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Ranking States for Area Frame Development

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ABSTRACT

The National Agricultural Statistics Service has area sampling frames in every State except Alaska. Five objective criteria were used to construct a selection index for prioritizing 26 States for new frame development. The 15 top-ranked States were examined for the age and availability of stratification and sampling materials. Louisiana and Alabama were chosen for implementation of new frames in June 1991.

KEY WORDS: area frame sampling, selection index, stratification

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CONTENTS

SUMMARY

The National Agricultural Statistics Service (NASS) has area sampling frames covering every State except Alaska. Frames have been replaced since 1974 to shift from systematic to replicated sampling designs. In this analysis, the "statistical age" of each frame was measured by examining its properties and capabilities. The States were ranked for frame replacement in an analytical, documented process.

Five criteria were used to rank 26 States which were eligible for new frame implementation in 1991. Frames now in development will be implemented in 1989 and 1990. The five criteria were:

1. Change in the relative precision of the estimates of major commodities;
2. Nonoverlap contribution to the multiple frame estimates and variances;
3. Sample size from a multivariate optimum allocation performed at the national level;
4. Percentage of segments not meeting their original strata definitions;
5. Agricultural receipts of each State.

The five criteria were ranked separately, weights were applied to the ranks to construct a selection index, and the final selection index values were ranked. The 15 top-ranked States were Oklahoma, Louisiana, Arkansas, Texas, Georgia, Ohio, Alabama, Pennsylvania, Illinois, Tennessee, Virginia, Mississippi, Kansas, South Carolina, and Minnesota.

Based on the selection index rank and the availability of current satellite imagery and aerial photography, Louisiana and Alabama will have new frames implemented in June 1991. The other 13 top-ranked States will be evaluated for availability of materials prior to completion of Alabama's frame. This analysis should be repeated within 4 years to order the next set of States.

RANKING STATES FOR AREA FRAME DEVELOPMENT

By Ralph V. Matthews

INTRODUCTION

The National Agricultural Statistics Service (NASS) conducts surveys based on area frame sampling in all States except Alaska. The surveys are conducted to estimate crop and livestock production, farm costs and returns, and farm labor use. Area sampling frames are replaced in two or three States each year. Construction of a new frame costs $150,000 in a typical State with labor comprising 75 percent of the cost [2].

Since 1974, frames with systematic sampling designs have been replaced with frames having replicated sampling designs [3]. The frames in the corn-belt States were replaced in the mid 1970's, followed by the southeastern States in the late 1970's and the States west of the Rocky Mountains in the early 1980's. New frames in 1989 for West Virginia and the New England States will complete this process.

This analysis was undertaken to prioritize objectively the States which will have new area sampling frames implemented from 1991 through 1995. Objective decisions about frame replacement are in keeping with the formation of the Statistical Standards Staff (SSS) in October 1986. Selection of States for frame development was identified as an activity requiring better documentation [1]. The current analysis provides objective criteria for deciding when to replace a frame.

METHODS

The implementation year of the NASS area sampling frames is shown in table 1. A decision was made when the analysis began in January 1988 that frames implemented in 1983 or later would not be considered for replacement. Data from five surveys was not considered adequate to track changes in the frames. States which are under development or planned for development and implementation through 1990 were also not considered. The 26 frames implemented from 1974 through 1982 were evaluated.

The method of ranking the States involved five indications of a State's need for a new frame. For each of the five criteria, the State most in need of a new frame received a rank of 1. The five sets of ranks were then combined into a selection index by weighting each factor's ranks, and a rank of 1 indicated the State with the greatest need for a new frame. Top-ranked States were compared for age and availability of stratification and sampling materials to make a work plan covering the last half of 1989.

