SUMMARY

The distinction is made between observational data and experimental data, and the analytic and interpretive consequences discussed. The method of path analysis is presented as an aid in this analysis and interpretation. Illustration is made by an analysis of kill data from goose fields around Lake Mattamuskeet, North Carolina in the 1960-61 season. The method proves helpful in defining the system, and several interesting interpretations are made.

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RESULTS OF DESIGN TESTS OF METHODS OF ESTIMATING DOVE HARVEST *

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I. INTRODUCTION

During the 1960 hunting season, Louisiana and Tennessee conducted a pilot study to determine the feasibility of using the telephone and field sampling frames to estimate hunter kill of mourning doves. This study was requested by the Dove Committee of the Southeast Section of the Wildlife Society after theoretical sampling methods were explored and reported on by Chapman, Overton and Finkner (1959).

Methodology and a cursory inspection of data obtained from the pilot study was reported by Legler, Stern and Overton (1961) and the reader should refer to that publication for details regarding operational procedures. In the present paper are presented analytic and estimation procedures, and an evaluation, of the general method from the standpoint of the data collected.

The survey was based on a complex frame, consisting of two sub-frames, which was considered by Chapman *et al.* (1959) to be theoretically the most promising of all frames studied. This complex frame consisted of:

1. The primary frame of telephone subscribers. In our field test we used two exchanges in Louisiana and one in Tennessee. From each of these ex-

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changes, a sample of subscribers was selected in such a way that there were several "independent" sub-samples. These subscribers were contacted by telephone to determine their dove hunting activity and success.

2. The secondary frame, consisting of sampling units defined in time and space over the dove season and area of interest. Within selected units, hunters were contacted in the field in order to obtain ratios of, for example, kill by persons not in the telephone frame to kill by persons in the telephone frame. For this sampling we selected Acadia Parish in Louisiana and Wilson County in Tennessee.

II. THE TELEPHONE SAMPLING FRAME

Since both Louisiana and Tennessee had a split dove season, provisions were made in the sampling design to survey telephone subscribers after each season. Two arrangements for this were considered:

1. A different sample after each season,
2. The same sample after each season.

For this purpose, the sub-samples were allocated at random to two groups, as in *Table* 1.

TABLE 1. NUMBER OF SUB-SAMPLES OF SUBSCRIBERS FOR TELEPHONE FRAME

	Group I Called after each season		*Group II* Called only after the second season	
Exchange	*No. of Sub-samples*	*Size of Sub-samples*	*No. of Sub-samples*	*Size of Sub-samples*
Eunice	6	100	9	100
Rayne	4	100	6	100
Wilson Co.	7	200	5	200

Interviewing procedures were briefly as follows, with regard to subscribers. Following the first season, subscribers in Group I were contacted by telephone. All were asked a screening question: Have you ever hunted doves? Those answering "yes" were interviewed further regarding dove hunting activity during the first season. Following the second season, the persons from Group I who had answered "yes" to the screening question were called again on the telephone and interviewed with regard to dove hunting activity during the second season. At the same time, subscribers in Group II were contacted by telephone, screened by the same question, and those answering "yes" were interviewed with regard to dove hunting activity during both seasons, separately.

It is seen, then, that estimates of kill and activity are available from two sources for each dove season. Such estimates are potentially useful in evaluation of memory errors. However, we are here primarily interested in operational feasibility of the methods, so that observations on memory are lagely incidental. It was the opinion of the interviewers that hunters interviewed at the close of the second season had little difficulty in distinguishing between kills and trips made during the two seasons. We attribute this, in Louisiana, to the short 18 day season in September when only a few hunts were made and to the relatively long interval between seasons. Whether a three-way split will impair hunter memory remains to be determined.

Of primary interest in this study was the activity of the individual telephone subscriber, since these persons are precisely defined by the telephone frame. However, it is apparent that, conceptually, one can define a "household" for each subscriber, which definition will include a much greater proportion of the total dove hunting activity than will the simpler subscriber frame. Some data were collected from "others" in the household in an attempt to determine the feasibility of such a definition. Also, an additional question was asked of the non-subscribers during the field sampling to separate those in a household with a telephone from those not in such a household. Certain difficulties were met in obtaining the desired information from these "others" in the telephone phase, and the use of this expanded frame is uncertain.

Some of the questions then, that need to be answered when considering results and future use of the telephone frame are:

1. Can sufficiently accurate results be obtained from a telephone survey of reasonable size and cost?
2. Is it necessary to sample after segments of the season, or is it possible to obtain the desired results from a sample after the close of the season?
3. In the telephone frame, should we define only the telephone subscribers (the persons in whose name the telephone is listed) or should we define all persons in the households of these subscribers?
4. What aspects of the telephone survey need further work before general application of the method?

