Agricultural Statistics

FEDERAL AGRICULTURAL STATISTICS--
STATUS, IMPROVEMENT AND THOSE ON THE HORIZON

Introduction

The Statistical Reporting Service (SRS) and the Bureau of the Census have many parallel requirements such as sampling frames, data needs, survey capabilities, statistical techniques and staff resources for conducting their respective agricultural statistics programs. Many are often cited incorrectly as total duplications of effort. The SRS program centers around many sample surveys for currently reporting the potential or realized production, supply, price and other characteristics of the agricultural economy. It issues about 475 reports annually giving State and national estimates of crop acreages, yields and production, livestock inventories and production, stocks and prices of agricultural commodities, value and utilization of farm products and prices paid for production inputs. The entire statistical program centers around small scientifically designed sample surveys that require precise and timely data collection for rigid reference dates that typically precede the announced release data by about two weeks.

The Bureau of the Census conducts the Census of Agriculture, typically at 5-year intervals. This census provides the only periodic comprehensive data about the nation's agriculture at the county level, that covers the entire country. The central focus of the Census of Agriculture is to provide a good historical picture of the changes in American agriculture each five years. These data provide information on farms that can be used for classification of operations based on major types of activity, size, legal form of organization, age of operator, etc. The Census attempts to achieve as complete coverage as possible of all operating units. Most of the data are collected by mail to reduce data collection costs; however, this extends the survey over a six-month period.

The principal overlap in activities is (1) the identical requirement for a general purpose list of farmers' names and addresses that is current and reasonably complete, and (2) the acquiring of data on crop acreage and production, livestock inventories and data on land in farms every fifth year. Both agencies have sought in recent years to minimize overlap to the extent possible within existing legislation and support legislative efforts currently underway that would enhance their ability to expand cooperation.

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THE STATISTICAL REPORTING SERVICE SYSTEM

By William E. Kibler 1/

Basic Sampling Methodologies

During the past two decades the methodology for developing current agricultural statistics on crops, livestock and prices has shifted almost entirely from non-probability mail surveys to probability surveys using area and list sampling frames. With probability surveys, estimates for characteristics of interest can be generated without dependence on prior survey relationships or benchmark data such as the 5-year Census of Agriculture. Such surveys also provide the data necessary to derive sampling errors for evaluating the reliability of estimates generated and for optimizing sample designs and allocation of sampling units.

A basic requirement for any probability survey is a complete sampling frame which is an aggregation of the elements from which a sample can be selected. An area frame is the principal frame used for estimating major crop acreages, yields and production. This frame is made up of small geographic units of land called "segments" which may be sampled. It is constructed using the most current aerial photography available to classify (stratify) all land according to its current use./1/ The stratification is based on extent and type of farming and can be described in four broad categories: (1) intensively cultivated areas where a significant portion of the land is under cultivation, (2) extensive agricultural areas used primarily for grazing and producing livestock, (3) highly developed land found in city residential shipping and industrial areas, and (4) non-agricultural land such as parks, military reservations and other recreational areas./2/

As frames for individual States are periodically updated, by using additional materials such as satellite imagery, more sophisticated stratification procedures have been used. Examples include the addition of an agri-urban stratum which is used as a transition zone between the city and agricultural strata. Within the intensive agricultural stratum refinements have been made by including additional information such as soil type and topography to develop crop-specific strata. For example, a fruit/vegetable stratum in California, a dry land wheat stratum in Oregon and Washington, and rice, peanuts, wheat/sorghum, and cotton strata in Texas. Geographic stratification is sometimes used, in addition to the land use stratification, to separate differing agricultural areas. This is accomplished by grouping counties into type-of-farming districts.

About two decades ago research showed that an optimum size segment should include about two farms and be about one square mile in intensively cultivated areas, several square miles in extensively farmed areas and one-tenth square mile in industrial or urban areas. As additional refinements have been made in both the area sampling frame and sampling methodology over the past decade, segment size has generally been reduced to an average of about .7 square mile for the intensively cultivated strata. In many states .5 square mile segments are used. This, combined with increasingly sophisticated sample designs, has permitted

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significant reductions in data collection costs (up to 30 percent in some States) without adverse impact on the error level of the estimates from the June Enumerative Survey. This has been of primary benefit in helping to cover inflation costs in the absence of increased appropriations.