Table 1 -- Implementation year of current and planned area sampling frames; States in bold type are candidates for new frames in 1991

State	Year	State	Year
ALA	**1978**	NEBR	1983
ARIZ	1984	NEV	1987
ARK	**1974**	N H	1989
CALIF	**1979**	N J	1987
COLO	1984	N MEX	1985
CONN	1989	**N Y**	**1979**
DEL	1986	**N C**	**1978**
FLA	1983	**N DAK**	**1977**
GA	**1979**	**OHIO**	**1975**
HAW[1]	1976	**OKLA**	**1974**
IDAHO	**1982**	**OREG**	**1980**
ILL	**1975**	**PA**	**1981**
IND	**1976**	R I	1989
IOWA	1990	**S C**	**1979**
KANS	**1975**	**S DAK**	**1976**
KY	**1977**	**TENN**	**1977**
LA	**1978**	**TEX**	**1982**
MAINE	1989	UTAH	1988
MD	1986	VT	1989
MASS	1989	**VA**	**1978**
MICH	1990	**WASH**	**1980**
MINN	**1975**	W VA	1989
MISS	**1978**	**WIS**	**1977**
MO	1988	WYO	1985
MONT	1986		

[1] Frame used for labor surveys only

The first question for evaluating the frames was, "How has the relative precision changed over the life of the frame?" The June Agricultural Survey (JAS) coefficients of variation (CV's) for the acreage of the top three crops and land in farms were examined in years 2, 3, and 4 of the frame's use versus 1985, 1986, and 1987. Starting with the second year avoided data collection problems in the first year and allowed for any sample reallocation that occurred after the first year. The average CV for the four variables in the three early years was compared with the average CV for the four variables in the three latest years, and a percentage change was calculated. An increase in the average CV indicated a frame more in need of replacement than a frame in which the average CV decreased.

The second question for examining the frames was, "How important was the area sampling frame for each State's multiple frame estimates?" Two Agency publications [4,5] presented the area frame's percentage nonoverlap contribution to the multiple frame estimates of the JAS. This was the portion of the multiple frame estimates found only by area frame sampling. The nonoverlap percent of the multiple frame variance was also calculated. The variables for 1986 were land in farms and number of farms. These two, along with cattle and calves, hogs and pigs, total cropland, and grain storage capacity were published for 1987. The percent contributions to the eight estimates and eight variances were averaged to show the reliance of the State on the area sampling frame for its nonoverlap capability. Although the nonoverlap contribution indicates more about the quality of the list frame than the area frame, a State with a high nonoverlap contribution should receive more consideration for a new area frame, because the State relies on it more.

The third question for evaluation of the frames was, "How important is the State to the national survey program?" To evaluate this, an alternative national optimum allocation based on 1987 JAS area data was examined [6]. Although this allocation was not in use operationally, it indicated the relative importance of each State. The allocation was designed for moderate improvement in the CV's of the nonoverlap portion of the multiple frame estimates. This multivariate allocation was based on two livestock, seven crop acreage, and two grain stock variables. A modification was made to the original analysis [6] to have a maximum of 1,200 segments and a minimum of 250 segments per State.

The fourth question for ranking the frames was, "What percent of a State's segments did not meet the original strata definitions?" This factor is considered routinely before stratification begins in new frame construction [7]. Ideally, the percentage would be very low, but acceptable estimates can result if it is not. The percentage was calculated using 1987 JAS area data, and the higher the percentage of segments not meeting the strata definitions, the more a State may need a new area sampling frame. Data from a single survey were deemed sufficient, because 80 percent of the sample does not change from year to year.

The fifth question for examining the frames was, "How important is a State's agriculture relative to other States?" To evaluate this, the cash receipts from livestock, crops, and government payments were averaged for 1985 and 1986 [8,9]. A ranking of the States with respect to this variable showed which State was the most important agriculturally.

The five variables were analyzed and ranked. After consultation with other statisticians of the Area Frame Section, selection index weights were chosen. A selection index was constructed by assigning weights to each variable's ranks and summing to a single index value for each State.

The average change in CV's was judged the most important variable, because change was measured over the years of the frame's use. The other four variables, based on the most recent one or two years of data, compared the frames as they are now in use. The cash receipts variable was given the lowest weight, since it is not a statistical measure of the frame's effectiveness. The nonconforming segment percentage was also given the lowest weight, because it is biased against regions with more heterogeneous land. The nonoverlap percentage contribution and the optimum allocation figures were given intermediate weights which reflected their importance relative to the other variables.