III. THE FIELD SAMPLING FRAME

The field sampling frame is a mechanical partitioning of space (geographic area) and time (days) into primary sampling units. (In the present case, the PSU's were defined to be one day and the amount of area that could be "covered" in the half day during which doves are shot.) The PSU's are all defined prior to the season, a sampling scheme decided upon and a sample selected. The resulting sample of PSU's is then developed further in terms of definition of a sampling scheme to be used in the field on any particular day. If a further geographic breakdown is used, these sub-units are called secondary sampling units, SSU's, although it is not always necessary that SSU's be developed. The point is that the plan for sampling within the PSU's is not executed until after the sample of PSU's is drawn, so that detailed materials are developed only for those units in which field sampling will take place.

The field sampling frame was not attractive to the field biologists, mainly because much effort and time was spent in unproductive sampling units. It is hoped that this resistance will diminish as the biologists become more familiar with characteristics of the ratios being developed in the field sampling, and more proficient in field application of unequal probability sampling. In order to develop accurate ratios, it is not really necessary to contact a great many hunters, but it is highly desirable that a probability sample be obtained. Although our number of contacts was relatively low for the amount of time spent in the field, these few contacts nevertheless provided an adequate ratio by which to expand the telephone data (See Section IV).

The necessity for probability sampling in this frame is discussed by Legler *et al.* (1961), and we went to great lengths to follow the sampling design during the first season. During the second season, a system of judgment sampling was used.

As pointed out by Legler *et al.* (1961), "a weighting system for sampling hunters in the fields should consist of a three-phase set of weights, one to take into account the trends in pressure through the season and differences in day of the week, one to account for general quality of hunting in the PSU's and a third to allow concentration of effort in the more productive areas within the primary sampling unit." It is readily seen that the general effect of a successful unequal probability sampling scheme is to concentrate sampling effort in areas of good hunting during periods of good hunting, and minimize the amount of effort spent in unproductive search for hunters.

Although we feel it will be possible in future work to establish an unequal probability sampling scheme in time, we made no attempt to do so in the present study. The telephone interviews and the field bag checks contributed data that will be helpful in developing such a scheme. An attempt was made to apply the unequal probability sampling concept at the other two stages, as described later in the paper. The application to selection of primary sampling units on the basis of evaluation prior to the season seems satisfactory, but little progress was made at the third level.

It seems apparent that satisfactory weighting of secondary sampling units within an area selected for census in an afternoon must depend on current conditions; that evaluation prior to the season would be unsatisfactory. We have restricted our consideration to evaluations that could be made during the morning prior to the census, or during the census itself. General physical features—cropland, pasture, woodland—are available from aerial photographs and cursory examination, and will be useful as a base.

The usefulness of road counts made in the morning prior to census was examined in Louisiana, Table 2. Although these are not exactly representative of the variability among possible sampling units on a single day, and therefore do not exactly represent the relationship we are here interested in, it seems certain that the degree of variability is far too great for there to be any utility in such a road count insofar as predicting hunting activity in a small area on a particular day is concerned. The general conclusion here is that the unequal probability sampling scheme at the third stage will have to be associated with some criterion of the hunting, itself. Development of such a scheme remains for future study.

TABLE 2. CONTROLLED ROAD COUNTS, ACADIA PARISH. NUMBER OF DOVES SEEN DURING MORNING COUNTS IN RELATION TO NUMBER OF HUNTERS CHECKED.

Date (Sept.)	*P.S.U*	*Road Count No. 1*		*Road Count No. 2*		*No. of hunters*
		Time	*No. of doves seen*	*Time*	*No. of doves seen*	*checked*
3	41	....	..	10:30-11:30	6	25
3	16	....	..	10:55-11:55	0	0
4	36	8:45-9:45	2	11:00-12:00	5	0
4	67	....	..	11:00-11:50	1	13
5	15	7:50-9:00	0	10:50-12:00	0	5
5	16	....	..	11:00-11:50	0	0
7	19	8:10-9:10	0	11:00-11:50	0	0
8	39	6:30-7:30	3	11:00-12:00	0	0
9	55	6:30-8:00	0	11:00-12:00	0	0
10	22	....	..	10:30-11:30	1	0
10	08	6:30-8:00	24	11:00-12:00	50	0
11	26	6:30-7:30	0	11:00-12:00	0	3
12	30	6:30-7:45	22	10:50-12:00	1	0
13	67	6:30-7:40	0	10:50-12:00	0	0
14	19	6:20-7:00	0	11:00-11:40	0	0
15	61	6:30-7:30	2	11:00-12:00	1	0
16	50	6:30-7:30	18	11:00-12:00	1	0
17	17	6:30-7:30	0	11:00-11:34	0	0
17	48	....	..	11:00-11:50	1	0
18	12	....	..	11:00-11:55	0	0
18	57	....	..	11:00-11:53	0	6
19	43	6:30-7:20	19	11:00-11:45	0	0
20	07	6:30-7:20	14	11:00-11:45	0	0

