PRELIMINARY EVALUATION OF THE CONTROLLED ROAD SIGHT COUNT AS AN INDEX TO MOURNING DOVE POPULATION LEVELS

by

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INTRODUCTION

One of the major objectives of the Southeastern Cooperative Dove Study was the development of a census technique which would detect and measure changes in the population. It was stated that an 'ideal' technique must be "economical, practical, statistically appropriate, permit area-to-area and time-to-time comparisons, and be of sufficient sensitivity for detection of differences within high and low populations." During the course of the study, extensive random (uncontrolled) and controlled road counts, rural mail carrier winter road counts, warden winter road counts, winter plot counts, call counts, and area counts were conducted and evaluated to determine their usefulness as census techniques. When subjected to statistical analysis, the data from call count samples were characterized by substantially less variation than were the results obtained from both roadside and area samples. A smaller number of call count samples are, therefore, required to obtain equal reliability. For this reason it was concluded that the call count index was the most efficient of the several methods tested. On the basis of this evaluation, the call count was selected as the basic index, even though several states continued to collect other indices, notably the uncontrolled biologist road counts and some index to hunting success.

Since completion of the Cooperative Study, the May-June call count index has been continued in the Southeast and expanded to include 48 states. Currently, it is the only technique generally being employed to provide an index to the relative annual abundance of the dove population. It is recognized that the call count index has limitations. It is a measure of some function of breeding intensity as well as breeding density. It presumably does not reflect nesting success, although it may reflect some general condition conducive to nesting activity, and hence provide more than just an index to the abundance of breeders. Nevertheless, no data

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are available to determine the relationship between the call count index and the resulting fall population level.

It is well known that total production of young is not necessarily in direct proportion to the level of the breeding population. This has been reported true for quail, deer, and other species, and in this respect, dove populations seem to be no exception. The reproductive rate is believed to be a function of intra-specific density dependent characteristics, environmental factors such as weather, and interrelated effects of these factors (for an extensive discussion these ideas, see Lack 1954). Even in view of this knowledge, breeding population indices from the call counts are currently thought of as indicators of fall population levels, and are being administratively treated in this capacity, even though the relationships have not been established.

At this point a question arises: How important is it to be able to predict the population level at the time of the hunting season? In answer we must admit that from the public relations point of view, it is of very definite value for a state or federal game agency to be able to accurately inform the public of what it can expect when the season opens. But what about bag limits and season lengths - regulations in general? Should they fluctuate each season with annual changes in the fall population? The answer is not known, and this question was given high priority in the recent report by the National Mourning Dove Technical Committee. In light of the presently available data, it may well be that knowledge of the general welfare of the dove population at the time of breeding, or even during the previous hunting season, is sufficient to intelligently manage and protect the resource.

The ultimate test of this knowledge is its predictive value. That is, if we know the underlying relationships between, say, breeding population and fall population, and are able to estimate the breeding population and whatever other quantities are required by the model, then we can "predict" the fall population from these data. It is clear that reproductive rates and survival rates form the bridge between breeding and fall populations. The need for further study of these population parameters was indicated by the Cooperative Study and has also been listed by the national committee (Foote et.al., 1960).

Presumably this study of production is envisioned as a direct study of nesting success and survival. Again, this is surely an important aspect of the general study of the population, and we agree that it should be not only encouraged, but emphasized. However, in the present context of providing a better key to predicting fall densities, we wonder if this is the most promising approach. As mentioned earlier, nesting success and survival are functions of population densities as well as environmental factors. It seems reasonable that in interpreting the predictive value of the breeding index (call counts) and production index (nesting success and survival indices) we must use some procedure such as multiple regression to determine the relationships between these indices and the fall population. Before going into such a complex prediction model, why not determine if some general index to abundance a little later in the season will not suffice to predict the success of the nesting season? Or why not attempt to use breeding index and weather in a multiple regression, or any of several other models that require little or no further field work?

