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Sample Designs for Panel Surveys of Agricultural Production

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ABSTRACT

The Statistical Reporting Service has traditionally carried out a system of independent surveys conducted at several time points through out the year. Much of the data collected from a particular farm operator at one point in time exhibits a strong relationship to the data collected at a previous time point. This report presents a study which investigated the use of a double sampling regression estimation strategy to take advantage of this relationship. It is shown that the regression estimation strategy is more cost efficient than the current strategy.

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1. Introduction

The Statistical Reporting Service (SRS) of the United States Department of Agriculture (USDA) is charged with estimating the production levels of raw agricultural commodities in the U.S. This has traditionally been carried out through a strategy of independently analyzed surveys conducted through out the year. The Agency is currently developing its Integrated Survey Program (ISP). This program is intended to replace the current series of independent surveys with a series of coordinated surveys conducted every few months through out the year. Under the ISP, an initial survey would be conducted early in the season and follow up surveys fielded on a subsample of the initial sample. For a particular farm, the data collected at one time point exhibits a strong relationship to the data collected at a previous time point. This suggests the possibility of using a double sampling regression estimation strategy across time points to improve the efficiency of the survey design.

This report presents a study which compares two strategies for the list frame surveys. The first strategy is currently being used by the SRS and uses an expansion estimator for each survey. The second strategy uses a double sampling regression estimator whenever possible for the follow up surveys. The 1984 Tennessee ISP list sample data were used to study these two strategies.

An important concept used in this report is that of an optimal sample allocation for a survey strategy. This is the allocation of the survey resources, as measured by the sample sizes, that minimizes the total cost of the survey while still meeting the precision requirements on the survey estimates. In order to predict the optimal allocation for a survey strategy, a model for the total cost of the survey as a function of the sample sizes is required. It is often the case that the following linear cost model provides a suitable approximation

$$C = C^{*} + \sum_{h} C_h \, n_h \qquad (1.1)$$

where C is the total survey cost; C^{*} is the fixed cost component of the total cost; C_h is the cost per unit for level-h of the survey strategy; and n_h is the sample size for level-h. The levels of the strategy may represent strata, phases or stages of a sample design.

The determination of an optimal sample allocation also requires models of the variances for the survey estimates. A general variance model for an estimator U that encompasses most of the common survey designs is

$$\mathrm{Var}(U) = \sum_{h} A_h \, / \, n_h \qquad (1.2)$$

where A_h is the variance component for level-h of the design and n_h is the sample size. It can be shown that this variance model can accommodate most survey estimators for stratified, multistage and multiphase sample designs. For example, the variance of the usual estimator of a mean from a stratified simple random sample is

$$\mathrm{Var}(\bar{y}) = \sum_{h} W_h^2 \, S_h^2 \, / \, n_h$$

where W_h is the stratum weight and S_h^2 is the stratum-h population variance. In this case,

$$A_h = W_h^2 \, S_h^2 \, .$$

The general design allocation problem can now be stated as:

Find $n_1,\ldots,n_H$ that minimize

$$C = C^* + \sum_{h=1}^{H} C_h \, n_h$$

subject to L variance constraints

$$\mathrm{Var}(U_1) = \sum_{h=1}^{H} A_{1h} \, / \, n_h \;\leq\; V_1^2$$

$$\vdots$$

$$\mathrm{Var}(U_L) = \sum_{h=1}^{H} A_{Lh} \, / \, n_h \;\leq\; V_L^2 \, .$$

The quantities $V_1^2,\ldots,V_L^2$ are the maximum allowable variances on the estimates $U_1,\ldots,U_L$. The solution to this problem is called the optimal allocation for the survey strategy described by the cost and variance models. When only a single constraint is included in the problem, Neyman (1934) showed that the optimal allocation was obtained by taking n_h proportional to $[A_h/C_h]^{1/2}$. With multiple constraints, a closed form solution does not exist. For this study, an iterative algorithm for solving this problem due to Bethel (1985a) was used.

Chapter 2 develops a variance model for the double sampling regression estimator suitable for use in this study. The 1984 ISP data from Tennessee is discussed in Chapter 3 and the actual design study in Chapter 4. A summary of the conclusions is presented in Chapter 5.

2. Double Sampling Regression Estimator

2.1. Introduction

This Chapter develops the double sampling regression estimator and models for its variance that are consistent with the sample allocation problem presented in Chapter 1. The variance models are later used to explore the implications of using such a design and estimator for the ISP. All of the models are developed assuming either simple random sampling (srs) or stratified srs. The reader is referred to Sukhatme and Sukhatme (1970) Chapter 5 or Raj (1968) Chapter 7 for further information on either double sampling or regression estimation.

A regression estimator is appropriate when the analysis variable y exhibits a relationship with an ancillary variable x which is available for the entire population. In its simplest form, the regression estimator of the mean of the y variable is

$$\bar{y}^{*} = \bar{y} + b(\bar{X} - \bar{x})$$

where $\bar{y}$ and $\bar{x}$ are the means of the sample values of y and x; $\bar{X}$ is the population mean of x; and b is the estimated regression coefficient obtained by regressing y on x for the sample members. This is an adjusted mean of y which accounts for the departure of the sample x mean from the population x mean. When the population x mean is not available it is sometimes fruitful to obtain an estimate of it from a sample and only collect the y values for a subsample. This idea motivates the consideration of double sampling designs.

Doubling sampling refers to a class of sample designs in which the sample of units is drawn in two phases. A first phase sample of units is drawn and then a smaller second phase sample is drawn from among those units selected in the first phase. The definition of a sampling unit is the same for both phases of sampling. This should be distinguished from two stage sampling in which the definition of a sampling unit changes from stage to stage. In two stage sampling, clusters of the ultimate sampling units are selected at the first stage and then, within each cluster, a sample of the ultimate units is selected.

2.2. Simple Random Sampling at Both Phases

The estimator and its variance will first be developed assuming simple random sampling (srs) at both phases. That is, assume that a first phase full sample of size n is selected from a population of size N and the values of a variate labeled x are measured. From among the n full sample members a simple random subsample of size m is drawn and the values of another variate, say y, are measured. Let a and b be the estimated least squares intercept and slope, respectively, for predicting y as a function of x obtained from the subsample data. The double sampling regression estimator of the mean of the y variable is

$$\bar{y}^{*} = \sum_{i=1}^{n} [a + bx_i]/n$$

$$= a + b\bar{x} \qquad (2.1)$$

where the summation is over all full sample members and $\bar{x}$ is the full sample mean of the x variable. Noting that the least squares intercept is

$$a = \bar{y}' - b\bar{x}'$$

where $\bar{y}'$ and $\bar{x}'$ are the subsample means of the y and x variables yields the more standard form of the double sampling regression estimator

$$\bar{y}^{*} = \bar{y}' - b(\bar{x}' - \bar{x}) \ . \qquad (2.2)$$

The population variance of the double sampling regression estimator is a function of the population variance of the y variable, say S^2, and R the population correlation between y and x. Assuming that the full sample finite population correction factor (n/N) is negligible,

$$\mathrm{Var}(\bar{y}^{*}) = S^2 / n + (1 - m/n)\, S^2 (1 - R^2) / m$$

$$= S^2 R^2 / n + S^2 (1 - R^2) / m \ . \qquad (2.3)$$

Thus, as R approaches one, the variance of $\bar{y}^{*}$ approaches that of a simple random sample of size n.

2.3. Stratified Simple Random Sampling at the First Phase

The sample design that will claim the most attention in this report is a stratified srs at the first phase followed by a simple random subsample within each stratum at the second phase. Assume that the population is stratified into H strata and that stratum-h contains N_h units. A srs of size n_h is drawn from stratum-h and then a simple random subsample of size m_h is selected from the n_h previously selected units.

The double sampling regression estimator of the mean for stratum-h is

$$\bar{y}_h^{*} = \bar{y}_h' - b_h(\bar{x}_h' - \bar{x}_h) \ . \qquad (2.4)$$

The quantities in the equation above are the stratum-h analogues of those in equation (2.2). Also, as in equation (2.3), the variance of $\bar{y}_h^{*}$ is

$$\mathrm{Var}(\bar{y}_h^{*}) = S_h^2 R_h^2 / n_h + S_h^2 (1 - R_h^2) / m_h \ . \qquad (2.5)$$

Combining across the strata, the double sampling regression estimator of the mean is

$$\bar{y}^{*} = \sum_{h=1}^{H} W_h \bar{y}_h^{*} \qquad (2.6)$$

where W_h is the stratum weight, N_h/N. The corresponding estimator of the population total is

$$y^* = N \overline{y}^* . \tag{2.7}$$

Hence, the variance of y^* is

$$\mathrm{Var}(y^*) = \sum_{h=1}^{H} N_h^2 \, \mathrm{Var}(\overline{y}_h^*) . \tag{2.8}$$

Substituting equation (2.5) into equation (2.8) shows the variance of the double sampling regression total estimator to be

$$\mathrm{Var}(y^*) = \sum_{h=1}^{H} [N_h^2 \, S_h^2 \, R_h^2] \,/\, n_h \;+\; \sum_{h=1}^{H} [N_h^2 \, S_h^2 \, (1 - R_h^2)] \,/\, m_h$$

$$= \sum_{h=1}^{H} A_h \,/\, n_h \;+\; \sum_{h=1}^{H} A_h' \,/\, m_h . \tag{2.9}$$

Again, as $R_1, R_2, \ldots, R_H$ all approach one, the variance of y^* approaches that of a stratified simple random sample with sample sizes $n_1, n_2, \ldots, n_H$.

2.4. Stratified Sampling at Both Phases

This design alternative combines stratification at both the first and second phases of the sample. Assume the same stratified srs design for the first phase as was presented in the previous subsection. The strata for the first phase will be termed primary strata. Next, consider stratifying the n_h full sample members in primary stratum-h into K substrata. The number and type of substrata within each primary stratum could be allowed to vary. For clarity, the following exposition will assume a fixed number of substrata per primary stratum. Let n_{hk} be the number of full sample members in substratum-hk and assume that a srs of size m_{hk} is drawn from this substratum.