IV. ESTIMATES

The estimators used were selected from those proposed by Chapman *et al.* (1959), so that details of derivation are not necessary here. However, a brief summary is in order. In essence, the estimate of any total, T, is the product of this estimated total for the telephone frame and the appropriate ratio from the field samples.

$$\hat{T} = (\hat{Y}_T)(\hat{R} + 1) \qquad (1)$$

Now it has been shown (*c.f.* Goodman, 1962), that an estimate of the variance of T is,

$$V(\hat{T}) = (\hat{R} + 1)^2 V(\hat{Y}_T) + \hat{Y}_T^2 V(\hat{R}) - V(\hat{R})\, V(\hat{Y}_T), \qquad (2)$$

where we use V(T) as the estimated variance of T in order to dispense with extra notational devices. The "hat" (T) indicates estimated quantities other than variances and functions of variances.

Since the cross product of the variances is frequently much smaller than the other two terms, it is frequently possible to approximate V(T),

$$V(\hat{T}) \doteq (\hat{R}+1)^2 V(\hat{Y}_T) + \hat{Y}_T^2 V(\hat{R}). \qquad (3)$$

It is convenient to express the variance of this estimate T, as proportional to the square of the estimate, this being the squared estimated coefficient of variation,

$$CV^2(\hat{T}) = CV^2(\hat{Y}_T) + \frac{V(\hat{R})}{(\hat{R}+1)^2} - \frac{CV^2(\hat{Y}_T)V(\hat{R})}{(\hat{R}+1)^2}, \qquad (4)$$

and where, again, it is frequently possible to drop the last term.

The definition of YT is dependent on the frame and sampling procedure. In the present case, we did not attempt to sample so as to provide estimates for any paricular sub-division or region of Louisiana or Tennessee, but rather estimated the hunting activity in the respective states by subscribers of two exchanges in Louisiana and a single county in Tennessee. Sub-samples, as previously defined, were replicated simple random samples, without replacement. Each of the sub-samples provided estimates of the quantities of interest,

$$\hat{Y}_i = f_{1i}\sum_{j=1}^{n_i} y_{ij}, \qquad \text{for items estimated from the screening stage.}$$

$$(5)$$

$$= f_{2i}\sum_{j=1}^{m_i} y_{ij}, \qquad \text{for items estimated from the interview stage.}$$

where n_i is the total number of subscribers in the i^{th} sub-sample that were contacted at the screening stage.

m_i is the number of subscribers contacted in the i^{th} sub-sample at the interview stage.

f_{1i} = factor 1; total size (number of subscribers) of exchange or county divided by n_i.

f^2_i = factor 2; $f_{1i}(m_i/m_i)$.
in the i^{th} sub-sample.

m_i is the number of subscribers for which interviews were attempted in the i^{th} sub-sample.

This estimator involves the assumption that characteristics of subscribers not contacted are the same as those of subscribers contacted. This is made at the two stages, screening and interview.

Then, the overall estimate is the average of estimates from the k sub-samples

$$\hat{Y}_T = \frac{1}{k} \sum_{i=1}^{k} \hat{Y}_i \tag{6}$$

and

$$V(\hat{Y}_T) = \frac{1}{k(k-1)} \left\{ \sum_{i=1}^{k} \hat{Y}_i^2 - \frac{(\sum \hat{Y}_i)^2}{k} \right\}, \tag{7}$$

The reader will recognize (7) as the usual variance estimator for a simple random sample. We have simplified the calculations by the device of replicated sub-samples, by which we have produced several "independent" estimates of the quantity of interest. Then we have used an average of these "independent" estimates as the overall estimate and the variability among these in estimating the variance of the overall estimate. If we were attempting to estimate some quantity for the exchanges in his study, rather than merely to demonstrate the method, we would include a finite population correction factor. However, this would only confuse the present treatment, and the reader is cautioned that formulae 5, 6 and 7 are dependent on the sampling structure used, and will be re-specified for each survey. In many cases, the fpc will be appropriate.