The selection index weights are shown in table 2. Two alternative sets of weights were constructed to ensure that the data and not the weights led to the final priorities. The alternatives had a 50 percent decrease or increase in the weight assigned to the average change in CV's. The difference was distributed equally among the other four weights. The first alternative put approximately equal weight on each variable's ranks, and the second alternative placed minimal weight on all but the change in CV's variable.

Table 2 -- The weights assigned to each variable's ranks in three selection indexes

Variable	Selection index weight	Lower CV weight	Higher CV weight
Average change in CV's	.40	.20	.60
Average NOL contribution	.20	.25	.15
Optimum allocation	.20	.25	.15
Nonconforming segments	.10	.15	.05
Cash receipts	.10	.15	.05

RESULTS

To evaluate the change in CV's during the frame's use, the top three acreage crops in table 3 were examined together with land in farms.

Table 3 -- Each State's three highest acreage crops, 1986 JAS area results

State	Crop 1	Crop 2	Crop 3
ALA	soybeans	corn	winter wheat
ARK	soybeans	long grain rice	winter wheat
CALIF	upland cotton	winter wheat	corn
GA	soybeans	corn	winter wheat
IDAHO	barley	winter wheat	spring wheat
ILL	corn	soybeans	winter wheat
IND	corn	soybeans	winter wheat
KANS	winter wheat	sorghum	soybeans
KY	corn	soybeans	winter wheat
LA	soybeans	upland cotton	long grain rice
MINN	corn	soybeans	spring wheat
MISS	soybeans	upland cotton	winter wheat
N Y	corn	winter wheat	potatoes
N C	soybeans	corn	winter wheat
N DAK	spring wheat	barley	durum wheat
OHIO	corn	soybeans	winter wheat
OKLA	winter wheat	sorghum	upland cotton
OREG	winter wheat	barley	spring wheat
PA	corn	winter wheat	soybeans
S C	soybeans	corn	winter wheat
S DAK	corn	spring wheat	winter wheat
TENN	soybeans	corn	winter wheat
TEX	winter wheat	upland cotton	sorghum
VA	corn	soybeans	winter wheat
WASH	winter wheat	barley	spring wheat
WIS	corn	soybeans	winter wheat

Table 4 contains the percentage change in the average of the CV's for the three crops and land in farms from years 2, 3, and 4 of the frame's use versus the average from 1985, 1986, and 1987. Since the Idaho and Texas frames were first used in 1982, the average from 1983 and 1984 was compared with the average of 1986 and 1987.

Table 4 -- Average change in JAS area CV's for top three acreage crops and land in farms

State	Average CV change (%)
OKLA	52.4
LA	48.6
ARK	38.8
GA	32.2
TENN	20.2
ILL	17.9
VA	17.2
OHIO	16.8
ALA	14.6
PA	13.4
KY	12.5
MINN	10.4
N C	8.3
TEX[1]	6.4
S C	4.9
KANS	3.7
IDAHO[1]	2.1
MISS	1.3
S DAK	1.0
IND	-1.8
WIS	-2.0
WASH	-2.7
N Y	-3.6
CALIF	-7.8
OREG	-12.9
N DAK	-13.9

[1] 1983,1984 vs. 1986,1987

Six of the top 10 States in table 4 were from the South. The average change in the CV's was greater than 30 percent in Oklahoma, Louisiana, Arkansas, and Georgia. In 15 other States the CV's increased. In seven States, the average change in the CV's was negative, and the relative precision improved during the frame's use. This variable alone would indicate that the 12 States with changes of less than 5 percent would not be candidates for new frames.

The second variable was the nonoverlap contribution to the JAS multiple frame estimates and variances. Table 5 shows that Louisiana was in a class of its own with a nonoverlap contribution of nearly 70 percent. A new area frame will not reduce the nonoverlap contribution, because the quality of the list frame is the determining factor. Nevertheless, the States which exceeded a 50 percent nonoverlap contribution warrant more consideration for area frame replacement than the States with less than a 20 percent nonoverlap contribution.