The double sampling regression estimator for the mean of substratum-hk is

$$\overline{y}_{hk}^* = \overline{y}_{hk}' - b_{hk}(\overline{x}_{hk}' - \overline{x}_{hk}) . \tag{2.10}$$

The above quantities are the substratum-hk analogues of those in equation (2.2). Now, letting W_{hk} be the substratum weight (n_{hk}/n_h), which is conditional on the n_h first phase sample members, the estimator for the primary stratum-h mean is

$$\overline{y}_h^* = \sum_{k=1}^{K} W_{hk} \, \overline{y}_{hk}^* . \tag{2.11}$$

The variance of this estimator is

$$\mathrm{Var}(\overline{y}_h^*) = S_h^2 \,/\, n_h \;+\; \sum_{k=1}^{K} (1 - f_{hk}) \, W_{hk}^2 \, S_{hk}^2 \, (1 - R_{hk}^2) \,/\, m_{hk}$$

$$= [S_h^2 - \sum_{k=1}^{K} W_{hk} \, S_{hk}^2 \, (1 - R_{hk}^2)] \,/\, n_h$$

$$+ \sum_{k=1}^{K} [W_{hk} S_{hk}^2 (1 - R_{hk}^2)] / n_h f_{hk} \qquad (2.12)$$

where, for substratum-hk, S_{hk}^2 is the population variance, R_{hk} is the population correlation between y and x, and f_{hk} (= m_{hk}/n_{hk}) is the subsampling rate.

The total population mean estimator is formed by multiplying the primary strata estimates by the strata weights, $W_h = N_h/N$, and summing to obtain

$$\bar{y}^* = \sum_{h=1}^{H} W_h \bar{y}_h^* . \qquad (2.13)$$

Hence, the estimator of the population total is

$$\begin{aligned} y^* &= N \bar{y}^* \\ &= \sum_{h=1}^{H} N_h \bar{y}_h^* \end{aligned} \qquad (2.14)$$

with variance

$$Var(y^*) = \sum_{h=1}^{H} N_h^2 Var(\bar{y}_h^*) . \qquad (2.15)$$

Substituting equation (2.12) into (2.15) provides the variance model for y^*

$$\begin{aligned} Var(y^*) &= \sum_{h=1}^{H} N_h^2 [S_h^2 - \sum_{k=1}^{K} W_{hk} S_{hk}^2 (1 - R_{hk}^2)] / n_h \\ &\quad + \sum_{h=1}^{H} \sum_{k=1}^{K} [N_h^2 W_{hk} S_{hk}^2 (1 - R_{hk}^2)] / n_h f_{hk} \\ &= \sum_{h=1}^{H} A_h / n_h + \sum_{h=1}^{H} \sum_{k=1}^{K} A'_{hk} / r_{hk} . \end{aligned} \qquad (2.16)$$

The above model is set up to yield an optimal first phase allocation (n_1, n_2, ..., n_H) and optimal subsampling rates (f_{11}, f_{12}, ..., f_{HK}). The latter being obtained from the relationship $f_{hk} = r_{hk}/n_h$. The model also assumes that the substratum weights, W_{hk}, are fixed. In reality, these weights are random variables which vary depending upon the observed full sample. However, the expected value of $W_{hk} = N_{hk}/N_h$, or an estimate, can generally be used in equation (2.16).

This model will not be pursued further in this report. It is included to demonstrate that variance models for more complex situations can be developed. As plans for the ISP grow, further evaluations may be necessary. Possible extensions are suggested in the conclusion to this report.

3. Data

The data for the main part of this study were drawn from the 1984 ISP Tennessee surveys. This series of surveys impanelled a stratified simple random sample (srs) of approximately 3,000 list operators for the June 1984 survey from four independently selected replicates. Follow up surveys of different subsamples of the June sample operators were conducted in September, October, December and January 1985. The follow up surveys were stratified within each of the June primary strata by data obtained in the June survey. The June survey forms the first phase or full sample of a double sampling design, while each follow up survey is a second phase or subsample.

The December and January surveys both collected the data items used in this study using similar questionnaires and survey methods. In addition, the December survey used operators only from sample replicates one and two, while the January survey used replicates three and four. Thus, the December and January surveys are two independent samples collecting the same data and were combined to yield more precise estimates. Table 3-1 displays the list population and sample sizes by primary strata.

For this study, attention will be confined to the June survey, the full sample, and the combined December/January survey, the subsample. This combination of time points was chosen because they represent the most extreme use of a double sampling design possible with the current data. The June full sample provides the earliest data on the number of acres planted for several crops and the December/January subsample is the source of the acres actually harvested and the levels of production. Also, for livestock data, where the relationship between inventories at two points in time is less obvious, these two extreme time points will provide the most stringent test of using double sampling for livestock estimation.

Expansion factors or sampling weights were calculated for the full sample and the subsample farm operators. These are, as usual, the inverse of the probability that an operator is included in the sample. For the full sample, the common expansion factor for the members of stratum-h is the population size for the stratum divided by the stratum sample size. The subsample expansion factor for the members of substratum-hk was obtained by dividing the full sample factor for stratum-h by the subsampling rate for substratum-hk. The subsample weights were then ratio adjusted to reproduce list frame population counts by primary strata.

Table 3-1. Population and Sample Sizes for the 1984 Tennessee ISP by Primary Stratum

Stratum Description	Population Size	Sample Sizes: June	Sample Sizes: Subsample
All Strata	94,257	3,002	2,223
CRD* 10, 20	12,128	380	229
CRD 30, 40, 50	37,436	901	613
CRD 60	28,823	560	386
Cattle 50-99	5,972	241	208
Cattle 100-499	2,209	141	122
Dairy 50-199	1,357	89	77
Hogs 50-99	2,969	200	155
Hogs 100-499	2,073	220	180
Crop land 500-1999	463	80	66
Sheep 1-39	188	40	37
Cattle 500-1499	72	8	8
Hogs 500-1999	303	31	31
Crop land 2000+	36	36	36
Cattle 1500+	7	7	7
Dairy 200-499	97	12	12
Dairy 500+	4	4	4
Sheep 40+	65	16	16
Hogs 2000+	29	29	29
HPLA 3000+	26	7	7

*Crop Reporting District

4. Design Study

4.1. Cost and Variance Models

This study is intended to evaluate survey designs that minimize the total cost of conducting a series of agricultural production surveys. In order to accomplish this, an integrated set of cost and variance models are required which explain the cost and precision of a multiple set of surveys. These models are discussed below.

To simplify the situation to a manageable and interpretable analysis, assume that two surveys are under consideration -- one at the beginning of the survey cycle (the full sample or first phase) and the other at the conclusion of the cycle (the subsample or second phase). The full sample is assumed to be a stratified simple random sample (srs) of the list operators followed by a simple random subsample within each stratum as described in section 1.3. This design will be compared with a separate stratified srs at both time points.

Two types of estimators will be entertained -- a direct expansion estimator and a double sampling regression estimator. The expansion estimator is the one currently being used by the SRS and is of the form, using the notation of section 1.3,

$$y = \sum_{h=1}^{H} N_h \bar{y}_h \qquad (4.1)$$

for a stratified srs. The variance of y is

$$\begin{aligned} \mathrm{Var}(y) &= \sum_{h=1}^{H} N_h^2 S_h^2 / n_h \\ &= \sum_{h=1}^{H} A_h / n_h . \qquad (4.2) \end{aligned}$$

The variance model for the double sampling regression model is given in equation (2.9).

The current SRS strategy is to ignore the double sampling aspects of the design and to produce direct expansion estimates independently from both the full sample and the subsample. The sample design problem for this situation takes the form:

Minimize the cost

$$C = \sum_{h=1}^{H} n_h C_h + \sum_{h=1}^{H} m_h C_h' \qquad (4.3)$$

subject to variance constraints of the form

$$\sum_{h=1}^{H} A_{1h}/n_h \leq V_1^2 \qquad (4.4)$$

$$\sum_{h=1}^{H} A_{2h}'/m_h \leq V_2^2 \, . \qquad (4.5)$$

The parameters n_h and m_h are the first phase and second phase sample sizes for stratum-h, respectively; C_h and C_h' are the costs per unit for the first and second phase samples in stratum-h; and A_{1h} and A_{2h}' are respectively the first and second phase variance components for stratum-h whose forms are given in equation (4.2). Inequality (4.4) is a variance constraint placed on an estimate from the first phase, while (4.5) is one for a second phase estimate. V_1^2 and V_2^2 are the maximum allowable variance constraints for these two estimates. In practice, there would be constraints on several different estimates for each phase of the form shown.

The above strategy will be compared to an alternative one that will use a double sampling regression estimator to take advantage of the overlap between the two samples. The form of the design problem for this situation is:

Minimize the cost

$$C = \sum_{h=1}^{H} n_h C_h + \sum_{h=1}^{H} m_h C_h' \qquad (4.6)$$

subject to variance constraints of the form

$$\sum_{h=1}^{H} A_{1h}/n_h \leq V_1^2 \qquad (4.7)$$

$$\sum_{h=1}^{H} A_{2h}/n_h + \sum_{h=1}^{H} A_{2h}'/m_h \leq V_2^2 \qquad (4.8)$$

$$\sum_{h=1}^{H} A_{3h}'/m_h \leq V_3^2 \, . \qquad (4.9)$$

The cost function (4.6) is of the same form as (4.3). Also, inequalities (4.7) and (4.4) correspond, as do (4.9) and (4.5). Inequality (4.8) represents a variance constraint on a double sampling regression estimate from the subsample and is of the form given in equation (2.9). Again, in practice there would be multiple variance constraints of each of the three types.

The main difference between the design alternatives is the use of the regression estimator to take advantage of the double sampling. Estimates made only from the first phase sample at the beginning of the survey cycle would have the exact same variance models under either alternative. That is, the variance models in the set represented by (4.4) are identical to the models in the set represented by (4.7). The set of estimates made at the end of the cycle under the current strategy, corresponding to (4.5), is split into two sets of estimates under the alternative strategy. The first set corresponds to (4.8) and consists of those estimates for which a regression estimator is appropriate. The second set corresponds to (4.9) and contains the remaining end of cycle estimates for which an expansion estimator is used. The variance models for this latter set of estimates are identical to their counterparts for the current strategy.

The stratification scheme chosen for use in this study was developed by Bethel (1985b) and is shown in Table 4-1. This scheme differs from the one used to select the 1984 Tennessee ISP sample. It was selected because Bethel had just completed a thorough study of the stratification plans for the ISP samples. Table 4-1 also shows the optimal allocation that Bethel obtained for the June Tennessee ISP sample.

The selection of the estimates to include as constraints in the design optimization problem is a key step in the evaluation of the design alternatives. It is important that all the major estimates for which it is necessary to meet certain reporting requirements are included or that estimates with variance characteristics representative of all classes of estimates are included. Thought should be given to selecting variance constraints that will represent all uses of the data. This will guard against selecting designs that are inadequate for certain analyses. It is also important that ridiculously stringent or numerous requirements are not placed on the problem. This will lead to meaningless designs with unacceptably high total costs.