The definition of y_{ij}, the variable(s) of interest associated with the j^{th} subscriber in the i^{th} sub-sample is important. We have considered two definitions, as follows:

1. The characteristic of the subscriber, himself. This may be the number of times doves were hunted, the number of doves that were killed, whether or not the subscriber hunted doves, etc. Coding is simple. If the variable is numerical, the numerical value is the coded variable. If the variable is categorical, then a code is used. For example, any yes or no answer is coded as 1 or 0. Then the variable is treated exactly like a numerical variable.
2. The characteristic of the household. There may be several other dove hunters living in the household defined by the subscriber. Information from these people is available at little additional cost. The variables are now the sum of the appropriate variables over all persons in the household. A single observation is being made over a group of persons, and these totals are a single set of variables associated with the subscriber.

The definitions of the ratios of interest are somewhat less straightforward. In general, we define a ratio,

$$R = \frac{T_1}{T_2} \tag{8}$$

and

$$\hat{R} = \frac{\hat{T}_1}{\hat{T}_2} \tag{9}$$

It will be recognized that R is not in general an unbiased estimator of R. However, it has good large sample properties and is easy to work with. Under the definition (9), the estimation problem reduces to one of estimating the two quantities, T_1 and T_2. As these are to be estimated from the same survey, it is not necessary to complete these estimates, as any factor of proportionality will cancel. In the present application, these estimations take the form of summations over the primary sampling unit totals, but more complex forms could result from more complex sampling designs.

Definition of T_1 and T_2 is dependent on the definition of the variable associated with the subscriber in the first phase. If the first definition is used, then the telephone phase provides estimates only for subscribers, and the field phase must provide a ratio of kill, or other characteristic, for all non-subscribers to subscribers. That is, T_1 would be, for example, the total kill for all non-subscribers, and T_2 the total kill for all subscribers. On the other hand, if definition 2 is used, then T_1 would be the total for all persons not living in a household with a telephone, and T_2 would be the total for all persons living in a household with a telephone. Definition of T_1 and T_2 must follow these!

Unfortunately, this is not the only difference in ratio estimators here defined. as pointed out by chapman *et al.*, the form of the ratio estimator differs with the variables (or items) of interest. It is not necessary here to go into details of why this is so, but the reason for the differences is that a person is contacted (under random sampling in time and space) with probability proportional to the length of time he is in the field. The following estimators are modified from Chapman *et al.* Here R_1 is the ratio to be used in expanding kill, R_2 the ratio to be used in expanding number of days of dove hunting, and R_3 the ratio to be used in expanding number of dove hunters.

$$\hat{R}_1 = \frac{Y_1}{Y_2} \qquad (10)$$

$$\hat{R}_2 = \frac{H_1^2 T_2}{H_2^2 T_1} \qquad (11)$$

$$\hat{R}_3 = \frac{H_1^3 T_2 D_2}{H_2^3 T_1 D_1} \qquad (12)$$

where $Y = \sum w_i y_i$

y_i = sum of kill in the i^{th} sampling unit.

w_i = weight inversely proportional to probability with which the i^{th} unit was selected.

$H = \sum w_i h_i$

h_i = sum of hunters contacted in the i^{th} unit.

$T = \sum w_i t_i$

t_i = sum of hours hunted prior to contact in the i^{th} unit.

$D = \sum w_i d_i$

d_i = sum of days hunted so far in season by persons contacted in the i^{th} unit.

and where all within sampling unit summations are over the appropriate entries defined by the definition of Y_T. For example, if we defined the variable in the primary phase as the sum of all dove kill by members of the household, then we would define

$$Y_1 = \sum w_i y_{i1} \ ,$$

where y_{i1} = sum of doves killed by all persons contacted in the i^{th} sampling unit who did not live in a household in which there was a telephone.

and $$Y_2 = \sum w_i y_{i2}$$

where y_{i2} = sum of doves killed by all persons contacted in the i^{th} sampling unit who lived in a household in which there was a telephone.

We will consider the sampling error only of the first of these R_1. By the usual expression of variance of a ratio, we can write,

$$V(\hat{R}_1) = \frac{n\hat{R}^2}{n-1}\left\{\frac{\sum z_i^2}{(\sum z_i)^2} + \frac{\sum u_i^2}{(\sum u_i)^2} - \frac{2\sum u_i z_i}{(\sum u_i)(\sum z_i)}\right\}, \quad (13)$$

where $$z_i = w_i y_{i1}$$

$$u_i = w_i y_{i2}$$

Again, we have dropped the fpc. It is unlikely that in a practical application the sampling rate will be sufficiently high to consider a finite population correction!