Two sampling methods are followed in selecting sample segments. A systematic-sample approach is used in some States with the frame units arrayed geographically to ensure proper dispersion over the area of interest. Since 1974 all new samples have used interpenetrating designs to provide flexibility in computing sampling variation and segment rotation.

Crop Sampling Methodology

A sample of 15,700 segments (about 350 per State) representing about 0.4 percent of the universe is selected and enumerated about June 1 to collect data on crops planted and livestock numbers as well as characteristics of farms. Both direct expansion and ratio estimators are used for aggregating sample data to State, regional and national totals. Survey data from each segment are expanded by the reciprocal of the probability of selection (typically a factor of about 250) to obtain the direct expansion estimate. A ratio estimate is also computed using current and previous years' data since about 80 percent of the segments are enumerated in successive years. This estimate is particularly useful in evaluating changes from year to year for identical segments. Sampling errors for acreage planted to major crops are about 2 percent at the national level, 3 to 4 percent at the regional level and 4 to 6 percent at the State level.

Sampling Errors from the 1981 June Enumerative Survey
for Planted Acreages at State, Regional and National Levels

Commodity	National	East North Central Region	Illinois	Mississippi
	- - - P e r c e n t - - -			
Corn	1.2	1.2	2.5	18.7
Soybeans	1.3	1.6	3.0	6.0
W. Wheat	1.6	3.2	6.6	15.6
Cotton	3.3	-	-	10.8
Sorghum	4.3	-	32.9	24.4

Followup objective yield surveys are made for wheat, corn, soybeans and cotton to update planted acres for fields actually planted after June 1, to collect information for forecasting yields during the growing season, and to estimate actual yields at harvest. These surveys provide information based directly on counts, measurements and weights of the crop made from small randomly selected plots in sample fields. Samples are designed to produce estimates of at harvest yield with sampling errors of 1 to 2 percent. Large nonprobability mail surveys are conducted to gather data for strengthening State and sub-State estimates for crops important to the State's agricultural sector and to support cooperative State-Federal programs. Samples for such surveys vary in size from 150,000 to 200,000 and operate fairly effectively for disaggregating accurate annual benchmarks based on probability surveys.

Livestock Multiple Frame Sampling

Multiple frame sampling utilized more than one sampling frame to cover the universe of interest. The theory for multiple frame sampling was first developed in the 1960's. /3/ Its use has rapidly grown because of its distinct advantages in efficiency of costs in data collection and its ease of adaptation for specialized characteristics associated with a small portion of firms in a universe. The theoretical concepts of multiple frame sampling are basically the same as those for probability sampling concerning known probabilities and randomness of selection. In addition, two other characteristics must hold: (1) every element of the population must belong to at least one of the frames, and (2) it must be possible to specifically identify the frame(s) to which, if any, each selected sample unit belongs other than the one from which it was drawn. The use of the area frame as described earlier satisfies the first characteristic. The second characteristic requires the proper classification of each farm operator as to whether his name is included on the list(s) frame(s). Multiple frame sampling technology is used for rice, potatoes, quarterly hog surveys in 14 States, and semi-annual cattle surveys in 28 States.

With multiple frame sampling, data can be collected more efficiently by mail or telephone and more efficient sampling can be accomplished by stratification of the list by size of operation. A variety of list sources such as ASCS, State Farm Censuses, brand inspections, etc., is used in assembling list frames. However, due to rapid organizational and operational changes that occur, lists must be updated periodically to retain their advantages in sampling and cost efficiencies. There are also some complex operating problems associated with identifying and measuring overlap between the two frames (area and list) that increase nonsampling errors. Typical sampling errors for these multiple frame surveys for cattle and hogs are shown in the following table:

Sampling Errors for 1980 and 1981 Based on
Multiple Frame Surveys for Hogs and Cattle
at Various Geographic Levels

Survey	23 State Level	14 State Level	28 State Level	Iowa	Georgia
			Percent		
December 1, 1980 Hogs	2.1	2.3	--	3.5	11.9
June 1, 1981 Hogs	1.8	2.0	--	4.1	9.2
January 1, 1981 Cattle	--	--	1.3	3.6	4.9
July 1, 1980 Cattle	--	--	.8	3.5	6.5

New Probability Surveys for Prices

The area and list sampling frames described earlier are not suited for collecting current information on prices farmers receive for commodities they sell or prices paid for inputs used in production. An indirect method is used to establish these frames and select appropriate samples. For obtaining prices received for grains, a list of all grain and oilseed elevators (about 14,000) is maintained from administrative records, available as a byproduct of licensing requirements. These are stratified by storage capacity and a probability sample of about 1 in 6 selected for surveying. Similar lists for cotton, peanut, and rice buyers serve as frames for these crops.