In order for a regression estimator to be effective, a strong relationship must exist between the data collected in the two phases. By considering equation (2.3), it can be seen that the squared multiple correlation coefficient (R^2) must be greater than 0.50 for double sampling to reduce the subsample size. Experience has shown that a value of at least 0.75 is needed before double sampling becomes practical. The strength of the relationship for this application was investigated using the expanded data described in Chapter 3. The number of acres planted for corn, soybean, cotton, tobacco and hay along with the number of cattle, dairy cattle and hogs on the farm were collected in the June survey. These quantities were used as independent variables in simple linear regression models to predict the December/January values of the variables shown in Table 4-2 (the obvious dependent variable from above being used in each model). Table 4-2 also displays the percent squared multiple correlation coefficient for each model. The December/January data exhibit a substantial linear relationship with the June data for all the variables except the two hay variables, which display a neutral level of association. This indicates that a double sampling regression estimation strategy may be effective for the situation at hand. More sophisticated models were explored for the variables in Table 4-2, however, meaningful improvements over the simple linear models reported could not be found.

In addition, predictive models for December/January corn stocks and soybean stocks as functions of June data were explored. It was not possible to identify models with a percent squared multiple correlation coefficient greater than 10 percent. For this reason, these two variables will always be included in the design study as expansion estimates and not as regression estimates.

The available data from the 1984 Tennessee ISP were reviewed with SRS staff in the Survey Research Section to identify the estimates that were used in this design study. The 29 estimates shown in Table 4-3 were selected. These estimates fall into three groups. The first group is the set of expansion estimates made from the first phase survey at the beginning of the survey cycle. The second set consists of the double sampling regression estimates made from the combined data from both phases. These double sampling regression estimates replace the expansion estimates made only from the second phase data under the current SRS strategy. The final group is made up of second phase expansion estimates for which a regression estimator is not appropriate. The first group corresponds to inequality (4.7); the second to inequality (4.8); and the final group to (4.9).

Statistically consistent weighted estimates of the population parameters in the variance models were obtained using the data described in Chapter 3. This was done for the 29 variables listed in Table 4-3 for each of the strata in Table 4-1. A detailed presentation of these estimates is given in the Appendix. Some editing of the original estimates was done prior to inclusion in the Appendix to account for questionable estimates due to small sample sizes for some strata.

Estimates of the cost per sample unit for use in the cost models were taken from Bethel (1985b). He determined that for the June Tennessee ISP survey that the cost per interview of a list frame operator is approximately \$5.50. For this analysis, it was assumed that this unit cost would be appropriate for all strata for both phases and for both design alternatives. That is, $C_h = C_h' = \$5.50$ for all h in both equations (4.3) and (4.6). While the double sampling regression estimation alternative is more difficult to implement and use, this will probably result in a larger fixed cost rather than an increased variable cost per interview. In addition, the increased fixed cost should diminish over time as software and methods for a regression estimator become established. For these reasons a constant unit cost was used for all analyses.

4.2. Comparison of Survey Strategies

The efficiency of two different survey strategies are being compared in this study -- an expansion estimation strategy with a double sampling regression estimation strategy. For this study, the efficiency of each strategy will be measured by the minimum total cost of the strategy needed to satisfy a particular set of maximum variance constraints on the estimates. Markedly different total costs are obtained as the levels of the variance constraints are varied. In fact, it is possible for the most efficient strategy to change between two different sets of variance constraints. This implies that the levels of the variance constraints should be chosen thoughtfully.

The approach taken for this study in setting the variance constraints was to determine the precision levels that are currently being obtained by the SRS in the June Tennessee survey and use these as the constraints. This approach is logical since it will determine if the alternative double sampling regression estimation strategy is more efficient than the current expansion estimation strategy. The exact variance constraints were obtained by substituting the optimal sample allocation determined by Bethel (1985b), see Table 4-1, into the expansion estimation variance models for all 29 estimates in Table 4-3. This yielded the variance constraints, expressed as percent coefficients of variation (cv), also presented in Table 4-3. These constraints are consistent with those used by Bethel in his study.

Table 4-4 compares the sample allocation that minimizes the total cost of the expansion strategy under the constraints given in Table 4-3 to the minimum cost allocation for the regression strategy under the same constraints. These two optimal allocations are very similar with total costs differing by only $308. This unsatisfying result implies that there is no advantage to be gained by using the double sampling regression estimation strategy rather than the current expansion estimation approach. This conclusion is at odds with the expectations raised by Table 4-2 and is investigated further below.

Separate allocations for the regression estimation strategy were obtained for each of the six commodity groups listed in Table 4-5. Each allocation minimizes the cost of the survey when only the variance of the estimates listed for the commodity group are constrained at the levels shown in Table 4-3. The remaining estimates are not constrained and may not satisfy the variance requirements in Table 4-3. Table 4-5 only presents the total sample sizes for the first and second phases and the subsampling percent for all of the strata combined. It is evident that substantial gains due to regression estimation can be obtained for all of the groups except hay since their subsampling percents are at most 61 percent. However, hay requires two samples of approximately equal total size to satisfy its variance constraints. This indicates that hay may be the dominant constraint in determining the allocation in Table 4-4. This is consistant with the low squared multiple correlations in Table 4-2 for the two hay variables.

Two new sets of sample allocations were obtained, see Table 4-6, that minimize the total cost of each strategy subject to the variance constraints in Table 4-3 excluding the second phase constraints on hay acres planted, hay production, corn stocks, soybean stocks and winter wheat intentions. These sample allocations display a savings of approximately $2,100 (7.5 percent) of the double sampling regression estimation strategy over the expansion estimation approach. The regression approach calls for a larger first phase sample than the expansion strategy (2980 versus 2610 operators) but a smaller subsample (1782 versus 2537 operators). While this savings is not large, four follow up surveys (September, October, December and January) are currently conducted in Tennessee. In addition, similar surveys are conducted in several states. A savings of $2,000 on each survey could accumulate to a sizable total savings.

The effect of deleting the five estimates from the variance constraints is further explored in Table 4-7. This shows that the increase in cv that these five estimates incurred was small, particularly for the hay estimates. The importance of selecting appropriate variance constraints is pointed out by these five estimates. When these estimates were included, gains from double sampling regression estimation were not realized. Without them, possible gains became evident. If it can be argued that the cv's for the excluded estimates (or any other estimate not is this study) are adequate under the regression allocation in Table 4-6, then gains from using the double sampling regression estimation strategy can be enjoyed.

The preceding analyses have shown that for many of the Tennessee estimates it is possible to obtain as precise of estimates with a subsampling strategy by using a regression estimator as can be obtained with two independent surveys of the same size with an expansion estimator. The currently used designed for the Tennessee ISP is a subsampling design but an expansion estimator is used rather than a regression estimator. Thus, it is possible to improve the precision of many of the Tennessee estimates without increasing the current sample size. This is demonstrated in Table 4-8 which presents the model predicted list sample cv's for both the expansion estimator and the regression estimator for a set of samples allocated as the 1984 Tennessee June (first phase) sample and the combined December/January (second phase) sample. A marked reduction in the variances of the estimates in Table 4-8 is obtained by using the regression estimator.

Table 4-1. Tennessee Design Study Strata and Optimal June Allocation Obtained by Bethel (1985b)

Stratum	Boundaries: Dairy	Land	Hogs	CRD*	June Allocation
	All Strata				2584
1	0-9	0-59	0-9	10,20	257
2	0-9	0-59	0-9	30,40,50	613
3	0-9	0-59	0-9	60	452
4	0-9	0-59	10-499		557
5	0-9	60-499	0-9		189
6	0-9	60-499	10-499		60
7	10-99	0-59	0-9		179
8	10-99	0-59	10-499		42
9	10-99	60-499	0-9		37
10	10-99	60-499	10-499		11
11		500+			55
12	100+				44
13			500+		58
14	Cattle 1500+				7
15	Sheep 40+				16
16	HPLA 3,000+				7

*Crop Reporting District

Table 4-2. Percent Squared Multiple Correlation Between June Data and December/January Data from 1984 Tennessee ISP

Estimate	Percent
Corn	
Acres Planted	86
Acres Harvested	79
Production	76
Soybeans	
Acres Planted	86
Acres Harvested	86
Production	84
Cotton	
Acres Planted	95
Acres Harvested	95
Production	91
Tobacco	
Acres Planted	76
Production	73
Hay	
Acres Planted	51
Production	44
Livestock	
Cattle	79
Dairy	77
Hogs	72

Table 4-3. Estimates and Variance Constraints Used in the Design Study

Estimate	Percent CV
First Phase Expansion Estimates	
Corn Acres Planted	7.4
Soybean Acres Planted	9.1
Cotton Acres Planted	23.1
Tobacco Acres Planted	6.6
Hay Acres Planted	4.9
Cattle	4.4
Dairy	7.2
Hogs	12.8
Corn Stocks	26.8
Soybean Stocks	40.0
Second Phase Regression Estimates	
Corn	
Acres Planted	7.2
Acres Harvested	8.3
Production	8.7
Soybeans	
Acres Planted	9.0
Acres Harvested	9.1
Production	9.1
Cotton	
Acres Planted	20.6
Acres Harvested	20.6
Production	21.2
Tobacco	
Acres Planted	6.0
Production	6.3
Hay	
Acres Planted	4.8
Production	5.1
Livestock	
Cattle	4.4
Dairy	8.7
Hogs	11.8
Second Phase Expansion Estimates	
Corn Stocks	13.9
Soybean Stocks	27.1
Winter Wheat Intentions	10.8

Table 4-4. Sample Allocations and Costs for both Strategies under the Constraints in Table 4-3

Stratum	Expansion Allocation		Regression Allocation		
	First Phase	Second Phase	First Phase	Second Phase	Percent Subsample
1	251	254	259	198	76
2	611	587	597	621	104
3	482	453	501	498	99
4	568	584	558	524	94
5	179	165	175	139	79
6	63	77	75	69	92
7	184	169	186	149	80
8	40	37	40	41	103
9	44	38	41	44	107
10	15	18	13	13	100
11	61	60	59	64	109
12	53	48	50	61	122
13	51	51	56	57	102
14	2	2	3	2	67
15	2	3	2	2	100
16	4	2	2	3	150
Total	2610	2548	2617	2485	95
Total Cost		$28,369		$28,061	