Note that if equal probability sampling is used, the weights cancel out of (13) and calculations are made directly with primary sampling unit totals.

V. RESULTS

In the present application, the field bag check in Wilson County, Tennessee was conducted in accordance with an unequal probability sampling scheme, with regard to area. The county was partitioned into primary sampling units of size such that it was possible to travel from one part to another in 30 minutes. These units were assigned weights in accordance with the pre-season anticipated hunting pressure. Then, on each day on which field sampling was scheduled, a PSU was selected with probability proportional to the assigned weight, and bag checks were made within that PSU during the afternoon. It is seen that the weighted estimates (10, 11, 12) are appropriate under this scheme, and that the variance estimator (13) is probably somewhat inflated. However, (13) is a reasonable working approximation, particularly when the number of PSU's greatly exceeds n, the number of samples.

The PSU's in Acadia Parish were selected with equal probability, but an unequal probability element was imposed by (1) using two census crews on days of anticipated heavy pressure in the first half and (2) using different selection rates for weekends and week days in the second half. Again, the formulae fit this scheme, with variance estimator probably inflated slightly.

In order to illustrate use of the formulae, several examples are given of computations with test data, Tables 4, 9 and 10, and certain other computations are outlined in the following text. In addition, summaries of key results are given (Tables 5, 6, 7, 8) to aid in discussion and conclusions.

TABLE III. SUMMARY OF ACADIA PARISH BAG CHECK RATIO ESTIMATES, UNDER THE TWO DEFINITIONS CONSIDERED AND THE TWO DOVE SEASONS

	Definition 1		Definition 2	
Item	*First*	*Second**	*First*	*Second**
Kill: R_1	.35385	.41212	.10000	.13936
Man days: R_2	.86636	.57111	.15499	.13234
Hunters: R_3	.79693	.48830	.14667	.08329
$V(R_1)$	.0001086	?	.000349	?

* Field sampling during the late (2nd) season was haphazard, with no attempt at a probability sample.

Now, from data in Tables 3 and 5, we can evaluate the precision of an estimate of total kill (even if this estimate is not meaningful) to illustrate the process for an operational survey. Refer to formula 4. For Acadia Parish, we get the following estimate of total kill,

$$\hat{T}_K = 6,805(1.35385) = 9,213,$$

$$\text{and} \quad CV^2\hat{T}_K = .0105600 + \frac{.0001086}{(1.35385)^2} - (.0105600)\frac{.0001086}{(1.35385)^2}$$

$$= .0105600 + .00005925 - (.0105600)(.00005925)$$

$$= .01061925 - .00000063$$

$$= .0106186.$$

$$\text{then} \quad CV\hat{T}_K = .10305.$$

Thus we see that the third term is very small and can be ignored. It is also seen that the error contributed by the telephone estimate dominates the error of the total estimate. This is as expected, as the ratios are fairly small and the variables defined for numerator and denominator are highly correlated (Table 10). The implication here is that a very small field survey will do a nice job of estimating a ratio by which to expand the totals from the telephone phase. The primary problems are in maintaining a probability sample and in defining some of the estimators needed. Much work is yet to be done on this, but it is demonstrated here that this is a satisfactory means of providing at least simple ratios.

Another example can be constructed from the Wilson County, Tennessee data. Under Definition 1, we have the following expanded total estimated kill for the early season.

$$\hat{T}_K = (5402)(1.52874) = 8258$$

$$CV^2(\hat{T}_K) = .017328 + \frac{.03736}{(1.52874)^2} - (.017328)\frac{.03736}{(1.52874)^2}$$

$$= .017328 + .015986 - .000277$$

$$= .033037,$$

$$\text{and} \quad CV = .18176$$

So, the pilot study yielded estimates with a standard error of approximately 10 and 18 percent of the estimate. Note, too, that the Wilson County pilot study was closely balanced, with each phase contributing almost identically the same error to the total. Again, it is seen that satisfactory ratios can be obtained from little data so long as a probability sample is maintained.

From Tables 5 and 6 one is tempted to test the observed differences between the two sets of sub-samples, I and II. However, as mentioned in the introduction, primary effort was toward determining the operational feasibility of the method. In the present case, the comparisons are not meaningful with respect to, say, hunter's memory, since call-back non-response through oversight was not recorded for Group I at the time of obtaining the second season's data. However, it is generally indicated from these data, that unless one is interested in studying memory error or some associated factor, the single contact at the close of the second season is satisfactory.

