



# Farm Production Expenditures Methodology and Quality Measures

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## Agricultural Resource Management Survey Methodology for Farm Production Expenditures

**Scope and Purpose:** Estimates of farm production expenditures are based on data collected in the Agricultural Resource Management Survey (ARMS). The ARMS provides an annual snapshot of the financial health of the farm sector and farm household finances. The ARMS is the only source of information available for objective evaluation of many critical policy issues related to agriculture and the rural economy. In addition to obtaining farm production expenditures, the ARMS also collects data on production practices and costs of production for designated crop and livestock commodities each year, selected on a rotational basis. The production practices and cost of production surveys for these designated commodities are conducted in the top producing states for the selected commodity, while the farm production expenditures survey is conducted in all states, except Alaska and Hawaii. The ARMS is cosponsored by the USDA's Economic Research Service (ERS).

The ARMS is conducted in three phases. The initial phase (ARMS I) screens a large sample of farms and ranches to determine which farms qualify for subsequent phases of ARMS. Subsamples of qualifying farms are selected for the other two phases. The second phase (ARMS II) collects data on agricultural production practices, chemical use, and costs of production for each designated crop commodity. ERS is responsible for estimating the cost of production for major commodities and determines the commodity rotation.

The third phase (ARMS III) collects whole farm finance and operator characteristics information for a calendar year. Respondents from the second phase are included in the third phase to obtain financial and farm production expenditure data for the entire operation. It is vital that both the ARMS II and ARMS III be completed for these designated crop commodity operations. Data from both phases provide the link between agricultural resource use and farm financial conditions and allows for economic impact analysis of regulation and policy. This is a cornerstone of the ARMS design. In addition, production practices, costs of production, and farm production-expenditure data for designated livestock commodities are collected in one interview during the third phase (ARMS III).

Farm production expenditures are estimated for five regions, which include the fifteen leading cash receipt states and the other states within each region to account for all states except Alaska and Hawaii. Farm production expenditures are also estimated for eight economic sales classes and two farm type categories.

**Survey Timeline:** Data collection and analysis for the ARMS I are conducted from May through July. The ARMS II data collection begins in September and runs through December. The ARMS III data collection begins in January and concludes in April with further analysis and review continuing until the results are published in late July.

**Sampling:** The target population for the ARMS is all agricultural establishments with more than \$1,000 in agricultural sales (or potential sales). NASS uses a dual frame approach, consisting of list frame and area frame components, to provide complete coverage of this target population.

NASS maintains a list of farm and ranch operators, known as the list frame. NASS is constantly seeking new operations from outside list sources confirmed to be qualifying farms before being added to the list. A profile, known as control data, of each operation is maintained which indicates what the farm has historically produced and a general indication of size. This information allows NASS to define list-frame sampling populations that are specific to each survey and employ advanced and more efficient sample designs.

The ARMS list sample is selected based on a calculated Farm Value of Sales (FVS). All farms on the list frame with an estimated FVS of \$1,000 or more are eligible. The value of sales control data need not be exact as it is used to stratify similar list operations into homogeneous groups.

NASS utilizes the Sequential Interval Poisson (SIP) sampling method to select the ARMS I sample. In a SIP sample design, each operation is assigned a Permanent Random Number (PRN) between 0 and 1 from a uniform distribution. A sample can be defined as all operations falling within a specified range of PRNs. This provides a mechanism to control overlap across multiple surveys. In this case, SIP is used to minimize overlap between the previous year's ARMS sample and the current year Agricultural Survey sample, which is a large-scale quarterly acreage and grain stocks survey program.

Calculating a probability of selection for each operation in the ARMS population is a complicated task. There are multiple questionnaire versions in the ARMS III. Each designated commodity for the production practices versions requires a separate sample.

For the two farm production expenditure subsamples, target sample sizes by Farm Value of Sales (FVS) strata determine the probability of selection for each operation. For designated-commodity samples in the production practices versions, probabilities of selection are computed based on probability proportional to size (PPS) using crop acres or livestock inventory for the designated commodities.

The SIP sampling procedure is flexible and allows the use of different sample designs for each version in the ARMS III. It also ensures that each operation is selected for one and only one version. Once the probabilities of selection are assigned, the PRN determines which, if any, of the ARMS III versions will be assigned to that operation.