Table 4-5. Separate Allocations by Commodity Group for the Regression Strategy

Commodity	Total Sample Size: Full Sample	Total Sample Size: Subsample	Combined Subsampling Percent
Corn Acres Planted Acres Harvested Production	2392	1363	57
Soybean Acres Planted Acres Harvested Production	1875	974	52
Cotton Acres Planted Acres Harvested Production	816	287	35
Tobacco Acres Planted Production	2774	1690	61
Hay Acres Planted Production	2316	2575	111
Livestock Cattle Dairy Hogs	2927	1714	59

Table 4-6. Sample Allocations and Costs for both Strategies Excluding Five Constraints from Table 4-3

Stratum	Expansion Allocation		Regression Allocation		
	First Phase	Second Phase	First Phase	Second Phase	Percent Subsample
1	252	252	307	121	39
2	604	609	722	442	61
3	484	409	453	370	82
4	566	588	668	387	58
5	180	173	209	87	42
6	63	80	109	49	45
7	187	169	213	147	69
8	40	35	38	26	68
9	44	37	48	25	52
10	14	20	19	15	79
11	61	59	56	33	59
12	54	47	64	29	45
13	53	51	65	46	71
14	3	2	2	2	100
15	2	4	4	1	25
16	3	2	3	2	67
Total	2610	2537	2980	1782	60
Total Cost	$28,309		$26,191		

Table 4-7. Changes in CV for the Estimates Excluded in Table 4-6

Estimate	Constrained Percent CV	Unconstrained Percent CV
Hay		
Acres Planted	4.8	5.2
Production	5.1	5.6
Corn Stocks	13.5	17.0
Soybean Stocks	26.8	34.5
Winter Wheat Intentions	10.8	13.2

Table 4-8. Comparison of the Expansion Estimator with the Double Sampling Regression Estimator for the 1984 Tennessee ISP

Estimates	Expansion Percent CV	Regression Percent CV
Corn		
Acres Planted	11.3	8.0
Acres Harvested	12.9	9.3
Production	13.7	9.9
Soybean		
Acres Planted	15.2	9.9
Acres Harvested	15.4	10.0
Production	15.2	10.2
Cotton		
Acres Planted	35.3	21.8
Acres Harvested	35.4	21.8
Production	35.7	23.3
Tobacco		
Acres Planted	9.6	7.1
Production	10.1	7.5
Hay		
Acres Planted	7.8	6.5
Production	8.2	7.0
Livestock		
Cattle	7.1	5.2
Dairy	14.6	12.1
Hogs	17.1	13.0

5. Conclusion

The analyses presented in section 4.2 indicate that a double sampling regression estimation strategy is more efficient than the expansion estimation strategy. While the savings are not large for any particular survey, it could accumulate to a sizable amount across the many surveys that the SRS conducts. In addition, for the current Tennessee ISP design, a marked reduction in the variance of certain estimates can be obtained through a regression estimation approach. Similar results were obtained from the 1984 Illinois data. These results were not reported because the sample design for Illinois would not support the detail of analysis presented for the Tennessee data.

A second result of this study is the presentation of several variance models which can be used to explore the effects of double sampling and regression estimation on the precision of SRS estimates. One of the simplest models was used in this first exploration of regression estimation to try to understand the basic processes at play. This model was realistic enough to allow valid conclusions to be drawn but simple enough to be readily understood. Future investigations should probably use the substratified model in section 2.4. This more complicated model closely resembles the design that SRS is currently using but incorporates a regression estimator and takes advantage of substratification.

Another estimator that might be explored is a combined regression estimator. The regression estimator discussed in this report is more specifically called a separate regression estimator since a separate regression coefficient is estimated for each strata. The combined regression estimator uses a common coefficient for all of the strata. This estimator would be of importance for commodities that are only grown on a few farms in each strata. A better estimate of a common coefficient can be obtained by combining the data across the strata rather than estimating separate coefficients for each strata. The combined estimator might have a larger bias than the separate estimator but a smaller mean square error in certain situations.

The regression estimation approach can also be expanded to compensate for nonsampling survey response errors due to such effects as panel bias or proxy respondents. This can be accomplished by including effects in the regression model for the response variables and then producing regression adjusted means. The adjustment is made to levels of the response variables that are felt to induce the least bias. For example, assume that a farm operator could be included in several successive samples. The estimated regression model could include effects for the number of previous surveys in which the operator was included. An adjusted (or predicted) estimate could then be produced as if all the operators were first time respondents. Likewise, by including an effect in the model for proxy respondents, adjusted estimates could be produced as if all the operators reported for themselves. This approach is being investigated for the National Crime Survey by LaVange and Folsom (1985).

6. References

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Appendix

The tables presented in this appendix contain the estimated variance models used in this study. The item labeled Total in each table is the estimated total (Y) for the variable under consideration for the state of Tennessee. The tables are broken out by stratum and present the population size (N_h), the population variance (S_h^2), and the squared multiple correlation (R_h^2) in percent for the models discussed in section 4.1. The variance components, relative to the squared total, used in the design optimizations are also reported. The full sample and the subsample components are discussed in equation (2.9) and the expansion component in (4.2). These are explicitly,

Full Sample Component

$$N_h^2 \; S_h^2 \; R_h^2 \; / \; Y^2 \qquad (A.1)$$

Subsample Component

$$N_h^2 \; S_h^2 \; (1 - R_h^2) \; / \; Y^2 \qquad (A.2)$$

Expansion Component

$$N_h^2 \; S_h^2 \; / \; Y^2 \; . \qquad (A.3)$$

The models predict the relative variance or the coefficient of variation squared of an estimate since they have been scaled by the square of the total.

Table A-1. Tennessee 1984 ISP: Second Phase Corn Acres Planted Variance Model

Total= 555633

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	938.2	86	2.3219E+01	3.7799E+00	2.6999E+01
1	0-9	0-59	0-9	10,20	8960	406.9	94	9.9462E-02	6.3486E-03	1.0581E-01
2	0-9	0-59	0-9	30,40,50	29959	141.8	42	1.7314E-01	2.3910E-01	4.1224E-01
3	0-9	0-59	0-9	60	25730	25.1	40	2.1530E-02	3.2294E-02	5.3824E-02
4	0-9	0-59	10-499		17557	1154.7	90	1.0376E+00	1.1529E-01	1.1529E+00
5	0-9	60-499	0-9		3560	652.0	85	2.2750E-02	4.0148E-03	2.6765E-02
6	0-9	60-499	10-499		1644	2065.6	67	1.2116E-02	5.9674E-03	1.8083E-02
7	10-99	0-59	0-9		3896	1341.4	88	5.8037E-02	7.9141E-03	6.5951E-02
8	10-99	0-59	10-499		693	5571.1	95	8.2329E-03	4.3331E-04	8.6663E-03
9	10-99	60-499	0-9		683	3259.7	91	4.4821E-03	4.4329E-04	4.9254E-03
10	10-99	60-499	10-499		247	3662.0	86	6.2235E-04	1.0131E-04	7.2366E-04
11		500+			488	14283.5	67	7.3820E-03	3.6359E-03	1.1018E-02
12	100+				407	22261.1	92	1.0989E-02	9.5554E-04	1.1944E-02
13			500+		335	34929.8	93	1.1808E-02	8.8881E-04	1.2697E-02
14	Cattle 1500+				7	24383.3	60	2.3220E-06	1.5480E-06	3.8700E-06
15	Sheep 40+				65	9.4	85	1.0934E-07	1.9296E-08	1.2864E-07
16	HPLA 3,000+				26	8903.6	86	1.6766E-05	2.7294E-06	1.9496E-05

Table A-2. Tennessee 1984 ISP: Second Phase Corn Acres Harvested Variance Model

Total= 458370

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	776.9	79	2.5953E+01	6.8989E+00	3.2852E+01
1	0-9	0-59	0-9	10,20	8960	372.5	94	1.3379E-01	8.5401E-03	1.4233E-01
2	0-9	0-59	0-9	30,40,50	29959	134.4	38	2.1818E-01	3.5597E-01	5.7414E-01
3	0-9	0-59	0-9	60	25730	24.0	36	2.7225E-02	4.8399E-02	7.5624E-02
4	0-9	0-59	10-499		17557	1147.9	89	1.4989E+00	1.8525E-01	1.6841E+00
5	0-9	60-499	0-9		3560	536.9	79	2.5585E-02	6.8011E-03	3.2386E-02
6	0-9	60-499	10-499		1644	1724.8	78	1.7306E-02	4.8813E-03	2.2188E-02
7	10-99	0-59	0-9		3896	709.0	54	2.7660E-02	2.3562E-02	5.1221E-02
8	10-99	0-59	10-499		693	4938.4	94	1.0611E-02	6.7729E-04	1.1288E-02
9	10-99	60-499	0-9		683	2886.9	83	5.3201E-03	1.0897E-03	6.4097E-03
10	10-99	60-499	10-499		247	4025.2	79	9.2337E-04	2.4545E-04	1.1688E-03
11		500+			488	13549.1	70	1.0750E-02	4.6072E-03	1.5357E-02
12	100+				407	10887.1	65	5.5793E-03	3.0043E-03	8.5836E-03
13			500+		335	35025.1	93	1.7399E-02	1.3096E-03	1.8708E-02
14	Cattle 1500+				7	6833.7	43	6.8531E-07	9.0844E-07	1.5937E-06
15	Sheep 40+				65	9.4	79	1.4933E-07	3.9696E-08	1.8903E-07
16	HPLA 3,000+				26	3364.0	79	8.5506E-06	2.2729E-06	1.0824E-05

Table A-3. Tennessee 1984 ISP: Second Phase Corn Production Variance Model

Total= 4.3E+07

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	7621629	76	2.8413E+01	8.9725E+00	3.7385E+01
1	0-9	0-59	0-9	10,20	8960	3060189	87	1.1801E-01	1.7633E-02	1.3564E-01
2	0-9	0-59	0-9	30,40,50	29959	1146503	36	2.0453E-01	3.6361E-01	5.6814E-01
3	0-9	0-59	0-9	60	25730	132388	35	1.6936E-02	3.1453E-02	4.8390E-02
4	0-9	0-59	10-499		17557	10201924	88	1.5279E+00	2.0835E-01	1.7362E+00
5	0-9	60-499	0-9		3560	4926010	77	2.6541E-02	7.9277E-03	3.4468E-02
6	0-9	60-499	10-499		1644	16670159	80	1.9900E-02	4.9751E-03	2.4875E-02
7	10-99	0-59	0-9		3896	9068069	53	4.0277E-02	3.5717E-02	7.5994E-02
8	10-99	0-59	10-499		693	79844437	88	1.8630E-02	2.5405E-03	2.1171E-02
9	10-99	60-499	0-9		683	29316892	79	5.9650E-03	1.5856E-03	7.5507E-03
10	10-99	60-499	10-499		247	20668729	68	4.7342E-04	2.2278E-04	6.9620E-04
11		500+			488	190308154	74	1.8516E-02	6.5057E-03	2.5022E-02
12	100+				407	110627784	65	6.5765E-03	3.5412E-03	1.0118E-02
13			500+		335	302793142	80	1.5009E-02	3.7523E-03	1.8761E-02
14	Cattle 1500+				7	105956620	36	1.0319E-06	1.8346E-06	2.8665E-06
15	Sheep 40+				65	131287	76	2.3275E-07	7.3500E-08	3.0625E-07
16	HPLA 3,000+				26	27418335	76	7.7773E-06	2.4560E-06	1.0233E-05