We wonder at several aspects of this problem. On attempting to analyze the predictive qualities of road counts, it was necessary to decide on a quantitative characterization of the fall population. For North Carolina, it is not unreasonable to set this as the index to the September abundance of doves. However, this would hardly be satisfactory for many other states, much less for the region as a whole. So we pose another question: If we hope to predict fall populations, _just what aspect of the population are we interested in_? Do we want to predict total numbers? This may be meaningless in an individual state. Do we want to predict peak numbers? Or the time at which the peak will occur? These are not at all clear to us, but definition of this quantity (or quantities) is necessary before any prediction procedure can be evaluated.

It is clear that in order to evaluate a predictor of the quantity in which we are interested, we must also have estimates of this quantity, or at least some index to it. We feel that the following is a very high priority problem: Definition of the aspect of the fall (and/or winter) population that is of primary interest, and establishment of an estimator or index to this quantity. (Note that this may be a compound characterization of the population; it is not restricted to a single quantitative value.) We emphasize the need for this estimate because it is the key to evaluation of all predictors.

The reader may wonder at our preoccupation with predictors. The primary consideration is not the direct result obtained from a prediction procedure, but the general knowledge of the population dynamics that will result when we are able to accurately predict characteristics of the population at a given time and, in turn, to evaluate or correlate these characteristics with functions of the environment and/or functions of population densities.

DISCUSSION OF NORTH CAROLINA STUDIES

North Carolina was requested by the Southeastern Dove Committee to study the possible use of controlled road counts as a predictor of fall populations. This request was stimulated by the analysis of biologist's uncontrolled road count data from Kentucky (Russell and Overton, 1959, unpublished) in which it was shown that the September index could be predicted with some success from the indices of the previous November through May. Similar data, available for seven years in North Carolina, were analyzed according to the model developed for Kentucky. In addition, road counts were conducted in the summer of 1960 on 20 random call count roads located throughout the state. These road counts were scheduled the first week of each month from May through September. Results of the two analyses are presented separately.

Uncontrolled Road Counts:

Biologist's road counts were conducted in North Carolina from 1949 to 1958. These data consist of a continuous record of doves seen by biologists while driving, and are tabulated by month in terms of doves per 100 miles, Table A-4. These data were reduced in the manner suggested by the analysis of the Kentucky data. No attempt was made to devise another reduction better suited to North Carolina. The definition of the variables is outlined in the appendix. The first year's data (1949-50) were not included in the analysis because of the low mileage represented each month.

We then considered four predictors of the September index.

$$\hat{Y}_1 = b_1' X_1 \quad (1)$$

$$\hat{Y}_2 = b_1 X_1 + b_2 X_2 + b_3 X_3 \quad (2)$$

$$\hat{Y}_3 = \bar{Y} \quad (3)$$

$$\hat{Y}_4 = Y^{(-1)} \quad (4)$$

where b_1' is the simple linear regression coefficient of Y on X_1 through the origin (not corrected for the mean).

b_i is the partial regression coefficient of Y on X_i; X_1, X_2, and X_3 considered simultaneously.

$\bar{Y}$ is the average September index for the seven years.

$Y^{(-1)}$ is the September index of the preceding year.

X_1 is the sum of the index for November, December, and January.

X_2 is the sum of the index for February, March, April, and May.

X_3 is the linear regression coefficient of index on months, February through May.

Now there are a great many other "predictors" that can be used in a case such as this. Most are complex, and cannot be used with such a small number (seven) of observations. Moreover, the simpler models should be considered first, more complex ones being studied only if the simple ones fail to achieve the desired precision.

We wish to compare the precision of the above four estimators as indicated by analysis of the North Carolina data. In doing this, we can estimate the variance of the predictor $\hat{Y}$, but must also indicate the effect of varying degrees of freedom left for estimating error. These comparisons are made in the appendix, and summarized in Table 1.

TABLE 1

COMPARISON OF PRECISION OF THE FOUR PREDICTORS CONSIDERED

Predictor	Estimated Variance	95 Per Cent Confidence Limits With Present Numbers of Observations. ($\pm$)
$\hat{Y}_1$	≥ 7.166	≥ 6.328
$\hat{Y}_2$	≥ 3.356	≥ 4.819
$\hat{Y}_3$	1.342	2.834
$\hat{Y}_4$	2.484	5.015

where (≥ 6.328) is read "equal to or greater than 6.328."