For commodities such as cattle, hogs, vegetables and fruits, a periodic point of sale survey is conducted to determine what portion of the total production is sold through each marketing channel such as auctions, dealers, commission firms, processors and packers. The universe list of these firms is then stratified by type of marketing channel and sampled using probabilities proportional to the channel's importance in the marketing of the commodity.

Firms sampled are surveyed monthly on about the 15th to collect actual quantities purchased and dollars paid farmers for each commodity during the previous month. These data are used to derive a self-weighted average published as the revised price received for the entire month. In addition, the exact price being paid to farmers about mid-month is obtained and published as the preliminary price as of the 15th of each month. The data on quantities purchased are used by the Economic Research Service (ERS) in estimating current cash receipts for aggregation and calculation of farm income. The typical entire monthly price received for corn has a sampling error of about 3 cents while the error for the aggregated 5-month average used for determining the level of deficiency payments is less than 1 cent.

In collecting data on prices paid for inputs used in commodity production, a periodic point of purchase survey is conducted to ascertain the portion of the various inputs that are bought through cooperatives, brokers or wholesalers, dealers or manufacturers. Lists of firms are assembled from phone directories, licensing bureaus, and the American Business Lists Inc., and classified by specific inputs sold. The listed firms are geographically grouped by counties to form a frame of primary sampling units. For primary sampling units selected to be surveyed, a second stage of sampling is performed to identify the individual firms to be included in the sample. The clustering by counties makes data collection more efficient by reducing travel. Much of the work requires personal interviews for establishing accurate specifications on inputs priced.

Reliability and Completeness of Principal Statistical Series

Many data users have requested that the Crop Reporting Board provide additional information on the sources of data used in establishing official estimates and measures of their reliability since social or economic costs of errors in forecasts can be significant./4/ Beginning in 1977, most major reports have included a general summary of survey procedures, comments about errors from sampling and non-sampling sources and typical sampling errors for surveys or Root Mean Square Errors for forecasts. The following is typical of the summaries provided for livestock reports:

> RELIABILITY AND ESTIMATING PROCEDURES: Primary data used in setting these hog estimates were obtained from a sample of farmers across the U.S. using probability surveys. Information was collected by mail,

telephone and personal interviews. Since all operations raising hogs were not included in the sample, survey estimates are subject to sampling variability. This variability, as measured by the relative standard error, is about two percent at the U.S. level for hog inventory. This means that chances are approximately 95 out of 100 that survey estimates will be within four percent of the complete coverage value if the same procedures were used to survey all producers. Survey estimates are also subject to non-sampling errors such as omissions, duplications, and mistakes in reporting, recording and processing the data. These errors cannot be measured directly, but they are minimized through rigid quality controls in the data collection process and a careful review of all reported data for consistency and reasonableness.

The sampling variability of survey estimates on intended farrowings is slightly larger than that for inventories. More important, actual farrowings may differ significantly from reported intentions due to unexpected economic and environmental conditions. These differences have exceeded four percent for about one-third of the quarterly pig crops during the last seven years.

In setting the inventory estimates, the Crop Reporting Board constructed a U.S. balance sheet using estimates on births, deaths and check data on slaughter, imports and exports. This balance sheet provided an additional check on survey inventory estimates./5/

Some users have commented that these have been useful in analyzing data but the numerical sampling or forecast errors have generally not been used extensively in modeling. In fact, some data users have completely ignored the cautions about intended farrowings and assumed that they will always represent what will occur during the next 6-month period. The table on page 5a illustrates the preliminary estimates for the inventory of all hogs and pigs based on sample survey data and the final estimate that was established after reevaluating all data when slaughter records became available six months later.

If we obtained perfect data collection the sampling errors would indicate that about 2 out of 3 of the estimates would require revisions of less than 2 percent and 19 out of 20 would require revisions of less than 4 percent. For the 20 estimates during this period, 18 required revisions of less than 2 percent and 19 required revisions of less than 4 percent. Hence, the sampling errors are reliable measures of the accuracy of the estimates. The same sample of producers is used to obtain data on farrowing intentions. Hence, the same statistical analysis can be applied to farrowing intentions using the table on page 5b.