Table A-4. Tennessee 1984 ISP: Second Phase Soybean Acres Planted Variance Model

Total= 1156244

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	6300.0	86	3.6005E+01	5.8613E+00	4.1867E+01
1	0-9	0-59	0-9	10,20	8960	18035.0	89	9.6388E-01	1.1913E-01	1.0830E+00
2	0-9	0-59	0-9	30,40,50	29959	318.0	53	1.1315E-01	1.0034E-01	2.1349E-01
3	0-9	0-59	0-9	60	25730	69.0	71	2.4260E-02	9.9090E-03	3.4169E-02
4	0-9	0-59	10-499		17557	3053.0	78	5.4906E-01	1.5486E-01	7.0393E-01
5	0-9	60-499	0-9		3560	11820.0	88	9.8606E-02	1.3446E-02	1.1205E-01
6	0-9	60-499	10-499		1644	3683.0	77	5.7332E-03	1.7125E-03	7.4457E-03
7	10-99	0-59	0-9		3896	2723.0	95	2.9370E-02	1.5458E-03	3.0916E-02
8	10-99	0-59	10-499		693	6508.0	95	2.2209E-03	1.1689E-04	2.3378E-03
9	10-99	60-499	0-9		683	25416.0	95	8.4251E-03	4.4342E-04	8.8685E-03
10	10-99	60-499	10-499		247	40286.0	68	1.2501E-03	5.8830E-04	1.8384E-03
11		500+			488	223159.0	80	3.1801E-02	7.9503E-03	3.9752E-02
12	100+				407	12131.0	93	1.3979E-03	1.0522E-04	1.5[illegible]-03
13			500+		335	75434.0	82	5.1924E-03	1.1398E-03	6.3322E-03
14	Cattle 1500+				7	27834.0	86	8.7735E-07	1.4282E-07	1.0202E-06
15	Sheep 40+				65	23.0	0	0.0000E+00	7.2687E-08	7.2687E-08
16	HPLA 3,000+				26	78367.0	86	3.4078E-05	5.5476E-06	3.9626E-05

Table A-5. Tennessee 1984 ISP: Second Phase Soybean Acres Harvested Variance Model

Total= 1143833

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	6251.0	86	3.6505E+01	5.9426E+00	4.2447E+01
1	0-9	0-59	0-9	10,20	8960	18035.0	89	9.8491E-01	1.2173E-01	1.1066E+00
2	0-9	0-59	0-9	30,40,50	29959	314.0	53	1.1417E-01	1.0124E-01	2.1541E-01
3	0-9	0-59	0-9	60	25730	69.0	71	2.4789E-02	1.0125E-02	3.4914E-02
4	0-9	0-59	10-499		17557	3050.0	78	5.6049E-01	1.5809E-01	7.1858E-01
5	0-9	60-499	0-9		3560	11829.0	88	1.0083E-01	1.3750E-02	1.1458E-01
6	0-9	60-499	10-499		1644	3515.0	77	5.5911E-03	1.6701E-03	7.2[illegible]-03
7	10-99	0-59	0-9		3896	2609.0	95	2.8755E-02	1.5134E-03	3.0268E-02
8	10-99	0-59	10-499		693	6511.0	95	2.2705E-03	1.1950E-04	2.3900E-03
9	10-99	60-499	0-9		683	25482.0	95	8.6312E-03	4.5428E-04	9.0855E-03
10	10-99	60-499	10-499		247	40286.0	68	1.2774E-03	6.0114E-04	1.8786E-03
11		500+			488	224515.0	80	3.2693E-02	8.1732E-03	4.0866E-02
12	100+				407	12131.0	93	1.4284E-03	1.0751E-04	1.5359E-03
13			500+		335	70066.0	82	4.9282E-03	1.0818E-03	6.0100E-03
14	Cattle 1500+				7	27834.0	86	8.9649E-07	1.4594E-07	1.0424E-06
15	Sheep 40+				65	23.0	0	0.0000E+00	7.4273E-08	7.4273E-08
16	HPLA 3,000+				26	78367.0	86	3.4822E-05	5.6687E-06	4.0491E-05

Table A-6. Tennessee 1984 ISP: Second Phase Soybean Production Variance Model

Total= 3E+07

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	4670810	84	3.8785E+01	7.3876E+00	4.6173E+01
1	0-9	0-59	0-9	10,20	8960	11582920	86	8.8981E-01	1.4485E-01	1.0347E+00
2	0-9	0-59	0-9	30,40,50	29959	175213	49	8.5740E-02	8.9240E-02	1.7498E-01
3	0-9	0-59	0-9	60	25730	65479	64	3.0869E-02	1.7364E-02	4.8233E-02
4	0-9	0-59	10-499		17557	2007040	73	5.0251E-01	1.8586E-01	6.8837E-01
5	0-9	60-499	0-9		3560	9318346	86	1.1301E-01	1.8396E-02	1.3140E-01
6	0-9	60-499	10-499		1644	2205548	75	4.9745E-03	1.6582E-03	6.6326E-03
7	10-99	0-59	0-9		3896	1515674	95	2.4318E-02	1.2799E-03	2.5598E-02
8	10-99	0-59	10-499		693	3687121	95	1.8717E-03	9.8512E-05	1.970[illegible]-03
9	10-99	60-499	0-9		683	18499184	95	9.1219E-03	4.8010E-04	9.6020E-03
10	10-99	60-499	10-499		247	25940543	63	1.1094E-03	6.5154E-04	1.7609E-03
11		500+			488	210775192	76	4.2446E-02	1.3404E-02	5.5850E-02
12	100+				407	7804184	93	1.3377E-03	1.0069E-04	1.4384E-03
13			500+		335	52288852	76	4.9623E-03	1.5670E-03	6.5293E-03
14	Cattle 1500+				7	117010511	84	5.3588E-06	1.0207E-06	6.3795E-06
15	Sheep 40+				65	21094	0	0.0000E+00	9.9164E-08	9.9164E-08
16	HPLA 3,000+				26	48979592	84	3.0946E-05	5.8945E-06	3.6841E-05

Table A-7. Tennessee 1984 ISP: Second Phase Cotton Acres Planted Variance Model

Total= 227119

Stratum	Boundaries				Pop			Full Samp	Subsamp	Expansion
	Dairy	Land	Hogs	CRD	Size	S-sq	%R-sq	Component	Component	Component
	All Strata				94257	1374.0	95	2.2482E+02	1.1833E+01	2.3665E+02
1	0-9	0-59	0-9	10,20	8960	3598.0	95	5.3198E+00	2.7999E-01	5.5998E+00
2	0-9	0-59	0-9	30,40,50	29959	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
3	0-9	0-59	0-9	60	25730	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
4	0-9	0-59	10-499		17557	133.0	95	7.5504E-01	3.9739E-02	7.9478E-01
5	0-9	60-499	0-9		3560	6978.0	95	1.6287E+00	8.5722E-02	1.7144E+00
6	0-9	60-499	10-499		1644	336.0	2	3.5210E-04	1.7253E-02	1.7605E-02
7	10-99	0-59	0-9		3896	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
8	10-99	0-59	10-499		693	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
9	10-99	60-499	0-9		683	303.0	95	2.6032E-03	1.3701E-04	2.7402E-03
10	10-99	60-499	10-499		247	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
11		500+			488	113472.0	95	4.9767E-01	2.6193E-02	5.2387E-01
12	100+				407	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
13			500+		335	7808.0	95	1.6138E-02	8.4936E-04	1.6987E-02
14	Cattle 1500+				7	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
15	Sheep 40+				65	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
16	HPLA 3,000+				26	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00

Table A-8. Tennessee 1984 ISP: Second Phase Cotton Acres Harvested Variance Model

Total= 226584

Stratum	Boundaries				Pop			Full Samp	Subsamp	Expansion
	Dairy	Land	Hogs	CRD	Size	S-sq	%R-sq	Component	Component	Component
	All Strata				94257	1372.0	95	2.2555E+02	1.1871E+01	2.3742E+02
1	0-9	0-59	0-9	10,20	8960	3598.0	95	5.3449E+00	2.8131E-01	5.6262E+00
2	0-9	0-59	0-9	30,40,50	29959	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
3	0-9	0-59	0-9	60	25730	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
4	0-9	0-59	10-499		17557	133.0	95	7.5861E-01	3.9927E-02	7.9853E-01
5	0-9	60-499	0-9		3560	6978.0	95	1.6364E+00	8.6128E-02	1.7226E+00
6	0-9	60-499	10-499		1644	336.0	2	3.5376E-04	1.7334E-02	1.7688E-02
7	10-99	0-59	0-9		3896	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
8	10-99	0-59	10-499		693	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
9	10-99	60-499	0-9		683	180.0	95	1.5537E-03	8.1776E-05	1.6355E-03
10	10-99	60-499	10-499		247	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
11		500+			488	113371.0	95	4.9958E-01	2.6294E-02	5.2588E-01
12	100+				407	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
13			500+		335	7808.0	95	1.6214E-02	8.5338E-04	1.7068E-02
14	Cattle 1500+				7	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
15	Sheep 40+				65	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00
16	HPLA 3,000+				26	0.0	0	0.0000E+00	0.0000E+00	0.0000E+00