The area frame contains all land in the United States (except Hawaii and Alaska) and is therefore complete for the ARMS III program. The land is stratified according to intensity of agriculture using satellite imagery. Land in each stratum is divided into segments of roughly one square mile. Segments are optimally allocated and sampled to effectively measure crops and livestock. Annually, NASS conducts the June Area Survey and conducts face-to-face interviews of every individual who operates or owns land within a sampled area segment. All farms and ranches found operating in these segments are checked to see if they are included in the list-frame ARMS III population. Farms and ranches that are not on the list frame are sampled for the ARMS III so that the target population is completely represented.

The United States list-frame sample size for the ARMS III is approximately 36,000. The area-frame sample size is approximately 2,000. Each list-frame and area-frame sampling unit is assigned a sampling weight which is used to create the survey estimates.

**Data Collection:** For consistency across modes, the paper version is considered the master questionnaire and Computer Assisted Web Interview (CAWI) and Computer Assisted Personal Interview (CAPI) instruments are built to model the paper instrument. ERS plays a significant role in the development of questionnaires. Questionnaire content and format are evaluated annually by NASS and ERS through a specifications process, where requests for changes are evaluated and approved or disapproved. Input may vary from question wording or formatting to a program change involving the deletion or modification of current questions or addition of new ones. If significant changes to either the content or format are proposed, a NASS survey methodologist will pre-test the changes for usability. Prior to the start of data collection, all modes of instruments are reviewed and the CAWI instrument is thoroughly tested.

All federal data collections require approval by the Office of Management and Budget (OMB). NASS must document the public need for the data, show the design applies sound statistical practice, ensure the data do not already exist elsewhere, and show that the public is not excessively burdened. The ARMS questionnaires must display an active OMB number that gives NASS the authority to conduct the survey, as well as a statement of the purpose of the survey and the use of the data being collected. The questionnaires must include a response burden statement that gives an estimate of the time required to complete the form, a confidentiality statement that the respondents' information will be protected from disclosure, and a statement saying that response to the survey is voluntary and not required by law. For the ARMS, respondents must be informed that their data will be shared with the cosponsor.

In addition to asking the specific economic and cost of production questions, all survey instruments collect information to verify the sampled unit, determine any changes in the name or address, identify any partners to detect possible duplication, verify the farm still qualifies for the target population, and identify any additional operations operated by the sampled operator.

Mail, web, telephone, and face-to-face interview modes of data collection are utilized for the ARMS survey. The ARMS III uses multiple questionnaire versions. Prior to 2012, a Core version of the questionnaire was used to obtain global farm level expense, income, and household data. This version was used for the mail portion of the sample and for web-based data collection in the fifteen leading cash receipt states. The Costs and Returns Report (CRR) asks for the same data as the Core questionnaire, but in greater detail and in all states. Prior to 2012, the Core version was collected by face-to-face interviews only; beginning in 2012, the Costs and Returns Report has been used for the mail and web-based portion of the sample in addition to face-to-face interviews. A separate ARMS III production practices questionnaire version is developed for each of the designated commodity samples with additional questions relating to the current year's designated crop and livestock commodities. A reminder postcard is mailed to sampled farms and ranches to request the return of a completed questionnaire. The postcard also thanks respondents if they have already returned their questionnaire.

**Survey Edit:** As survey data are collected and captured, they are edited for consistency and reasonableness using automated systems. Reported data are typically first edited as a “batch” of data when first captured. The edit logic ensures administrative coding follows the methodological rules associated with the survey design. Relationships between data items on the current survey are verified and, in certain situations, items are compared to data from earlier surveys to make sure certain relationships are logical. The edit determines the status of each record to be either “dirty” or “clean”. Dirty records must be either updated or certified by an analyst to be accurate. Corrected data are reedited interactively. Only clean records are eligible for analysis tools and summary.

**Analysis Tool:** Edited economic and cost of production data are processed through an interactive analysis tool that displays data for all reports by questionnaire item. The tool provides various scatter plots, tables, charts, and special tabulations that allow the analyst to compare an individual record to other similar records within their state. These tools make outliers and unusual data relationships evident and Regional Field Offices and Headquarters staff review them to determine if they are correct. Suspect data found to be in error are corrected, while data found to be correct are kept.

**Nonsampling Errors:** Nonsampling errors are present in any survey process. These errors include reporting, recording, editing, and imputation errors. Steps are taken to minimize the impact of these errors, such as questionnaire testing, comprehensive interviewer training, validation and verification of processing systems, detailed computer edits, and the analysis tool.