Table 5 -- Average nonoverlap contribution to the JAS multiple frame estimates and variances in 1986 (2 variables) and 1987 (6 variables)

State	Avg. NOL contribution (%)
LA	69.9
S C	54.2
WASH	50.5
MISS	48.5
OKLA	47.3
TEX	46.2
ALA	45.3
VA	43.5
PA	41.8
CALIF	40.6
GA	39.9
OHIO	39.7
IDAHO	38.3
TENN	36.4
ARK	36.0
N Y	36.0
OREG	34.2
N C	33.4
WIS	32.6
KY	32.4
IND	29.9
MINN	28.4
ILL	21.5
KANS	20.9
N DAK	19.8
S DAK	19.4

Table 6 has the alternative national optimum sample allocation based on the 1987 JAS area nonoverlap domain results. A maximum and minimum number of segments were set arbitrarily which differed from the original analysis [6]. Kansas, Texas, and Oklahoma were in a class of their own and were substantially greater than the other 23 States.

Table 6 -- Number of segments per State in an alternative national optimum sample allocation, 1987 JAS area results

State	Segments
KANS	1,200
TEX	1,200
OKLA	855
MISS	620
CALIF	560
OHIO	550
S DAK	540
ARK	540
WASH	530
LA	460
MINN	440
GA	395
IDAHO	395
ILL	380
OREG	375
IND	370
VA	295
S C	290
ALA	290
TENN	280
N Y	250
PA	250
WIS	250
N C	250
N DAK	250
KY	250

NOTE: The 1,200 maximum and 250 minimum differ from the original analysis [6]

Table 7 contains each State's percentage of segments not meeting the sampling frame strata definitions. The 1987 JAS area results showed that in New York and South Dakota more than 50 percent of the segments did not meet the strata definitions. In all 26 States, the figure exceeded 24 percent.

Table 7 -- Percent of segments not conforming to each State's area sampling frame strata definitions, 1987 JAS area results

State	Nonconforming segments (%)
N Y	52.3
S DAK	51.0
PA	46.3
OKLA	44.0
KANS	41.0
S C	40.9
ALA	40.0
WIS	38.8
TENN	38.7
LA	37.4
TEX	37.1
ARK	36.1
OHIO	35.8
GA	35.7
MISS	35.2
ILL	35.0
N C	34.9
IND	33.9
VA	33.6
MINN	32.9
N DAK	31.8
KY	30.2
OREG	28.0
WASH	27.5
CALIF	25.5
IDAHO	24.2

Table 8 shows the average cash receipts from 1985 and 1986. The $4 billion figure divided the group of 26 States after rank 7. The top seven States were California, Texas, and five midwestern States.

Table 8 -- Average cash receipts from livestock, crops, and government payments, 1985 and 1986

State	Cash receipts ($ billion)
CALIF	14.35
TEX	9.78
ILL	8.01
MINN	6.91
KANS	6.26
WIS	5.29
IND	4.67
OHIO	3.98
N C	3.91
ARK	3.47
GA	3.36
PA	3.19
N DAK	3.11
S DAK	3.03
WASH	3.02
OKLA	2.96
KY	2.74
N Y	2.61
IDAHO	2.17
MISS	2.16
ALA	2.11
TENN	2.07
OREG	1.88
VA	1.65
LA	1.55
S C	1.01

Table 9 contains the rankings for the variables in tables 4 through 8. A number 1 ranking indicates the frame most in need of replacement for each variable. For example, Oklahoma's average CV change of 52.4 percent ranked number 1 in table 4. The ranks in table 9 were multiplied by the weighting factors to construct the selection index and its two alternatives. Table 9 facilitates comparisons between the ranking of an individual variable and the ranking of the selection index values.

Table 9 -- Rankings of five input variables for a selection index to prioritize States for area sampling frame development

State	Avg.CV change	Avg.NOL contrib.	Alternative allocation	Nonconforming segments	Cash receipts
	ranks				
ALA	9	7	18	7	21
ARK	3	15	7	12	10
CALIF	24	10	5	25	1
GA	4	11	12	14	11
IDAHO	17	13	12	26	19
ILL	6	23	14	16	3
IND	20	21	16	18	7
KANS	16	24	1	5	5
KY	11	20	21	22	17
LA	2	1	10	10	25
MINN	12	22	11	20	4
MISS	18	4	4	15	20
N Y	23	15	21	1	18
N C	13	18	21	17	9
N DAK	26	25	21	21	13
OHIO	8	12	6	13	8
OKLA	1	5	3	4	16
OREG	25	17	15	23	23
PA	10	9	21	3	12
S C	15	2	18	6	26
S DAK	19	26	7	2	14
TENN	5	14	20	9	22
TEX	14	6	1	11	2
VA	7	8	17	19	24
WASH	22	3	9	24	15
WIS	21	19	21	8	6