Table A-9. Tennessee 1984 ISP: Second Phase Cotton Production Variance Model

Total= 1.1E+08

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	381424421	91	2.3953E+02	2.3689E+01	2.6322E+02
1	0-9	0-59	0-9	10,20	8960	918890621	85	4.8705E+00	8.5950E-01	5.7300E+00
2	0-9	0-59	0-9	30,40,50	29959	0	0	0.0000E+00	0.0000E+00	0.0000E+00
3	0-9	0-59	0-9	60	25730	0	0	0.0000E+00	0.0000E+00	0.0000E+00
4	0-9	0-59	10-499		17557	27986802	95	6.3658E-01	3.3504E-02	6.7009E-01
5	0-9	60-499	0-9		3560	1734670031	95	1.6222E+00	8.5382E-02	1.7076E+00
6	0-9	60-499	10-499		1644	76327351	1	1.6024E-04	1.5863E-02	1.6024E-02
7	10-99	0-59	0-9		3896	0	0	0.0000E+00	0.0000E+00	0.0000E+00
8	10-99	0-59	10-499		693	0	0	0.0000E+00	0.0000E+00	0.0000E+00
9	10-99	60-499	0-9		683	34923453	95	1.2022E-03	6.3271E-05	1.2654E-03
10	10-99	60-499	10-499		247	0	0	0.0000E+00	0.0000E+00	0.0000E+00
11		500+			488	35244449889	89	5.8023E-01	7.1713E-02	6.5194E-01
12	100+				407	0	0	0.0000E+00	0.0000E+00	0.0000E+00
13			500+		335	1845177272	95	1.5280E-02	8.0422E-04	1.6084E-02
14	Cattle 1500+				7	0	0	0.0000E+00	0.0000E+00	0.0000E+00
15	Sheep 40+				65	0	0	0.0000E+00	0.0000E+00	0.0000E+00
16	HPLA 3,000+				26	0	0	0.0000E+00	0.0000E+00	0.0000E+00

Table A-10. Tennessee 1984 ISP: Second Phase Tobacco Acres Planted Variance Model

Total= 42327

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	2.130	76	8.0276E+00	2.5350E+00	1.0563E+01
1	0-9	0-59	0-9	10,20	8960	0.710	95	3.0225E-02	1.5908E-03	3.1816E-02
2	0-9	0-59	0-9	30,40,50	29959	1.349	77	5.2038E-01	1.5544E-01	6.7582E-01
3	0-9	0-59	0-9	60	25730	0.865	51	1.6302E-01	1.5662E-01	3.1964E-01
4	0-9	0-59	10-499		17557	2.986	81	4.1614E-01	9.7613E-02	5.1375E-01
5	0-9	60-499	0-9		3560	5.791	86	3.5230E-02	5.7352E-03	4.0966E-02
6	0-9	60-499	10-499		1644	6.308	89	8.4694E-03	1.0468E-03	9.5161E-03
7	10-99	0-59	0-9		3896	4.873	76	3.1377E-02	9.9086E-03	4.1286E-02
8	10-99	0-59	10-499		693	2.417	7	4.5353E-05	6.0255E-04	6.4790E-04
9	10-99	60-499	0-9		683	5.873	72	1.1010E-03	4.2818E-04	1.5292E-03
10	10-99	60-499	10-499		247	18.637	76	4.8233E-04	1.5232E-04	6.3465E-04
11		500+			488	2.001	52	1.3831E-04	1.2767E-04	2.6598E-04
12	100+				407	27.558	81	2.0639E-03	4.8412E-04	2.5480E-03
13			500+		335	2.316	95	1.3782E-04	7.2538E-06	1.4508E-04
14	Cattle 1500+				7	158.694	76	3.2986E-06	1.0417E-06	4.3403E-06
15	Sheep 40+				65	13.004	92	2.8213E-05	2.4533E-06	3.0667E-05
16	HPLA 3,000+				26	7.550	76	2.1651E-06	6.8371E-07	2.8488E-06

Table A-11. Tennessee 1984 ISP: Second Phase Tobacco Produced Variance Model

Total= 8.8E+07

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	10319412	73	8.5937E+00	3.1785E+00	1.1772E+01
1	0-9	0-59	0-9	10,20	8960	2811996	95	2.7538E-02	1.4494E-03	2.8987E-02
2	0-9	0-59	0-9	30,40,50	29959	6063085	76	5.3105E-01	1.6770E-01	6.9875E-01
3	0-9	0-59	0-9	60	25730	3889239	50	1.6531E-01	1.6531E-01	3.3061E-01
4	0-9	0-59	10-499		17557	15878754	74	4.6508E-01	1.6341E-01	6.2848E-01
5	0-9	60-499	0-9		3560	28748143	84	3.9297E-02	7.4852E-03	4.6783E-02
6	0-9	60-499	10-499		1644	38209352	92	1.2199E-02	1.0608E-03	1.3260E-02
7	10-99	0-59	0-9		3896	23661772	73	3.3665E-02	1.2452E-02	4.6117E-02
8	10-99	0-59	10-499		693	15040582	10	9.2748E-05	8.3474E-04	9.2748E-04
9	10-99	60-499	0-9		683	30251972	70	1.2684E-03	5.4362E-04	1.8121E-03
10	10-99	60-499	10-499		247	73976509	73	4.2304E-04	1.5647E-04	5.7951E-04
11		500+			488	9472239	46	1.3324E-04	1.5641E-04	2.8965E-04
12	100+				407	110123662	81	1.8973E-03	4.4504E-04	2.3423E-03
13			500+		335	9571897	95	1.3103E-04	6.8966E-06	1.3793E-04
14	Cattle 1500+				7	634775510	73	2.9155E-06	1.0783E-06	3.9938E-06
15	Sheep 40+				65	52107773	92	2.6007E-05	2.2615E-06	2.8269E-05
16	HPLA 3,000+				26	41837910	73	2.6510E-06	9.8052E-07	3.6315E-06

Table A-12. Tennessee 1984 ISP: Second Phase Hay Acres Planted Variance Model

Total= 959208

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	733.0	51	3.6097E+00	3.4682E+00	7.0779E+00
1	0-9	0-59	0-9	10,20	8960	519.0	29	1.3133E-02	3.2153E-02	4.5285E-02
2	0-9	0-59	0-9	30,40,50	29959	440.0	42	1.8027E-01	2.4895E-01	4.2922E-01
3	0-9	0-59	0-9	60	25730	366.0	53	1.3958E-01	1.2377E-01	2.6335E-01
4	0-9	0-59	10-499		17557	623.0	49	1.0227E-01	1.0645E-01	2.0872E-01
5	0-9	60-499	0-9		3560	1661.0	47	1.0753E-02	1.2126E-02	2.2879E-02
6	0-9	60-499	10-499		1644	1675.0	42	2.0665E-03	2.8538E-03	4.9203E-03
7	10-99	0-59	0-9		3896	1759.0	65	1.8862E-02	1.0157E-02	2.9019E-02
8	10-99	0-59	10-499		693	721.0	81	3.0483E-04	7.1504E-05	3.7634E-04
9	10-99	60-499	0-9		683	1393.0	44	3.1076E-04	3.9551E-04	7.0626E-04
10	10-99	60-499	10-499		247	1400.0	23	2.1351E-05	7.1480E-05	9.2832E-05
11		500+			488	2353.0	43	2.6188E-04	3.4714E-04	6.0903E-04
12	100+				407	9005.0	35	5.6743E-04	1.0538E-03	1.6[illegible]-03
13			500+		335	2911.0	27	9.5867E-05	2.5920E-04	3.5506E-04
14	Cattle 1500+				7	111426.0	51	3.0264E-06	2.9077E-06	5.9341E-06
15	Sheep 40+				65	1125.0	21	1.0849E-06	4.0811E-06	5.1660E-06
16	HPLA 3,000+				26	5362.0	33	1.3001E-06	2.6395E-06	3.9396E-06

Table A-13. Tennessee 1984 ISP: Second Phase Hay Production Variance Model

Total= 1954818

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	3819.0	44	3.9068E+00	4.9722E+00	8.8790E+00
1	0-9	0-59	0-9	10,20	8960	1156.0	28	6.8002E-03	1.7486E-02	2.4286E-02
2	0-9	0-59	0-9	30,40,50	29959	1484.0	41	1.4291E-01	2.0565E-01	3.4856E-01
3	0-9	0-59	0-9	60	25730	2362.0	44	1.8005E-01	2.2916E-01	4.0921E-01
4	0-9	0-59	10-499		17557	3686.0	45	1.3380E-01	1.6353E-01	2.9733E-01
5	0-9	60-499	0-9		3560	4443.0	38	5.5995E-03	9.1360E-03	1.4735E-02
6	0-9	60-499	10-499		1644	7219.0	43	2.1955E-03	2.9103E-03	5.1058E-03
7	10-99	0-59	0-9		3896	8453.0	49	1.6453E-02	1.7124E-02	3.3577E-02
8	10-99	0-59	10-499		693	7411.0	82	7.6374E-04	1.6765E-04	9.3139E-04
9	10-99	60-499	0-9		683	12944.0	47	7.4267E-04	8.3748E-04	1.5801E-03
10	10-99	60-499	10-499		247	5769.0	60	5.5263E-05	3.6842E-05	9.2105E-05
11		500+			488	7554.0	51	2.4009E-04	2.3067E-04	4.7076E-04
12	100+				407	60770.0	51	1.3435E-03	1.2908E-03	2.6343E-03
13			500+		335	87704.0	15	3.8636E-04	2.1894E-03	2.5757E-03
14	Cattle 1500+				7	477948.0	44	2.6966E-06	3.4320E-06	6.12[illegible]E-06
15	Sheep 40+				65	5589.0	11	6.7974E-07	5.4997E-06	6.1794E-06
16	HPLA 3,000+				26	14424.0	26	6.6343E-07	1.8882E-06	2.5516E-06

Table A-14. Tennessee 1984 ISP: Second Phase Cattle Variance Model

Total= 1670105

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	%R-sq	Full Samp Component	Subsamp Component	Expansion Component
	All Strata				94257	2357.0	79	5.9310E+00	1.5766E+00	7.5076E+00
1	0-9	0-59	0-9	10,20	8960	1384.0	82	3.2665E-02	7.1703E-03	3.9835E-02
2	0-9	0-59	0-9	30,40,50	29959	1125.0	71	2.5703E-01	1.0498E-01	3.6201E-01
3	0-9	0-59	0-9	60	25730	794.0	76	1.4323E-01	4.5230E-02	1.8846E-01
4	0-9	0-59	10-499		17557	1197.0	75	9.9213E-02	3.3071E-02	1.3228E-01
5	0-9	60-499	0-9		3560	4403.0	88	1.7605E-02	2.4007E-03	2.0006E-02
6	0-9	60-499	10-499		1644	7371.0	70	4.9997E-03	2.1427E-03	7.1424E-03
7	10-99	0-59	0-9		3896	5775.0	66	2.0742E-02	1.0685E-02	3.1427E-02
8	10-99	0-59	10-499		693	3024.0	78	4.0612E-04	1.1455E-04	5.2067E-04
9	10-99	60-499	0-9		683	6242.0	76	7.9340E-04	2.5055E-04	1.0439E-03
10	10-99	60-499	10-499		247	3270.0	2	1.4305E-06	7.0094E-05	7.1524E-05
11		500+			488	10781.0	70	6.4433E-04	2.7614E-04	9.2047E-04
12	100+				407	48408.0	83	2.3861E-03	4.8873E-04	2.8749E-03
13			500+		335	9321.0	90	3.3753E-04	3.7503E-05	3.7503E-04
14	Cattle 1500+				7	461576.0	54	4.3787E-06	3.7300E-06	8.1087E-06
15	Sheep 40+				65	434.0	68	4.4703E-07	2.1037E-07	6.5740E-07
16	HPLA 3,000+				26	38256.0	79	7.3246E-06	1.9471E-06	9.2717E-06