VI. DISCUSSION AND CONCLUSIONS

The telephone frame presented fewer problems than were originally anticipated and, because of its characteristics, provided a good primary sampling frame. It is not possible from these results to generalize over a region or state, but the indications are strong that a telephone survey over a large area will be highly feasible. The precision of estimates in the present pilot studies is surprising and, although a similar survey over a larger region cannot be of comparable precsion per telephone call, due to the added variability from one locality to another, results indicate an adequate overall precision and high utility of the telephone survey.

The use of replicated sub-samples in measuring sampling variability will also be more complex in a state-wide survey, as a single stage sample will not likely be feasible. In any broad use of the method, it will be necessary to design the sampling scheme with respect to the objectives of the study, one of which is usually the estimation of precision of other estimates. In certain designs, replicated sub-samples can be used to advantage (Koop, 1960).

If operational telephone surveys of dove harvest are conducted in the future, our present results indicate that it is possible and feasible to interview only after the last season, which would make the sampling more economical. However, more research needs to be done on the problem of memory bias, and future studies should include appropriate designs for examining these and other response errors. Such designs might include sampling after each part of the season.

A clear decision of whether to sample only the telephone subscriber (Definition 1) or to expand the definition of the frame to cover all persons living in a household with a phone (Definition 2) cannot be made from our results. Although, theoretically, we can get these added data with little extra time and cost, as pointed out previously, there are factors present which make the collection of the additional data by telephone difficult. We collected data from "others in the household" for only a part of the telephone samples and the major problems that confronted us were:

1. Actually defining who were members of a household. This definition must be constant over both frames.
2. Increased difficulty in obtaining complete information due to the larger number of persons involved. This results in a higher rate of call backs and, ultimately, additional non-response.

The major problem of the field frame remains in devising a scheme of probability sampling that will be operationally feasible. Though the present tests have demonstrated that the field frame provides adequate estimates, there are nevertheless a number of reasons for which it is desirable to further refine the methodology. There was some discussion of this problem earlier in the paper. Collection of the necessary data from hunters contacted in the field presented no problem.

Even though very few hunters were contacted in relation to time spent in the field, ratios obtained from the field sampling frame during the first season were of acceptable precision. This is most encouraging, and indicates that it is possible and practical to use the field frame, with unequal probability sampling of PSU's, over a large area. At the same time, however, our results indicate that use of unequal probability sampling concepts in the other two dimensions, over time and within PSU's, would provide considerably greater precision. This should be further investigated.

Another point should be considered if field sampling to obtain ratios is set up on a yearly operational basis. It is clear that the ratios (with respect to the telephone frame) will change in time as telephones become increasingly common. It is also clear that this change should be quite gradual, so that we would expect ratios from one year to be close to ratios of the next. This relationship will allow a procedure which takes advantage of estimates from prior years in computing the ratios for the current year. If such a scheme is used, sampling (and expense of the survey) in a given year will be less for a fixed precision.

In summary, the use of telephone and field sampling frames in estimating kill and hunting pressure of mourning doves, as recommended by Chapman *et al.* (1959), was very satisfactory in the tests conducted in Tennessee and Louisiana in 1960. There still remain several problems that must be solved before a perfected sampling scheme is available, but it is indicated that the present designs are operationally feasible. Details of operational schemes will vary depending on items of interest and the area surveyed.

Certainly, if a reliable kill estimate is necessary in management work, then serious thought should be given to continuing this study over state-wide areas. The results of the present study have already been used in designing a statewide telephone survey in Tennessee, which survey is now in the stage of tabulation and analysis. An extensive application of the field sampling frame is in order, although certain associated problems should receive intensive study.

TABLE IV

EXPANSION OF TELEPHONE SURVEY DATA, FIRST DOVE SEASON, 1960, ACADIA PARISH, SUB-SAMPLE GROUP I. ALL ITEMS ARE APPROPRIATELY CODED AND SUMMED BY SUB-SAMPLE AND EXCHANGE. THEN THESE TOTALS ARE MULTIPLIED BY THE APPROPRIATE EXPANSION FACTORS TO YIELD ESTIMATES