**Nonresponse Adjustment:** Response to the ARMS III is voluntary. Some producers refuse to participate in the survey, others cannot be located during the data collection period, and some submit incomplete reports. These nonrespondents must be accounted for if accurate estimates of total farm expenditures are to be made. For this survey, item level nonresponse is accounted for by imputing data where there are missing values using a multivariate approach. Prior to the implementation of the multivariate approach, NASS used an un-weighted conditional means imputation system that placed records into homogenous groups and imputed based on reported data from those groups. From 2014 to 2018 NASS used a technique called Iterative Sequential Regression (ISR), a multivariate method where parameter estimates and imputations are obtained using a Markov chain Monte Carlo sampling method. Beginning in 2019 the new multivariate approach uses a regression-based hot deck imputation methodology called Predictive Mean Matching (PMM) which creates a multivariate model of the fully and partially observed records to create a donor pool of records who reported values are used and imputed values. PMM allows for the relationships within the data to be preserved and the imputed values to better represent the variability of the data. Records with imputed data are re-edited to ensure the returned value is acceptable.

**Calibration:** Calibration is a weighting technique used in survey sampling to adjust the survey weights for sampled elements so that the weighted sum of a set of benchmark variables equals a pre-determined set of values for the population. The input to the calibration algorithm used for ARMS III is the weights generated from the sampling procedures. Sampling weights are calculated based on numerous factors so that the sample allocation can be

representative of the entire population of farms at the state level for the fifteen leading cash receipts states and at the regional level for all other states. Due to survey nonresponse and the possibility of disproportionate responses across different farm types and economic sales classes, weights are adjusted through a calibration algorithm. Calibration adjusts the sampling weights so that the expanded data will match several known commodity, livestock, and farm number published totals. This ensures that the expense data collected will accurately represent the expense breakdowns for all farm types and farm sizes as well as cover the expenses for the entire target population.

**Estimators:** The ARMS III utilizes calibrated direct expansions for all survey indications. For both the list and area frame respondents, calibrated direct expansions are calculated by summing the reported or imputed economic and expenditure values weighted by the calibration weights. Variance estimates are computed for all expansions. The dual frame calibrated direct expansion and variance are the sum of the estimates from the list frame and the portion of the area frame that contains operations not included on our list frame population for the ARMS III.

**Outliers:** NASS conducts a formal review of outliers found in the expanded data. Outliers may be caused by aging control data resulting in misstratification, data errors, or the nonresponse and calibration adjustments to the sampling weight. A preliminary calibration and summary are run and any individual record accounting for 0.5 percent of the national expansion for total expenses or 2.5 percent of a regional expansion for total expenses is tagged as an outlier. After verifying the data have not been misrecorded or mishandled, background information on these outliers is compiled and presented to a National Outlier Board. This Board is a team of NASS and ERS analysts that meets to discuss the national outliers and form a consensus on a course of action. Most outliers trace back to unique situations that do not exist in the target population as often as a large calibrated sample weight indicates. The Board looks at other reports of the same type and sales class as the reported data on the outlier. The Board examines the weights of the comparable reports and most often overrides the outlier's weight with the median weight of the comparable reports. After the extreme outliers have been addressed, the Board reviews the national totals by expense category following the same methodology and, when necessary, overrides the outlier's weight with the median weight of the comparable reports. Finally, Headquarters staff examines outliers found at the state level for the published expense categories. A determination is made as to whether a weight adjustment is justified. Adjustments are not made to all outliers, but they are reviewed closely for accuracy. Once all adjustments are made, the calibration program is executed again to create the final set of weights for summary purposes.

**Estimation:** When all samples are accounted for, all responses fully edited, and the analysis material is reviewed, Headquarters staff executes a summary that generates state level totals for the fifteen leading cash receipt states and regional totals for the remaining states. Since all states (except Hawaii and Alaska) conduct identical surveys, the samples can be pooled and national survey results computed. The summary results provide point estimates and their standard errors for each estimated data series. It also provides information used to assess the performance of the current survey and evaluate the quality of the survey estimates, such as expansions by farm types and economic sales classes, response rates, and the effectiveness of calibration.

The ARMS III supports the annual estimates of total farm expenditures and the total expenses related to the following categories: Livestock, Feed, Farm Services, Rent, Agricultural Chemicals, Fertilizer, Interest, Taxes, Labor, Fuels, Farm Supplies and Repairs, Farm Improvements and Construction, Tractors and Self-Propelled Farm Machinery, Other Farm Machinery, Seeds, Trucks and Autos, and Miscellaneous Capital Expenses.

Regional Field Offices are responsible for performing a detailed review and providing comments that justify survey results. Any irregularities revealed by the summary must be investigated and, if necessary, resolved. Regional Field Offices see their states' survey results only and do not have access to other states' results.