Table A-15. Tennessee 1984 ISP: Second Phase Dairy Cattle Variance Model

Total= 216872

Stratum	Boundaries				Pop			Full Samp	Subsamp	Expansion
	Dairy	Land	Hogs	CRD	Size	S-sq	%R-sq	Component	Component	Component
	All Strata				94257	322.8	77	4.6951E+01	1.4024E+01	6.0[illegible]E+01
1	0-9	0-59	0-9	10,20	8960	0.1	31	5.2914E-05	1.1778E-04	1.7069E-04
2	0-9	0-59	0-9	30,40,50	29959	23.7	12	5.4272E-02	3.9800E-01	4.5227E-01
3	0-9	0-59	0-9	60	25730	0.5	28	1.9706E-03	5.0673E-03	7.0379E-03
4	0-9	0-59	10-499		17557	2.8	87	1.5965E-02	2.3856E-03	1.8351E-02
5	0-9	60-499	0-9		3560	15.0	49	1.9805E-03	2.0614E-03	4.0419E-03
6	0-9	60-499	10-499		1644	11.4	38	2.4893E-04	4.0616E-04	6.550[illegible]E-04
7	10-99	0-59	0-9		3896	2566.9	57	4.7219E-01	3.5621E-01	8.2840E-01
8	10-99	0-59	10-499		693	731.6	75	5.6027E-03	1.8676E-03	7.4702E-03
9	10-99	60-499	0-9		683	1294.1	73	9.3697E-03	3.4655E-03	1.2835E-02
10	10-99	60-499	10-499		247	669.2	86	7.4652E-04	1.2153E-04	8.6805E-04
11		500+			488	432.2	41	8.9722E-04	1.2911E-03	2.1884E-03
12	100+				407	16785.9	83	4.9069E-02	1.0050E-02	5.9119E-02
13			500+		335	1298.0	95	2.9423E-03	1.5486E-04	3.0971E-03
14	Cattle 1500+				7	843.6	77	6.7673E-07	2.0214E-07	8.788[illegible]E-07
15	Sheep 40+				65	0.5	41	1.8415E-08	2.6500E-08	4.4915E-08
16	HPLA 3,000+				26	3538.8	77	3.9164E-05	1.1698E-05	5.0862E-05

Table A-16. Tennessee 1984 ISP: Second Phase Hog Variance Model

Total= 691321

Stratum	Boundaries				Pop			Full Samp	Subsamp	Expansion
	Dairy	Land	Hogs	CRD	Size	S-sq	%R-sq	Component	Component	Component
	All Strata				94257	7497	72	1.0034E+02	3.9022E+01	1.3937E+02
1	0-9	0-59	0-9	10,20	8960	1459	78	1.9116E-01	5.3918E-02	2.4508E-01
2	0-9	0-59	0-9	30,40,50	29959	65	33	4.0283E-02	8.1787E-02	1.2207E-01
3	0-9	0-59	0-9	60	25730	2	49	1.3575E-03	1.4129E-03	2.7704E-03
4	0-9	0-59	10-499		17557	4449	71	2.0373E+00	8.3215E-01	2.8695E+00
5	0-9	60-499	0-9		3560	402	3	3.1981E-04	1.0340E-02	1.0660E-02
6	0-9	60-499	10-499		1644	5525	84	2.6246E-02	4.9992E-03	3.1245E-02
7	10-99	0-59	0-9		3896	60	20	3.8112E-04	1.5245E-03	1.9056E-03
8	10-99	0-59	10-499		693	40813	95	3.8961E-02	2.0506E-03	4.1011E-02
9	10-99	60-499	0-9		683	17937	95	1.6632E-02	8.7539E-04	1.7508E-02
10	10-99	60-499	10-499		247	30049	33	1.2658E-03	2.5700E-03	3.8359E-03
11		500+			488	4943	37	9.1132E-04	1.5517E-03	2.4630E-03
12	100+				407	36175	95	1.1911E-02	6.2691E-04	1.2538E-02
13			500+		335	1184064	63	1.7516E-01	1.0287E-01	2.7804E-01
14	Cattle 1500+				7	0	72	0.0000E+00	0.0000E+00	0.0000E+00
15	Sheep 40+				65	2462	72	1.5671E-05	6.0942E-06	2.1765E-05
16	HPLA 3,000+				26	1984	60	1.6838E-06	1.1225E-06	2.8063E-06

Table A-17. Tennessee 1984 ISP:
Second Phase Corn Stocks Variance Model

Total= 9903485

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	1321978	1.1975E+02
1	0-9	0-59	0-9	10,20	8960	92782	7.5946E-02
2	0-9	0-59	0-9	30,40,50	29959	130197	1.1915E+00
3	0-9	0-59	0-9	60	25730	42664	2.8798E-01
4	0-9	0-59	10-499		17557	519464	1.6326E+00
5	0-9	60-499	0-9		3560	126227	1.6311E-02
6	0-9	60-499	10-499		1644	3513588	9.6823E-02
7	10-99	0-59	0-9		3896	292119	4.5209E-02
8	10-99	0-59	10-499		693	50986117	2.4966E-01
9	10-99	60-499	0-9		683	949979	4.5183E-03
10	10-99	60-499	10-499		247	1356992	8.4410E-04
11		500+			488	9319528	2.2629E-02
12	100+				407	105286843	1.7782E-01
13			500+		335	42367177	4.8478E-02
14	Cattle 1500+				7	27042041	1.3510E-05
15	Sheep 40+				65	131836	5.6792E-06
16	HFLA 3,000+				26	64190612	4.4243E-04

Table A-18. Tennessee 1984 ISP:
Second Phase Soybean Stocks Variance Model

Total= 1944722

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	229138	5.3828E+02
1	0-9	0-59	0-9	10,20	8960	86158	1.8289E+00
2	0-9	0-59	0-9	30,40,50	29959	23665	5.6162E+00
3	0-9	0-59	0-9	60	25730	22751	3.9826E+00
4	0-9	0-59	10-499		17557	42504	3.4643E+00
5	0-9	60-499	0-9		3560	34301	1.1495E-01
6	0-9	60-499	10-499		1644	35769	2.5562E-02
7	10-99	0-59	0-9		3896	37108	1.4893E-01
8	10-99	0-59	10-499		693	963587	1.2236E-01
9	10-99	60-499	0-9		683	161261	1.9891E-02
10	10-99	60-499	10-499		247	0	0.0000E+00
11		500+			488	30172234	1.8999E+00
12	100+				407	450807	1.9745E-02
13			500+		335	896359	2.6598E-02
14	Cattle 1500+				7	0	0.0000E+00
15	Sheep 40+				65	21094	2.3565E-05
16	HFLA 3,000+				26	48979592	8.7548E-03

Table A-19. Tennessee 1984 ISP:
Second Phase Winter Wheat Intentions Variance Model

Total= 248148

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	378.2	5.4567E+01
1	0-9	0-59	0-9	10,20	8960	118.3	1.5423E-01
2	0-9	0-59	0-9	30,40,50	29959	128.4	1.8715E+00
3	0-9	0-59	0-9	60	25730	39.4	4.2360E-01
4	0-9	0-59	10-499		17557	311.8	1.5608E+00
5	0-9	60-499	0-9		3560	569.3	1.1717E-01
6	0-9	60-499	10-499		1644	449.8	1.9742E-02
7	10-99	0-59	0-9		3896	277.7	6.8453E-02
8	10-99	0-59	10-499		693	2392.0	1.8655E-02
9	10-99	60-499	0-9		683	2825.0	2.1401E-02
10	10-99	60-499	10-499		247	551.3	5.4621E-04
11		500+			488	12330.6	4.7687E-02
12	100+				407	14543.3	3.9123E-02
13			500+		335	4350.1	7.9281E-03
14	Cattle 1500+				7	22984.8	1.8290E-05
15	Sheep 40+				65	43.8	3.0052E-06
16	HPLA 3,000+				26	991.8	1.0888E-05

Table A-20. Tennessee 1984 ISP:
First Phase Corn Acres Planted Variance Model

Total= 486453

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	822.3	3.0873E+01
1	0-9	0-59	0-9	10,20	8960	322.2	1.0931E-01
2	0-9	0-59	0-9	30,40,50	29959	98.9	3.7512E-01
3	0-9	0-59	0-9	60	25730	14.0	3.9167E-02
4	0-9	0-59	10-499		17557	948.1	1.2350E+00
5	0-9	60-499	0-9		3560	608.5	3.2590E-02
6	0-9	60-499	10-499		1644	1049.5	1.1987E-02
7	10-99	0-59	0-9		3896	1039.0	6.6646E-02
8	10-99	0-59	10-499		693	6399.0	1.2987E-02
9	10-99	60-499	0-9		683	4374.6	8.6238E-03
10	10-99	60-499	10-499		247	4419.5	1.1394E-03
11		500+			488	13891.4	1.3980E-02
12	100+				407	17543.9	1.2281E-02
13			500+		335	31357.4	1.4871E-02
14	Cattle 1500+				7	23554.8	4.8775E-06
15	Sheep 40+				65	8.4	1.4998E-07
16	HPLA 3,000+				26	10256.8	2.9301E-05

Table A-21. Tennessee 1984 ISF:
First Phase Soybean Acres Planted Variance Model

Total= 1054641

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	5910	4.7207E+01
1	0-9	0-59	0-9	10,20	8960	13004	9.3861E-01
2	0-9	0-59	0-9	30,40,50	29959	272	2.1949E-01
3	0-9	0-59	0-9	60	25730	97	5.7735E-02
4	0-9	0-59	10-499		17557	2838	7.8651E-01
5	0-9	60-499	0-9		3560	13588	1.5483E-01
6	0-9	60-499	10-499		1644	2517	6.1161E-03
7	10-99	0-59	0-9		3896	3362	4.5880E-02
8	10-99	0-59	10-499		693	5860	2.5302E-03
9	10-99	60-499	0-9		683	19867	8.3323E-03
10	10-99	60-499	10-499		247	3949	2.1661E-04
11		500+			488	259386	5.5536E-02
12	100+				407	10061	1.4984E-03
13			500+		335	90565	9.1378E-03
14	Cattle 1500+				7	61101	2.6918E-06
15	Sheep 40+				65	0	0.0000E+00
16	HFLA 3,000+				26	122449	7.4421E-05