These intentions forecasts also have a sampling error of about 2 percent. Note the very large deviations for some 6-month periods cannot be explained by statistical measures such as sampling errors. Thus, these deviations must be associated with either problems in acquiring accurate data on intentions from producers or changes in plans made by producers due to such things as weather, feed cost, market prices, or as a direct result of the published intentions report. Hence, analysts should use these data with much more caution than the inventory data.

Comparison of Preliminary and Final Estimates of U.S. Inventory of all Hogs and Pigs, 1971-1980

Year and Survey	All Hogs and Pigs Inventory		
	Preliminary Estimate Based on Survey	Final Estimate Based on Slaughter	Change
	---- 1,000 Head ----		--Percent--
1971:			
June 1	66,070	65,718	-0.5
December 1	62,972	62,412	-0.9
1972:			
June 1	61,556	60,626	-1.5
December 1	61,502	59,017	-4.0
1973:			
June 1	60,271	59,571	-1.2
December 1	61,022	60,614	-0.7
1974:			
June 1	59,437	58,878	-0.9
December 1	55,062	54,693	-0.7
1975:			
June 1	48,165	47,860	-0.6
December 1	49,602	49,267	-0.7
1976:			
June 1	52,643	53,930	+2.4
December 1	55,085	54,934	-0.3
1977:			
June 1	54,100	54,460	+0.7
December 1	57,587	56,539	-1.8
1978:			
June 1	54,930	55,240	+0.6
December 1	59,860	60,356	+0.8
1979:			
June 1	64,890	65,020	+0.2
December 1	66,950	67,353	+0.6
1980:			
June 1	65,930	65,255	-1.0
December 1	64,520	1/	

1/ Subject to future minor revisions.

Comparison of Farrowing Intentions Forecast and Actual Farrowings That Occurred, U. S. Total, 1971-1980

Year and Period	Intentions Forecast	Actual Estimate	Change
	---- 1,000 Head ----		--Percent--
1971:			
December-May 1/	7,222	7,237	+0.21
June-November	6,265	6,339	+1.18
1972:			
December-May 1/	6,544	6,498	-0.70
June-November	6,005	5,973	-0.53
1973:			
December-May 1/	6,980	6,438	-7.77
June-November	5,979	5,869	-1.84
1974:			
December-May 1/	6,491	6,315	-2.72
June-November	5,760	5,476	-4.94
1975:			
December-May 1/	5,385	4,973	-7.65
June-November	4,730	4,952	+4.02
1976:			
December-May 1/	5,353	5,777	+7.92
June-November	5,811	5,850	+0.67
1977:			
December-May 1/	6,109	6,050	-0.97
June-November	6,144	6,009	-2.20
1978:			
December-May 1/	6,620	6,034	-8.86
June-November	6,247	6,398	+2.42
1979:			
December-May 1/	6,903	7,179	+4.00
June-November	7,419	7,306	-1.53
1980:			
December-May 1/	7,176	7,231	+0.77
June-November	6,716		
1981:			
December-May 1/	6,780 2/		

1/ December previous year.
2/ Latest estimates - subject to future revision.

The SRS has concluded four years' experience in using the Root Mean Square Error (RMSE)/6/ statistic as an indication of the reliability of crop production forecasts made during the growing season. The Root Mean Square Error is calculated on the basis of past forecasting performance. It is derived by averaging the squared deviations between monthly forecasts and the final estimate over a given period. The square root of these averages is the RMSE./7/ The assumptions necessary to make this statistical measure valid are (a) a normally distributed series of forecasts compared to the final estimates, and (b) factors affecting the current year's crop after the forecast date are not greatly different from those influencing crop forecasts during the historic reference period. For crops, 20 years of data are used and a t-value of 1.725 is used to compute the 90 percent interval compared to the normal distribution value of 1.645. Its performance has exceeded expectations as shown in the table on page 6a.