For the national estimates, NASS assembles another joint panel of NASS and ERS analysts to serve as the Agricultural Statistics Board, which reviews the national level survey results and establishes the national estimates. Since larger sample sizes yield more precise results, NASS employs the "top-down" approach by determining the national estimates first and then reconciling the region and state estimates to the national number for all estimates. The Board has the advantage of being able to examine results across states, review the state comments and justifications, and utilize external administrative data available only at the U.S. level to corroborate survey results. The same estimators used in the state summaries are utilized by the national summary. Upon Board consensus, national level summary indications are adopted

as official national estimates except in cases where strong justification supports deviating from survey totals. In a separate process, a team of Field Office and Headquarters staff must reexamine the region and state results and adjust state estimates to sum to the national estimate. This process occurs both when indications are adopted as official estimates and when estimates deviate from survey totals.

Estimates are open to revision on a predetermined schedule only if new information becomes available. In general, revisions to the expenditure estimates may be considered one year later if there were revisions made to any of the calibration targets or other information became available that significantly impacts the previous year estimates. External information (administrative data) is also utilized in this process. In order to be considered, these data must be deemed to be reliable and come from unbiased sources. Census of Agriculture farm production expenditure estimates are available every five years and are used to assess the accuracy of the ARMS III results.

## Quality Metrics for Farm Production Expenditures

**Purpose and Definitions:** Under the guidance of the Statistical Policy Office of the Office of Management and Budget (OMB), the United States Department of Agriculture’s National Agricultural Statistics Service (NASS) provides data users with quality metrics for its published data series. The metrics tables below describe the performance data for the survey contributing to the publication. The accuracy of data products may be evaluated through sampling and nonsampling error. The measurement of error due to sampling in the current period is evaluated by the coefficient of variation for each estimated item. Non-sampling error is evaluated by response rates and the percent of the estimate from respondents.

**Sample size** is the number of observations selected from the population to represent a characteristic of the population. Operations that did not have the item of interest or were out of business at the time of data collection have been excluded.

**Response rate** is the proportion of the sample that completed the survey. This calculation follows Guideline 3.2.2 of the Office of Management and Budget Standards and Guidelines for Statistical Surveys (Sept 2006).

**Coefficient of variation** provides a measure of the size for the standard error relative to the point estimate. It is used to measure the precision of the results of a survey estimator.

**Weighted item response rate** is a ratio of reported survey data expanded by the original sampling weight compared to final nonresponse adjusted summary totals.

### Farm Production Expenditures Sample Size and Response Rates – United States: 2020 and 2021

State and region	Sample size		Response rate	
	2020 (number)	2021 (number)	2020 (percent)	2021 (percent)
<b>Atlantic</b> .....	3,627	4,837	40.6	33.2
North Carolina .....	1,538	1,494	46.6	40.6
Other States .....	2,089	3,343	36.3	29.9
<b>South</b> .....	5,823	6,369	37.8	39.4
Arkansas .....	1,408	1,612	41.4	47.7
Florida .....	1,842	1,883	31.1	30.7
Georgia .....	1,491	1,593	37.8	38.0
Other States .....	1,082	1,281	44.5	43.4
<b>Midwest</b> .....	10,371	12,272	34.4	36.3
Illinois .....	1,627	1,774	32.4	36.0
Indiana .....	1,512	1,759	30.0	32.9
Iowa .....	1,713	1,825	34.9	38.4
Minnesota .....	1,587	1,725	37.4	41.9
Missouri .....	1,623	1,842	35.2	34.0
Wisconsin .....	1,311	1,832	39.1	36.5
Other States .....	998	1,515	30.7	33.9
<b>Plains</b> .....	6,928	7,481	31.5	34.3
Kansas .....	1,619	1,731	27.8	31.7
Nebraska .....	1,644	1,612	28.7	30.0
Texas .....	2,494	2,660	37.4	41.4
Other States .....	1,171	1,478	28.1	29.5
<b>West</b> .....	5,605	6,443	42.2	38.8
California .....	2,219	2,558	48.0	46.1
Washington .....	1,792	1,928	37.6	34.1
Other States .....	1,594	1,957	39.4	34.0
United States .....	32,354	37,402	36.4	36.5

**Quality Metrics for Farm Production Expenditures – Region, Selected States, Farm Type, and Economic Class: 2020 and 2021**