Exchange (Number of Subscribers)	*Sample*	*Subscribers Contacted*	*Screening Data Dove*[1] *Hunters*	*Subscribers Interviewed*	*Interview Data Kill*	*Interview Data Days*	*Expansion Factor No. 1*	*Expanded Screening Data Dove*[1] *Hunters*	*Expansion Factor No. 2*	*Expanded Interview Data Kill*	*Expanded Interview Data Days*
Rayne	1	89	8	8	51	15	27.1236	217	same[2]	1383	407
(2414)	2	90	10	9	79	16	26.8222	268	29.8024	2354	477
	3	92	9	9	103	25	26,2391	236	same	2703	656
	4	92	7	7	223	28	26.2391	184	same	5851	735
	Total	363	...	...	...	..	......	905	......	12291	2275
	Average	...	...	...	...	..	......	226	......	3073	569
	1	94	9	9	74	18	35.5532	320	same	2631	640
Eunice	2	86	14	14	110	39	38.8605	544	same	4275	1516
(3342)	3	93	14	13	94	31	35.9355	503	38.6998	3638	1200
	4	85	7	7	43	18	39.3176	275	same	1691	708
	5	89	7	7	49	12	37.5506	263	same	1840	451
	6	78	7	7	138	26	42.8462	300	same	5913	1114
	Total	525	...	...	...	..	......	2205	......	19988	5629
	Average	...	...	...	...	..	......	367	......	3331	938
Acadia Parish		888	...	...	...	..	......	593	......	6404	1507

[1] Hunted in first season, 1960.
[2] "Same" indicates no change from expansion factor No. 1.

TABLE V

SUMMARY OF TELEPHONE SURVEY ESTIMATES OF DOVE KILL, FIRST SEASON, 1960

Exchange	*When Interviewed* *	*No. of Sub-Samples*	*Average Estimate,* Y_t	$CV^2 Y_t$	$CV Y_t$
Eunice	I	6	3,331	.03921	.1980
(Louisiana)	II	9	4,374	.010175	.1009
Rayne	I	4	3,073	.09908	.3148
(Louisiana)	II	6	2,698	.076191	.2760
Wilson County	I	7	5,629	.0288	.1697
(Tennessee)	II	5	5,085	.0532	.2307
Eunice, average	I and II	15	3,957	.00892	.0945
Rayne, average	I and II	10	2,848	.04307	.2075
Acadia Parish, average (Eunice plus Rayne)	I and II	**25**	6,805	.01056	.1028
Wilson County, average	I and II	**12**	5,402	.01733	.1316

* I. Interviewed immediately after first season.
II. Interviewed after second season.

TABLE VI

SUMMARY OF TELEPHONE SURVEY ESTIMATES OF DOVE KILL, SECOND SEASON, 1960

Exchange	*When Interviewed* *	*No. of Sub-Samples*	*Average Estimate,* Y_t	$CV^2\ Y_t$	$CV\ Y_t$
Eunice	I	6	10,674	.04801	.2192
(Louisiana)	II	9	10,084	.00666	.0816
Rayne	I	4	4,668	.02574	.1605
(Louisiana)	II	6	3,804	.01171	.1082
Wilson County	I	7	300	.0888	.2980
(Tennessee)	II	5	849.2	.0405	.2012
Eunice, average	I and II	15	10,320	.010505	.1025
Rayne, average	I and II	10	4,149	.008754	.0936
Acadia Parish, average ...... (Eunice plus Rayne)	I and II	25	14,469	.006064	.0779
Wilson County, average	I and II	12	529	.048756	.2208

* All data in this table were taken immediately after the second season, but those in Group I had been previously interviewed regarding the first season, those in Group II were interviewed with respect to both seasons on the same occasion.

TABLE VII

SUMMARY OF BAG CHECK RESULTS, ACADIA PARISH, LOUISIANA, 1960 SEASON

Period	*Item*	*Telephone Subscriber*	*Telephone in Household*	*No Phone*	*Subscriber + Household*	*Household + No Phone*	*Total*
Probability Sample	No. Hunters	28	17	7	45	24	52
	Total minutes	4448	2662	1110	7110	3772	8220
Acadia Parish	No. doves killed	65	15	8	80	23	88
September, 1960	No. Trips	44	29	12	73	41	85
	Doves/Minute	.0146	.0056	.0072	.0113	.0061	.0107
(First Season)	Minutes/Hunter	158.857	156.588	158.571	158.000	157.167	158.077
	Trip/Hunter	1.5714	1.7059	1.7143	1.6222	1.7083	1.6346
Judgment Sample	No. Hunters	100	39	18	139	57	157
	Total minutes	11,250	4415	1985	15665	6400	17650
Acadia Parish	No. doves killed	330	79	57	409	136	466
November and	No. Trips	327	125	93	452	218	545
December, 1960	Doves/minute	.0293	.0179	.0287	.0261	.0213	.0264
	Minutes/Hunter	112.5000	113.2051	110.2778	112.6978	112.2807	112.4204
(Second season)	Trip/Hunter	3.2700	3.2051	5.1667	3.2518	3.8246	3.4713