These data show that about 69 percent of the 189 forecasts made during the period have been within the expected 67 percent confidence interval and nearly 98 percent of the forecasts have been within the 90 percent confidence interval. Since the RMSE uses actual performance over a 20-year period to measure reliability, any improvements made in survey systems during recent years should make the measure a bit conservative when evaluating current year forecasts. An attractive concept of the RMSE statistic is that it can be derived well ahead of its expected use. The following table gives the RMSEs that have been or will be used in 1981 crop reports:

Root Mean Square Errors (Percent)
For 1981 Crop Production Forecast

(Derived from 1961-80 Forecasts as published by the Crop Reporting Board)

Crop	May	June	July	August	Sept.	Oct.	Nov.	Dec.
	Percent							
W. Wheat	6.7	5.9	3.4	1.3	--	--	--	8.0
O. Spring Wheat	--	--	10.2	6.7	3.2	3.1	--	--
D. Wheat	--	--	14.5	8.1	5.2	5.3	--	--
All Wheat	--	--	3.4	1.9	1.3	1.3	--	--
Barley	--	--	8.4	4.9	3.5	--	--	--
Oats	--	--	7.6	4.8	4.0	--	--	--
Corn	--	--	9.1	6.8	5.1	3.9	2.6	--
Sorghum	--	--	--	6.4	4.7	4.7	4.4	--
Feed Grains	--	--	--	5.5	4.1	3.1	2.1	--
Soybeans	--	--	--	5.1	4.2	3.3	2.6	--
Rice	--	--	--	4.2	3.2	2.6	2.3	--
Cotton	--	--	--	8.7	7.2	5.4	3.8	1.6

As should be expected, these data show that forecasts improve consistently as the growing season progresses and the RMSEs begin to approach the level of actual observed sampling error for at harvest estimates.

Data on Performance of the Root Mean Square Error Statistic
as an Indication of the Reliability of Crop Production Forecasts (1977-1980)

Forecast Period 1/	Total Number of Forecasts	67% Confidence Interval		90% Confidence Interval	
		Forecasts Within	Forecasts Outside	Forecasts Within	Forecasts Outside
			1977 Crop		
Early Season	23	20	3	23	0
Mid-To-Late Season	22	19	3	22	0
Total	45	39	6	45	0
			1978 Crop		
Early Season	25	16	9	24	1
Mid-To-Late Season	23	14	9	23	0
Total	48	30	18	47	1
			1979 Crop		
Early Season	25	15	10	22	3
Mid-To-Late Season	23	15	8	23	0
Total	48	30	18	45	3
			1980 Crop		
Early Season	25	14	11	25	0
Mid-To-Late Season	23	18	5	23	0
Total	48	32	16	48	0
GRAND TOTAL	189	131	58	185	4

1/ Early Season Forecast Months: December, May and June for Winter Wheat; July and August for Durum, Other Spring and All Wheat, Corn, Barley and Oats; August and September for Soybeans, Cotton, Rice, Sorghum Grain and all Feed Grains (1978-80). Mid-to-Late Season Forecast Months: July and August for Winter Wheat; September and October for Durum, Other Spring and All Wheat; September for Barley and Oats; September, October and November for Corn; October and November for Soybeans, Grain Sorghum, Feed Grains, Rice and Cotton.

Sampling Errors for 1980 Production Based on
Enumerative and Objective Yield Probability Surveys

Crop	Percent Sampling Error
All Wheat	2.2
Corn	1.6
Soybeans	1.9
Cotton	5.0

For less sophisticated data users the following type of table appears in each monthly crop report during the growing season:

Crop Production Forecasts

Ten-Year (1971-80) Record of Differences Between
First Monthly Forecasts and Final Estimate After Harvest

Crop and Month	Units	Quantity			Number of Years	
		Average	Smallest	Largest	Below Final Estimate	Above Final Estimate
July 1981						
Corn	Million Bu.	510	2	1,276	5	5
Oats	Million Bu.	45	8	92	5	5
Barley	Million Bu.	32	0	71	6	4
All Wheat	Million Bu.	54	2	143	5	5
Durum	Million Bu.	10	4	19	4	6
Other Spring	Million Bu.	31	3	97	6	4
Winter	Million Bu.	29	1	55	6	4
August 1981						
Rice	Million CWT	3	0	7	4	6
Soybeans	Million Bu.	78	1	165	6	4
Cotton	Thousand Bales	796	149	1,690	4	6
Sorghum	Million Bu.	34	2	78	5	5
Feed Grains	Million Tons	9	1	22	7	3

These are actual data that will appear in upcoming 1981 reports and are derived from records kept by the Crop Reporting Board to assist in analyzing its forecast record. For forecasts to maintain credibility they must be both reliable and objective. Producers always assert Crop Reporting Board forecasts are always too high. A simple measure such as the number of years forecasts are below or above the final estimates helps establish whether the Board errs consistently in an optimistic or conservative manner.