Table 10 contains the ranks for the selection index and its two alternatives. Based on the actual selection index values, a top-ranked group of 15 States was identified for further evaluation. The robustness of the selection index weights was evident, because each State had similar ranking for the three sets of weights. This occurred when the variables were weighted approximately equally and when the change in CV's variable was dominant.

Table 10 -- Selection index values to prioritize States for area sampling frame development

State	Selection index	Lower CV weight ranks	Higher CV weight
ALA	7	10	10
ARK	3	5	3
CALIF	17	11	21
GA	5	6	4
IDAHO	20	21	18
ILL	9	14	7
IND	23	23	22
KANS	13	8	15
KY	21	24	16
LA	2	3	2
MINN	15	17	12
MISS	12	7	14
N Y	24	22	24
N C	18	19	17
N DAK	26	26	26
OHIO	6	4	5
OKLA	1	1	1
OREG	25	25	25
PA	8	9	11
S C	14	12	13
S DAK	19	18	20
TENN	10	16	6
TEX	4	2	7
VA	11	15	7
WASH	16	13	19
WIS	22	20	23

The selection index rankings were most like the rankings for the change in CV's variable. Oklahoma, Louisiana, and Arkansas were ranked in the same order by both methods. Although Texas ranked 14 for changes in CV's, rankings of 1 for the optimum allocation and 2 for agricultural receipts raised it to a rank of 4 for the selection index. Tennessee and Illinois ranked 5 and 6, respectively, for the changes in CV's variable, but low rankings for the nonoverlap contribution and optimum allocation variables caused them to drop 5 (Tennessee) and 3 (Illinois) positions in the selection index ranking.

In table 11, the top-ranked group of 15 States is presented with rankings based on availability of current satellite images, aerial photographs, and topographic maps. Based on the two rankings, Louisiana and Alabama will receive new frames in 1991. When Alabama's frame construction is underway, the availability of materials will be updated.

Table 11 -- Fifteen States with highest selection index ranks and ranks based on availability of current stratification materials

State	Selection index rank	Materials rank
OKLA	1	13
LA	2	4
ARK	3	11
TEX	4	14
GA	5	10
OHIO	6	12
ALA	7	2
PA	8	8
ILL	9	9
TENN	10	7
VA	11	6
MISS	12	3
KANS	13	1
S C	14	5
MINN	15	15

Table 12 shows one result of the objective ranking process. These frames are at least 10 years old, but frame replacement will not be considered at this time. Chronologic age would have dictated that these States be considered, but the statistical measures in this analysis showed that the frames were performing satisfactorily and should not be replaced.

Table 12 -- States with area sampling frames at least 10 years old and their selection index ranks

State	Age (years)	Selection index rank
IND	12	22
KY	11	21
N C	10	19
N DAK	11	26
S DAK	12	18
WIS	11	23

CONCLUSIONS

This analysis ranked 26 States with objective criteria to determine the order in which States receive new area sampling frames. Data were drawn from published Agency estimates, publications, and research reports. Fifteen top-ranked States were then evaluated for availability of current stratification materials. Louisiana and Alabama will be the first two States to receive new frames as a result of this analysis.

Satellite and photographic coverage for the other 13 top-ranked States should be evaluated prior to completion of Alabama's frame to identify the next States for which to construct frames.

In 4 year's time, 10 new frames can be constructed. Prior to completing 10 new frames, this analysis should be repeated on the eligible States to plan the next sequence of frame construction.

RECOMMENDATIONS

Implement new frames for Louisiana and Alabama in 1991.

Select the States to follow Alabama using the selection index ranks and the updated ranks on the availability of satellite and photographic coverage.

Incorporate the variables in this analysis in the Area Frame database to allow more efficient examination of changes that occur during the frame's use.

Repeat this analysis within 4 years to prioritize the next set of States.

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