Table A-22. Tennessee 1984 ISF:
First Phase Cotton Acres Planted Variance Model

Total= 183339

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	1202.0	3.1770E+02
1	0-9	0-59	0-9	10,20	8960	2431.0	5.8062E+00
2	0-9	0-59	0-9	30,40,50	29959	0.0	0.0000E+00
3	0-9	0-59	0-9	60	25730	0.0	0.0000E+00
4	0-9	0-59	10-499		17557	117.0	1.0729E+00
5	0-9	60-499	0-9		3560	6994.0	2.6370E+00
6	0-9	60-499	10-499		1644	18.0	1.4473E-03
7	10-99	0-59	0-9		3896	0.0	0.0000E+00
8	10-99	0-59	10-499		693	0.0	0.0000E+00
9	10-99	60-499	0-9		683	217.0	3.0116E-03
10	10-99	60-499	10-499		247	0.0	0.0000E+00
11		500+			488	109657.0	7.7690E-01
12	100+				407	0.0	0.0000E+00
13			500+		335	7424.0	2.4787E-02
14	Cattle 1500+				7	0.0	0.0000E+00
15	Sheep 40+				65	0.0	0.0000E+00
16	HFLA 3,000+				26	0.0	0.0000E+00

Table A-23. Tennessee 1984 ISF:
First Phase Tobacco Acres Planted Variance Model

Total= 41439.8

Stratum	Boundaries				Pop Size	S-sq	Expansion Component
	Dairy	Land	Hogs	CRD			
	All Strata				94257	2.333	1.2070E+01
1	0-9	0-59	0-9	10,20	8960	0.726	3.3940E-02
2	0-9	0-59	0-9	30,40,50	29959	1.417	7.4061E-01
3	0-9	0-59	0-9	60	25730	1.424	5.4898E-01
4	0-9	0-59	10-499		17557	3.136	5.6291E-01
5	0-9	60-499	0-9		3560	5.448	4.0207E-02
6	0-9	60-499	10-499		1644	6.115	9.6242E-03
7	10-99	0-59	0-9		3896	4.784	4.2286E-02
8	10-99	0-59	10-499		693	1.540	4.3068E-04
9	10-99	60-499	0-9		683	8.469	2.3006E-03
10	10-99	60-499	10-499		247	22.414	7.9630E-04
11		500+			488	4.762	6.6038E-04
12	100+				407	25.199	2.4307E-03
13			500+		335	2.564	1.6756E-04
14	Cattle 1500+				7	158.694	4.5282E-06
15	Sheep 40+				65	8.499	2.0910E-05
16	HPLA 3,000+				26	11.602	4.5671E-06

Table A-24. Tennessee 1984 ISF:
First Phase Hay Acres Planted Variance Model

Total= 884511

Stratum	Boundaries				Pop Size	S-sq	Expansion Component
	Dairy	Land	Hogs	CRD			
	All Strata				94257	691.7	7.8549E+00
1	0-9	0-59	0-9	10,20	8960	285.3	2.9276E-02
2	0-9	0-59	0-9	30,40,50	29959	323.3	3.7090E-01
3	0-9	0-59	0-9	60	25730	374.1	3.1656E-01
4	0-9	0-59	10-499		17557	666.3	2.6252E-01
5	0-9	60-499	0-9		3560	1868.9	3.0275E-02
6	0-9	60-499	10-499		1644	804.0	2.7775E-03
7	10-99	0-59	0-9		3896	2137.1	4.1463E-02
8	10-99	0-59	10-499		693	747.7	4.5897E-04
9	10-99	60-499	0-9		683	1815.8	1.0827E-03
10	10-99	60-499	10-499		247	1201.4	9.3686E-05
11		500+			488	4250.5	1.2938E-03
12	100+				407	6546.4	1.3861E-03
13			500+		335	1893.9	2.7167E-04
14	Cattle 1500+				7	84373.6	5.2844E-06
15	Sheep 40+				65	556.2	3.0037E-06
16	HPLA 3,000+				26	9113.0	7.8741E-06

Table A-25. Tennessee 1984 ISP:
First Phase Cattle Variance Model

Total= 1634832

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	2359	7.8417E+00
1	0-9	0-59	0-9	10,20	8960	1105	3.3192E-02
2	0-9	0-59	0-9	30,40,50	29959	1218	4.0903E-01
3	0-9	0-59	0-9	60	25730	803	1.9891E-01
4	0-9	0-59	10-499		17557	1071	1.2352E-01
5	0-9	60-499	0-9		3560	6619	3.1387E-02
6	0-9	60-499	10-499		1644	3012	3.0459E-03
7	10-99	0-59	0-9		3896	5099	2.8959E-02
8	10-99	0-59	10-499		693	2959	5.3170E-04
9	10-99	60-499	0-9		683	7475	1.3047E-03
10	10-99	60-499	10-499		247	1427	3.2574E-05
11		500+			488	6261	5.5788E-04
12	100+				407	45771	2.8368E-03
13			500+		335	6672	2.8016E-04
14	Cattle 1500+				7	704232	1.2911E-05
15	Sheep 40+				65	665	1.0512E-06
16	HPLA 3,000+				26	24593	6.2203E-06

Table A-26. Tennessee 1984 ISP:
First Phase Dairy Cattle Variance Model

Total= 198946

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	243.0	5.4546E+01
1	0-9	0-59	0-9	10,20	8960	0.6	1.2170E-03
2	0-9	0-59	0-9	30,40,50	29959	14.9	3.3789E-01
3	0-9	0-59	0-9	60	25730	1.4	2.3417E-02
4	0-9	0-59	10-499		17557	3.0	2.3364E-02
5	0-9	60-499	0-9		3560	7.9	2.5296E-03
6	0-9	60-499	10-499		1644	17.5	1.1950E-03
7	10-99	0-59	0-9		3896	1141.6	4.3781E-01
8	10-99	0-59	10-499		693	1177.0	1.4281E-02
9	10-99	60-499	0-9		683	1035.0	1.2199E-02
10	10-99	60-499	10-499		247	815.0	1.2563E-03
11		500+			488	918.0	5.5235E-03
12	100+				407	12214.8	5.1122E-02
13			500+		335	1172.2	3.3237E-03
14	Cattle 1500+				7	195.9	2.4253E-07
15	Sheep 40+				65	0.2	2.1349E-08
16	HPLA 3,000+				26	4145.6	7.0805E-05

Table A-27. Tennessee 1984 ISP:
First Phase Hog Variance Model

Total= 707170

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	9330.0	1.6575E+02
1	0-9	0-59	0-9	10,20	8960	553.0	8.8776E-02
2	0-9	0-59	0-9	30,40,50	29959	64.0	1.1486E-01
3	0-9	0-59	0-9	60	25730	3.0	3.9715E-03
4	0-9	0-59	10-499		17557	6516.0	4.0164E+00
5	0-9	60-499	0-9		3560	131.0	3.3199E-03
6	0-9	60-499	10-499		1644	4744.0	2.5639E-02
7	10-99	0-59	0-9		3896	3.0	9.1057E-05
8	10-99	0-59	10-499		693	47531.0	4.5645E-02
9	10-99	60-499	0-9		683	13144.0	1.2261E-02
10	10-99	60-499	10-499		247	5567.0	6.7915E-04
11		500+			488	3959.0	1.8853E-03
12	100+				407	243676.0	8.0715E-02
13			500+		335	1222132.0	2.7426E-01
14	Cattle 1500+				7	0.0	0.0000E+00
15	Sheep 40+				65	2129.0	1.7987E-05
16	HPLA 3,000+				26	341.0	4.6095E-07

Table A-28. Tennessee 1984 ISP:
First Phase Corn Stocks Variance Model

Total= 3037803

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	222257	2.1398E+02
1	0-9	0-59	0-9	10,20	8960	73782	6.4187E-01
2	0-9	0-59	0-9	30,40,50	29959	284502	2.7671E+01
3	0-9	0-59	0-9	60	25730	2854	2.0475E-01
4	0-9	0-59	10-499		17557	17965	6.0008E-01
5	0-9	60-499	0-9		3560	23132	3.1768E-02
6	0-9	60-499	10-499		1644	84366	2.4709E-02
7	10-99	0-59	0-9		3896	1695878	2.7894E+00
8	10-99	0-59	10-499		693	1300779	6.7694E-02
9	10-99	60-499	0-9		683	139387	7.0460E-03
10	10-99	60-499	10-499		247	4550055	3.0081E-02
11		500+			488	457442	1.1805E-02
12	100+				407	2760587	4.9553E-02
13			500+		335	3555984	4.3244E-02
14	Cattle 1500+				7	0	0.0000E+00
15	Sheep 40+				65	53	2.4265E-08
16	HPLA 3,000+				26	0	0.0000E+00

Table A-29. Tennessee 1984 ISP:
First Phase Soybean Stocks Variance Model

Total= 874331

Stratum	Boundaries: Dairy	Land	Hogs	CRD	Pop Size	S-sq	Expansion Component
	All Strata				94257	42611	4.9522E+02
1	0-9	0-59	0-9	10,20	8960	11813	1.2406E+00
2	0-9	0-59	0-9	30,40,50	29959	51514	6.0482E+01
3	0-9	0-59	0-9	60	25730	13336	1.1549E+01
4	0-9	0-59	10-499		17557	14445	5.8246E+00
5	0-9	60-499	0-9		3560	98066	1.6258E+00
6	0-9	60-499	10-499		1644	5084	1.7975E-02
7	10-99	0-59	0-9		3896	0	0.0000E+00
8	10-99	0-59	10-499		693	58783	3.6929E-02
9	10-99	60-499	0-9		683	183187	1.1179E-01
10	10-99	60-499	10-499		247	0	0.0000E+00
11		500+			488	498836	1.5540E-01
12	100+				407	208368	4.5151E-02
13			500+		335	39170	5.7503E-03
14	Cattle 1500+				7	0	0.0000E+00
15	Sheep 40+				65	0	0.0000E+00
16	HPLA 3,000+				26	27551020	2.4363E-02