From Table 1 it is seen that the simple mean ($\hat{Y}_3$) provides the best prediction of the four considered. This is somewhat at odds with the results of the Kentucky analysis, in which $\hat{Y}_2$ was the better ($\hat{Y}_4$ was not considered in that analysis). In terms of the population, this result indicates a tendency for the September index to remain relatively constant, with changes only poorly indicated by changes in the index earlier in the year. Recall that we have looked only at the model suggested by the Kentucky data. If we look further at the simple linear regressions of Y, corrected for the mean of Y, on X_1, X_2, $\ldots X_6$, one at a time, it is seen that only in the case of X_3 is there a significant mean square due to regression (Table A-2). Hence it appears that we should consider a fifth predictor,

$$\hat{Y}_5 = \bar{Y} + b_3' (X_3 - \bar{X}_3) \qquad (5)$$

$$\text{where } b_3' = \frac{\sum (Y - \bar{Y})(X_3 - \bar{X}_3)}{\sum (X_3 - \bar{X}_3)^2} = 2.6178$$

However, it is not surprising to get one significant mean square out of six tests, and we can do no more than indicate the possibility of this relationship. In any event, note that X_3 is the slope of the spring population: after correcting for the mean, the level of none of the preceding months is related to the variation of the September index, but there is an indication that rate of change may be.

Predictor $\hat{Y}_4$ deserves a brief discussion. This is the simplest possible serial correlation model, and as such is of some interest here. If pronounced trends exist, this may well be a better predictor than $\hat{Y}_3$, particularly if more data are available such that a more precise estimate of variance is possible (we have only 3 degrees of freedom in our present example). Also, with more data, one could investigate more complex serial correlation models, attempting to better explain variation of the September index in terms of what has happened in past Septembers. Although more complex mathematically, these models are simpler than (1) and (2) in that they require knowledge of the index to a single month of the year. Of course, to these models can be added additional criteria such as indices to spring and summer density and/or weather data. In all likelihood, complex models such as this will prove most valuable, when sufficient data are available to test them.

In summary, we are unable to show conclusively that deviations of the September uncontrolled road count index in North Carolina can be predicted from similar indices to population density during the ten months preceding September, although some relationships of interest are indicated. Differences in these results and prior results from Kentucky appear to be due to basic differences in the fall populations in the two states.

Controlled Road Counts

Controlled road counts were conducted by biologists on 20 randomly selected call count roads, once a month for five months, May through September. Assignments were for the first week of each month, although a few were conducted later in the month. Several assignments were missed. Two of these were in

September, causing these roads to be eliminated from the anlaysis, for the September index is again considered the dependent variable. In addition, two assignments were missed in May. It was necessary to compute estimates for these missing observations by means of multiple regression of the May variable on the others, excluding September.

In setting up the controlled road counts, we had several questions: (i) How often must these be conducted to give useful results? (ii) Is it necessary to begin the road counts at 30 minutes after sunrise, or can the count be made later? (iii) How can precision of an individual count be increased? We were unable to gain information on the first of these, as the work load of the biologists involved prevented more than the barest minimum of counts. A special design was used in an attempt to gain information regarding the second and third questions. The observer began the 20 mile sample road at 30 minutes after sunrise, recorded doves seen in each mile segment, and when completing the 20 miles, recorded time finished and immediately repeated the procedure in the reverse direction. The total doves seen in both trips along the 20 miles was used as the index for that road and month.

Two analyses were made of these data. The first is similar to that described in the previous section of this report: September counts are treated as dependent variables, and all prior counts as independent variables, in a multiple regression analysis. As a call count index and a count of doves seen while conducting the call count are both available for all routes used, these were included in the analysis as two additional independent variables. We define the variables as follows:

X_1 = number of doves heard on call count, (May)

X_2 = number of doves seen on call count, (May)

X_3 = number of doves seen on road count, May

X_4 = number of doves seen on road count, June

X_5 = number of doves seen on road count, July

X_6 = number of doves seen on road count, August

Y = number of doves seen on road count, September

Then the multiple regression analysis can be summarized in an analysis of variance table.