Total	Coefficient of variation		Weighted item response rate	
	2020 (percent)	2021 (percent)	2020 (percent)	2021 (percent)
Total farm production expenditures .....	2.0	2.4	36.3	36.2
Livestock, poultry, and related expenses .....	6.4	9.1	50.0	56.9
Feed .....	4.0	5.6	39.0	40.2
Farm services .....	2.6	3.0	35.2	33.2
Rent .....	2.8	2.4	30.0	30.7
Agricultural chemicals .....	3.2	2.8	30.8	31.9
Fertilizer, lime, and soil conditioners .....	2.4	2.2	31.3	30.6
Interest .....	3.6	3.8	34.2	34.7
Taxes (real estate and property) .....	2.5	2.1	34.9	34.8
Labor .....	4.4	4.9	33.9	31.0
Fuels .....	2.7	2.1	34.1	32.8
Farm supplies and repairs .....	3.0	2.7	34.0	32.0
Farm improvements and construction .....	5.3	4.5	44.0	33.8
Tractors and self-propelled farm machinery .....	5.1	4.0	34.3	32.7
Other farm machinery .....	6.8	5.6	34.7	34.0
Seeds and plants .....	3.5	3.0	30.5	30.4
Trucks and autos .....	10.5	4.6	41.4	38.7
Miscellaneous capital expenses .....	13.3	5.5	43.0	37.7
<b>Regional - total farm production expenditure</b>				
<b>Atlantic</b> .....	6.7	7.1	39.1	32.0
North Carolina .....	4.6	13.2	38.0	37.4
Other States .....	8.9	8.5	39.5	30.0
<b>South</b> .....	6.3	4.7	35.2	34.2
Arkansas .....	3.7	3.0	34.4	40.5
Florida .....	20.6	15.3	30.7	18.9
Georgia .....	5.2	4.2	29.4	35.0
Other States .....	11.3	9.0	40.9	38.2
<b>Midwest</b> .....	1.7	4.0	30.4	36.7
Illinois .....	3.0	2.7	31.2	40.6
Indiana .....	2.7	2.3	27.3	27.3
Iowa .....	2.8	13.3	24.0	34.6
Minnesota .....	2.8	3.7	30.6	37.0
Missouri .....	5.3	5.7	36.2	40.3
Wisconsin .....	3.3	2.9	39.5	39.9
Other States .....	8.4	9.2	32.7	37.6
<b>Plains</b> .....	4.8	5.1	39.2	42.7
Kansas .....	11.2	18.1	36.4	53.3
Nebraska .....	9.3	8.6	35.8	45.0
Texas .....	8.2	4.8	52.7	49.4
Other States .....	9.7	6.7	31.8	24.5
<b>West</b> .....	5.0	6.1	40.2	31.2
California .....	5.2	5.5	32.8	33.9
Washington .....	11.4	10.1	43.2	23.1
Other States .....	10.2	13.1	48.3	30.1
<b>Farm type - total farm production expenditure</b>				
Crop .....	2.5	2.3	31.3	31.7
Livestock .....	3.3	4.5	42.1	41.2
<b>Economic class - total farm production expenditure</b>				
Less than \$10,000 .....	7.8	6.5	51.6	37.7
\$10,000-\$49,999 .....	5.4	3.9	48.3	46.4
\$50,000-\$99,999 .....	5.0	5.4	41.2	40.0
\$100,000-\$249,999 .....	4.0	3.6	36.7	34.3
\$250,000-\$499,999 .....	4.7	3.7	30.5	31.3
\$500,000-\$999,999 .....	3.8	3.6	28.3	30.0
\$1,000,000-\$4,999,999 .....	3.1	3.0	29.2	31.5
\$5,000,000 and over .....	5.9	7.2	44.9	43.1

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- Cornell’s Mann Library has launched a new website housing NASS’s and other agency’s archived reports. The new website, <https://usda.library.cornell.edu>. All email subscriptions containing reports will be sent from the new website, <https://usda.library.cornell.edu>. To continue receiving the reports via e-mail, you will have to go to the new website, create a new account and re-subscribe to the reports. If you need instructions to set up an account or subscribe, they are located at: <https://usda.library.cornell.edu/help>. You should whitelist [notifications@usda-esmis.library.cornell.edu](mailto:notifications@usda-esmis.library.cornell.edu) in your email client to avoid the emails going into spam/junk folders.

For more information on NASS surveys and reports, call the NASS Agricultural Statistics Hotline at (800) 727-9540, 7:30 a.m. to 4:00 p.m. ET, or e-mail: [nass@usda.gov](mailto:nass@usda.gov).

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