserv., Game Div. Rept. 2277. xiii + 169 pp.

Nelson, Robert D., Irven O. Buss, and Gary A. Baines. 1962. Daily and seasonal crowing frequency of ring-necked pheasants. J. Wildl. Mgmt. 26(3):269-272.

Petrides, George A. 1954. Estimating the percentage kill in ring-necked pheasants and other game species. J. Wildl. Mgmt. 18(3):294-297.

Robertson, William B., Jr. 1948. Investigations of ring-necked pheasants in Illinois. Illinois Dept. Conserv., Tech. Bull. 1. 138 pp.

Siegel, Sidney. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Company, Inc., New York, Toronto, and London. xvii + 312 pp.

Smith, Ronald H. and Steve Gallizioli. 1965. Predicting hunter success by means of a spring call count of Gambel quail. J. Wildl. Mgmt. 29(4):806-813.

Stokes, Allen W. [1954.] Population studies of the ring-necked pheasant on Pelee Island, Ontario. Ontario Dept. Lands and Forests Tech. Bull., Wildl. Serv. 4. 154 pp.

U. S. Bureau of the Census. 1961. U. S. Census of Agriculture:1959. U. S. Government Printing Office, Washington. xxv + 253 pp.

________. 1966. U. S. Census of Agriculture:1964 (preliminary report). U. S. Government Printing Office, Washington.

Wagner, Frederic H., C. D. Besadny, and Cyril Kabat. 1965. Population ecology and management of Wisconsin pheasants. Wisconsin Conserv. Dept. Tech. Bull. 34. 168 pp.

Zorb, Gordon L. 1959. Hunter permission survey, pheasant seasons, 1958 and 1959. Michigan Dept. Conserv., Game Div. Rept. 2250. 12 pp.

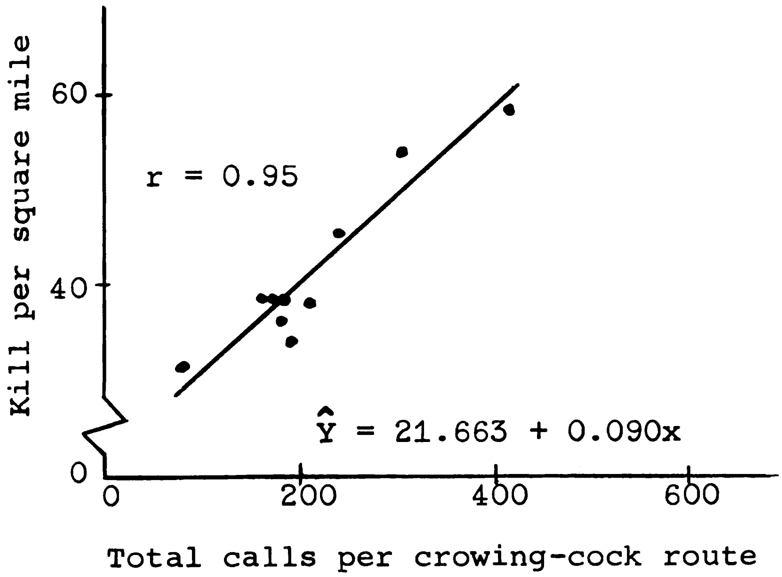
APPENDIX

Table 18. Regression equations for predicting area kill (hundreds of cock pheasants) per square mile ($\hat{Y}$) from total of calls per crowing-cock route (x), Michigan primary pheasant range, 1956-1965.

Area	Crowing-cock route	Equation
I	Bay	$\hat{Y} = 32.019 + 0.187x$
I	Huron W	$\hat{Y} = 30.434 + 0.112x$
I	Huron N	$\hat{Y} = 31.804 + 0.165x$
III	Ingham	$\hat{Y} = 15.027 + 0.045x$
III	Ionia	$\hat{Y} = 23.431 + 0.067x$
IV	Case	$\hat{Y} = 9.299 + 0.148x$
V	Ottawa	$\hat{Y} = 21.663 + 0.090x$

Table 19. Regression equations for predicting area kill (hundreds of cock pheasants) per square mile ($\hat{Y}$) from broods observed per 1000 miles (x) of travel by rural mail carriers, Michigan primary pheasant range, 1956-1965.

Area	Equation
I	$\hat{Y} = 3.093 + 2.787x$
II	$\hat{Y} = 26.661 + 2.584x$
III	$\hat{Y} = 10.194 + 1.858x$
IV	$\hat{Y} = 6.992 + 1.823x$
V	$\hat{Y} = 21.213 + 1.972x$



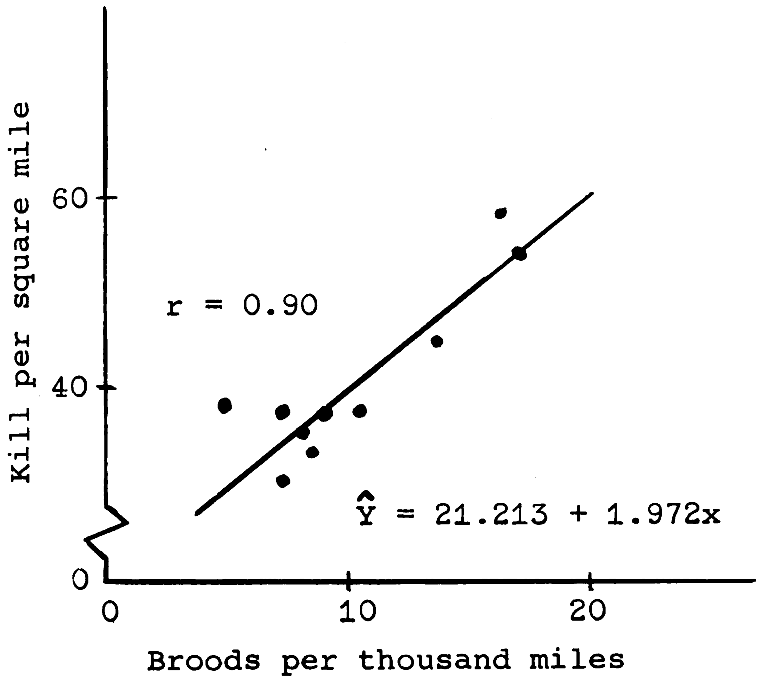


Figure 2. Typical relationship between kill densities and crowing-cock and rural mail carrier brood survey results, Area V, Michigan primary pheasant range, 1956-1965.