TABLE 2

ANALYSIS OF VARIANCE: *MULTIPLE REGRESSION OF SEPTEMBER ROAD COUNT INDEX* ON EARLIER ROAD COUNT AND CALL COUNT INDICES, NORTH CAROLINA, 1960

Source	d.f.	Sum of Squares	Mean Square
Sept.(Corrected for mean)	17	18896.9	
Regression on X_1	1	3225.4	3225.4
Reg. on $X_2 \mid X_1$	1	46.2	46.2
Reg. on $X_3 \mid X_1, X_2$	1	6238.8	6238.8
Reg. on $X_4, X_5, X_6 \mid X_1, X_2, X_3$	3	1835.4	611.8
Residual	11	7551.1	686.5
Reg. on X_3	1	7381.9	7381.9
Reg. on $X_4, X_5, X_6 \mid X_3$	3	2335.3	778.4
Residual	13	9179.7	706.13
Reg. on X_2	1	1629.8	1629.8
Reg. on $X_1 \mid X_2$	1	1641.8	1641.8

This analysis (Table 2) is difficult to interpret. First, this is an analysis of different sample roads in a single season, so no inference can be made about year-to-year predictability. We are actually predicting the attractiveness of the area along a particular road in September from the attractiveness in earlier months, with some indefinable effect of population level, nesting success, etc. If the population were completely mobile, if the individuals were distributed randomly over the areas in question between each count, then we would be studying only attractiveness. Hence, the degree of mobility of the breeding population and the population of summer non-breeders enters into the interpretation. At the present stage of knowledge, we must then be cautious in any interpretation of the analysis.

Secondly, there appears to be an inconsistency in the results (Table 2). Consider X_1, X_2 and X_3, all of which are taken in May. X_1 is the call count, X_2 is the road count taken simultaneously with X_1, and X_3 is a road count taken independently of X_1, but in the same general stage of the breeding season. It is clear that after fitting X_3, there is no benefit from fitting X_4, X_5, and X_6. However, X_3 and X_1 each supply appreciable information about Y, even after fitting first for the other. This is an indication that the road count and the call count supply knowledge of different aspects of the status of the May population, knowledge which has predictive value. Why then does not X_2 contribute after fitting for X_1? If this is not a vagary of sampling, we are at a loss as to a possible explanation.

In general, the controlled road counts show somewhat greater usefulness in the 1960 North Carolina data than do the call counts. In Table 2 it is shown that a greater predictability of the September index is obtained. It is also seen that in May the estimated variance and coefficient of variation of these two indices are as follows:

	Variance	Coefficient Of Variation	Mean Index
Road Counts	219.6	77.1	19.2
Call Counts	292.6	66.6	25.7

(These are variances between roads, state-wide)

On the basis of this comparison, the call counts are judged to be slightly better with regard to their precision as a direct index, which result is in agreement with the previously published data (Southeastern Association, 1957). However, it appears from the data here presented that both indices should be studied further in the capacity of predictors.

The other analysis of the controlled road counts involved fitting a fifth degree polynomial to the data in an effort to evaluate the changes in numbers observed in time, from 30 minutes after sunrise until completion of the count (about

80 minutes). This analysis is not really complete at the time of this report, but partial results are presented in the appendix. It is shown that in fitting the polynomial to the totals (overall 95 observations on the 20 routes) by hour and mile (counts from 1 through 40 at each observation), the cubic, quartic and quintic components are not significant. Thus, it appears that a second degree polynomial fits these data reasonably well. The peak of activity lies shortly before the mid-point, and a substantial number of doves are being observed at the end of the 40 miles. It is tentatively concluded that the design used in the current study is useful and practical.

Further analyses will be made to determine differences in the curve of observations by region and month.

SUMMARY

Analyses of North Carolina biologists uncontrolled road counts, available by month from 1949 to 1958, and controlled road counts conducted in spring and summer of 1960, are presented. The usefulness of winter and spring counts in predicting the September index is not as great as found elsewhere (Kentucky), largely because of less inherent variability in the September index in North Carolina. In the controlled study, it was shown that the May road count index of an individual road was a better predictor of the September index of that road than was the May call count index. There is also an indication that the two indices in May contribute independent information about the September index. These controlled studies should be continued over several years to determine the predictability of annual variation.