TABLE VIII

SUMMARY OF BAG CHECK RESULTS, WILSON COUNTY, TENNESSEE. PROBABILITY SAMPLE, FIRST SEASON, SEPTEMBER, 1960

Item	*Telephone Subscriber*	*Telephone in Household*	*No Phone*	*Subscriber + Household*	*Household + No Phone*	*Total*
No. Hunters	81	30	2	111	32	113
Total minutes	11,215	5,615	255	16,830	5,870	17,085
No. doves killed	174	85	7	259	92	266
No. Trips	81	30	2	111	32	113
Doves/minute	.015515	.015138	.027451	.015389	.015673	.015569
Minutes/Hunter	138.4568	187.1667	127,5000	151.6216	183.4375	151.1947
Trip/Hunter	1.000	1.000	1.000	1.000	1.000	1.000

TABLE IX

RATIO ESTIMATES, FIRST SEASON FIELD SAMPLING (SEE TEXT FOR FORMULAE AND TABLES 7 AND 8 FOR DATA SOURCE)

Location	*Item*	*Definition 1* *Ratio*	*Computation*	*Ratio*	*Definition 2* *Computation*	*Estimate*
Acadia Parish Louisiana	Kill	$R_1 =$	$\frac{23}{65}$	.35385	$\frac{8}{80}$	.10000
	Man Days	$R_2 =$	$\frac{(24)^2 (4448)}{(28)^2 (3772)}$	.86636	$\frac{(7)^2 (7110)}{(45)^2 (1110)}$	.15499
	Hunters	$R_3 =$	$\frac{(24)^3 (4448) (44)}{(28)^3 (3772) (41)}$	.79693	$\frac{(7)^3 (7110) (73)}{(45)^3 (1110) (12)}$	.14667
Wilson County Tennessee	Kill	$R_1 =$	$\frac{92}{174}$	.52874	$\frac{7}{259}$	.02703
	Man Days	$R_2 =$	$\frac{(32)^2 (11215)}{(81)^2 (5870)}$	.29819	$\frac{(2)^2 (16830)}{(111)^2 (255)}$	.02143
	Hunters	$R_3 =$	$\frac{(32)^3 (11215) (81)}{(81)^3 (5870) (32)}$	.29819	$\frac{(2)^3 (16830) (111)}{(111)^3 (255) (2)}$	.02143

Table X

Analysis of Variation, Ratio Estimates of Doves Killed, Acadia Parish, Louisiana, First Dove Season, 1960. $n = 25$, all Weights Equal and Cancel out. See Formula 13

Date (Sept.)		*Definition 1* Subscribers (X_1)	*Definition 1* Others (X_2)	*Definition 2* Subscribers and Household (X_1)	*Definition 2* No Phone (X_3)
3	41	52	18	63	7
4	67	7	3	10	0
5	15	3	1	4	0
11	26	0	0	0	0
18	57	3	1	3	1
Total		65	23	80	8
SSX_1		2771		4094	
SSX_2		335		50	
2 SCP		1926		888	
$V(R_1)$		.00010855		.000349	

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THE USE OF WEIRS IN COASTAL MARSH MANAGEMENT IN LOUISIANA

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Along the Louisiana coast, ponds and lakes subject to severe tidal action usually support very little aquatic vegetation. Also, marshes subject to tidal action and drastic salinity changes usually support undesirable plant types. Consequently, these areas are of little value to waterfowl or fur-bearing animals. As more canals are dug and stream channels deepened each year for navigation pipelines and drainage, the problem of tidal action and salt water intrusion becomes more severe.

Since the Louisiana coast is a major waterfowl wintering area and a highly potential fur-bearer producing area, marsh management is of extreme importance.

The ideal management technique should be capable of accomplishing several effects. It should reduce water level fluctuation, stabilize water salinity, minimize water turbidity and reduce the rate of tidal exchange. But mainly, the technique should encourage the growth of desirable plants in the marsh, and at the same time encourage the growth of aquatic vegetation in the ponds and lakes.

An ideal condition in coastal marsh management for both furbearing animals and waterfowl is the production of three-cornered grass (*Scirpus olneyi*) in the marshes and widgeongrass (*Ruppia maratima*) in marsh ponds and lakes. The roots of three-cornered grass are a favorite food of muskrats and blue and snow geese The foliage and seeds of widgeongrass are very desirable for practically all species of ducks. Also, the seeds of three-cornered grass and of different annual plants, that grow in a mixture with three-cornered grass, are widely used by ducks.

The use of impoundments has been very successful in southwestern Louisiana for waterfowl management (Chabreck, 1960). However, because of the fluid nature of the subsoil, most marsh areas in the Delta and Sub-delta marsh types as described by O'Neil (1949) will not support continuous levees. Consequently, in such areas impoundments can not be constructed.