The need for definition and annual estimation of a pertinent characterization of the fall and/or winter population density, either regionally or by management compartments, is discussed and emphasized. This quantity (or quantities) is vitally needed in evaluation and calibration of present predictors, and will

in addition provide a general yardstick against which to measure the success of the management program.

A great deal of road count and call count data has been collected in the Southeast in the last ten years. It is strongly recommended that these data be reviewed in much the same manner as have been the North Carolina and Kentucky data. This analysis will require definition of the quantity(s) of interest, as described in the preceding paragraph.

REFERENCES

Foote, et al, 1960. A Recommended Dove Management Program.

Lack, David, 1954. Natural Regulation of Animal Numbers. Oxford University Press. 343 pp.

Southeastern Association, 1957. Mourning Dove Investigations, 1948-1956. Tech. Bull. No. 1. 166 pp.

APPENDIX

Uncontrolled Biologist Road Counts

The model indicated by the Kentucky data is as follows:

$$Y = \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_6 X_6 + \varepsilon$$

Y = September Index

X_1 = Sum of Index, November, December, January

X_2 = Sum of Index, February, March, April, May

X_3 = Coef. of linear regression of Index on Months, February, March, April, May

X_4 = June Index

X_5 = July Index

X_6 = August Index

Table A-1. Analysis of Variance: Multiple regression of September Index on indices to levels in prior months. X_4, X_5 and X_6 are not included in the table, as they contribute no significant reduction in variability in this example. North Carolina Uncontrolled Road Counts, 1950-57.

Source	d.f.	Sum of Squares	Mean Square
September Index	7	743.711	106.24
Regression on X_1	1	703.551	703.551 1/
Residual	6	40.160	6.69
Regression on X_2 and X_3 after correction for X_1	2	28.116	14.06 2/
Residual	4	12.044	3.01

1/ significant at 99% level

2/ significant at 90% level

Estimators:

(1) $\hat{Y}_1 = b_1' X_1 = (.57163) X_1$

$\widehat{V(\hat{Y}_1)} = 6.693(1 + C_{11} X_1^2)$

where $C_{11} = .000464$

(2) $\hat{Y}_2 = b_1 X_1 + b_2 X_2 + b_3 X_3$

where $\underline{b} = \begin{matrix} 0.152115 \\ 0.359816 \\ 5.086107 \end{matrix}$

$\widehat{V(\hat{Y}_2)} = 3.011(1 + \underline{X}' CX)$

where $\underline{X}' = (X_1, X_2, X_3)$

$$C = \begin{bmatrix} .0108 & -.0091 & -.0054 \\ -.0091 & .0081 & -.0003 \\ -.0054 & -.0003 & 2.1443 \end{bmatrix}$$

(3) $\hat{Y}_3 = \bar{Y}$

$\widehat{V(\hat{Y}_3)} = 1.174(1 + \frac{1}{7}) = 1.3417$

(4) $\hat{Y}_4 = Y^{(-1)}$

where $Y^{(-1)}$ is the Y observation for the year prior to the year for which a prediction is desired.

Now $V(\hat{Y}_4) = E(Y_i - Y_{i-1})^2$, and it is clear that

$$\hat{\delta}_1^2 = \frac{1}{n-1} \sum_{i=2}^{n} (Y_i - Y_{i-1})^2$$

is an unbiased estimate of $V(\hat{Y}_4)$, this being the mean square successive difference due to Von Neumann (1942). However, even if we assume the Y's are distributed normally, δ_1^2 is not distributed as χ^2, hence we cannot use existing tables in setting confidence limits. Fortunately, alternate differences can reasonably be used in this capacity. Now we are interested in setting confidence limits for, say,

$$\hat{Y}_8 = Y_7 ,$$

so desire δ^2 independent of Y_7, and therefore cannot use Y_7 in computing this statistic. Here let

$$\delta^2 = \frac{1}{3} \left[(Y_2 - Y_1)^2 + (Y_4 - Y_3)^2 + (Y_6 - Y_5)^2\right]$$

$$= 2.4840 .$$

Table A-2. Analysis of Variance. Uncontrolled road counts. Linear regression of September Index on prior indices, with corrections for the mean.

Source	d.f.	Sum of Squares	Mean Square
September	7	743.7109	
Mean ($\bar{Y}$)	1	736.6680	
Residual	6	7.0429	1.1738
Regression on $X_3 \mid \bar{Y}$	1	3.1142	3.1142
Error	5	3.9287	.7857
Regression on $X_1 \mid \bar{Y}$	1	1.0777	
Regression on $X_2 \mid \bar{Y}$	1	.0056	
Regression on $X_4 \mid \bar{Y}$	1	.5794	
Regression on $X_5 \mid \bar{Y}$	1	.0534	
Regression on $X_6 \mid \bar{Y}$	1	.20813	

Table A-3. Analysis of Variance. Fifth degree polynomial fit to sum of 95 observations involving 20 sample roads. The resultant sum consists of 40 totals, one for each linear mile traveled in collecting the data. North Carolina, 1960. Controlled dove road count.

Source	d.f.	Sum of Squares	Mean Square	F
Total	40	477,490.0		
Mean	1	420,455.0		
Residual	39	57,035.0		
Linear	1	7,187.6		6.135*
Quadratic	1	6,505.7		5.554*
Residual	37	43,341.7	1171.4	
Cubic	1	1,758.9		
Quartic	1	259.0		
Quintic	1	640.9		
Residual	34	40,682.9		

Table A-4. Doves seen per 100 miles. North Carolina Biologist road counts (uncontrolled).

	Year						
	50-51	51-52	52-53	53-54	54-55	55-56	56-57
November	4.4	6.7	8.50	10.27	6.16	3.36	3.72
December	5.1	5.2	6.56	5.61	4.76	5.06	5.16
January	4.9	5.1	4.34	6.93	6.88	8.63	3.47
February	5.6	6.1	3.86	5.41	5.98	6.96	3.00
March	5.5	3.6	3.40	5.77	5.51	6.54	3.67
April	4.5	4.2	3.11	4.72	3.40	4.15	2.30
May	8.0	6.2	5.08	6.66	4.84	5.55	6.05
June: X_4	6.5	8.3	6.42	5.50	7.30	9.70	9.99
July: X_5	4.9	12.7	10.33	4.79	9.25	7.66	13.36
August: X_6	10.5	11.0	10.82	6.25	13.07	11.75	10.52
September: Y	11.8	10.3	9.47	10.36	10.50	8.40	10.98
X_1	14.40	17.00	19.40	22.81	17.80	17.05	12.35
X_2	23.60	20.10	15.45	22.56	19.73	23.20	15.02
X_3	.3100	.0450	.1685	.1350	-.2765	-.3310	.3890

TABLE A-5

NUMBERS OF DOVES SEEN (HEARD) PER ROUTE, NORTH CAROLINA CONTROLLED ROAD COUNTS AND CALL COUNTS, 1960

Station	*Route*	*Call Counts*		*Road Counts*				
		Heard	*Seen*	*May*	*June*	*July*	*August*	*Sept.*
Mountain	36	13	7	2	11	13	12	17
	52	2	0	1	5	5	5	5
	54	10	2	7	6	28	14	25
	92	3	0	0	2	2	6	2
	22	54	17	33	57	60	46	121
Piedmont	26	26	6	21	46	54	42	22
	24	41	52	55	77	272	133	70
	58	52	9	13	28	41	25.5	23.5
	60	15	31	26	55	202	77	75
	77	36	11	16	28	48	89	44
Upper Coastal Plain	63	16	35	37	50	74	99	80
	80	14	17	11	101	88	63	41
	96	15	6	6	16	28	18	23
	99	34	49	24	45	64	65	63
	98	31	18	13	54	35	51	..
Lower Coastal Plain	16	43	64	29.8 *	26	19	21	15
	65	51	68	34.5 *	81	34	38	9
	85	57	54	39	56	95	137	78
	112	15	14	21	18	19	13	13
	101	28	17	21	71	..	62	..
Code		X_1	X_2	X_3	X_4	X_5	X_6	Y

* "Missing Values": Computed by multiple regression of X_3 on X_1, X_2, X_4, X_5, X_6.