Appendix A.
Statistical Methodology

THE CENSUS POPULATION

The 2019 Census of Horticultural Specialties (CHS) was designed to cover all operations from which $10,000 or more of horticultural products were produced and sold, or normally would have been sold, during 2019. Horticultural products include annual bedding/garden plants, potted flowering plants, cut flowers, cut cultivated florist greens, trees, shrubs, ground covers, vines, fruit and nut trees, sod, dry bulbs, greenhouse produced vegetables, commercial vegetable transplants, vegetable and flower seeds, Christmas trees, short rotation woody crops, aquatic plants, unfinished or prefinished plants, propagation materials, and other nursery or greenhouse plants.

To reduce respondent burden, data collection for the 2020 Commercial Floriculture Survey was conducted in conjunction with the 2019 Census of Horticultural Specialties. Supplemental questions, not summarized in the 2019 Census of Horticultural Specialties, were included in the data collection to meet the requirements needed for the Floriculture Crops 2019 Summary report.

The 2019 CHS mail list was built from NASS's list frame. All records on the frame with $10,000 or more in horticultural sales were included on the mail list. A sample was selected for other horticultural operations on the frame that had less than $10,000 in horticultural sales or had unknown sales values. The final mail list included 38,598 operations.

DATA COLLECTION

Method of Enumeration

The 2019 CHS primary data collection method was mailout/mailback with paper forms, supplemented with Computer-Assisted Self Interviews (CASI) on the Internet, telephone enumeration, and personal enumeration for special classes of records. Personal enumeration (interviewing) involved the use of both Computer-Assisted Telephone Interviewing (CATI) and Computer-Assisted Personal Interviewing (CAPI). Office enumerators at the NASS National Operations Division (NOD) in St. Louis, MO, with assistance from NASS staff in MT and AR, conducted CATI data collection. In addition, field enumerators conducted phone and personal interviews with respondents. For the 2019 CHS, NASS implemented a pre-notification strategy in an effort to increase awareness, improve overall responses, and encourage respondents to report early to avoid continued correspondence. All records in the initial mailout received either a postcard or pre-recorded voice message announcing the census mail packets were coming.

Report Form

Three 28-page report forms were used to capture the number of horticultural products produced and sold and the value of sales for both retail and wholesale sales. The various types of plants sold were grouped by sections in the report forms. Additionally, information was obtained for area in production for several types of crops; marketing channels; estimated value of land, buildings, machinery, and equipment; production expenses; and the number of hired workers employed by the operation in 2019.

The three report forms used for the 2019 CHS included a U.S. (excluding Hawaii) horticulture report form (19-A624), a U.S. (excluding Hawaii) floriculture report form (19-A625), and a Hawaii horticulture report form (19-A627). The U.S. horticulture report form and the U.S. floriculture report form were exactly the same with the exception that they were printed in different colors to differentiate between horticulture operations (green forms) and floriculture operations (rose forms). The Hawaii horticulture report form content was unique. The Hawaii horticulture report forms were yellow forms. All of the report forms allowed respondents to write in specific commodities that were not listed on their form. See Appendix B for facsimiles of the report form and instruction sheet.

Report Form Mailings

The Census Bureau's National Processing Center (NPC) in Jeffersonville, IN was contracted to perform mail packet preparation, pre-census notification postcard printing and mailing, initial mailout, reminder/thank you postcard printing and mailing, and a follow-up mailing to nonrespondents. The NPC began pre-notification by postcard on December 16, 2019. The 2019 CHS report form was mailed from the NPC on December 30, 2019. Each operation selected for the census was mailed a packet that contained a cover letter, an EDR instruction letter, a report form instruction sheet, a labeled report form, and a return envelope addressed to either NPC or NOD for data capture. The report form carried a return due date of February 5, 2020.

The NPC mailed a reminder/thank you postcard on February 14, 2020. The follow-up mailing took place from NPC on February 24, 2020.

Respondent Follow-up

Telephone follow-up interviews to nonrespondents took place from March 16 to July 23, 2020 from a NASS Data Collection Center.

Data collection for the 2019 CHS was coordinated with other NASS surveys. In some cases, if a horticultural operation was also selected for a survey, NPC mailed the 2019 CHS materials to NASS regional field offices. Office personnel were responsible for collecting the horticulture data and completing other survey report forms in the most efficient way to reduce the number of contacts and minimize respondent burden.

REPORT FORM PROCESSING

Data Capture

NPC received and processed returned mail packets for all U.S. horticulture and floriculture report forms (19-A624, 19-A625, and 19-A627). NASS staff on site at NPC provided technical guidance and monitored NPC processing activities. All report forms returned to NPC were immediately checked in, using bar codes printed on the mailing label, and removed from follow-up report form mailings. All forms with any data were scanned and an image was made of each page of a report form. Optical Mark Recognition (OMR) was used to capture categorical responses and to identify the other answer zones in which some type of mark was present. All forms were reviewed prior to data keying to identify inconsistencies and ensure the data could be keyed. Major inconsistencies, respondent remarks, and blank forms were reviewed by analysts and adjusted prior to keying. In some cases, report forms were mailed to regional field offices for further editing.

Data entry operators keyed data from the scanned images using OMR results that highlighted the areas of the report forms with respondent entries. The keyers evaluated the contents and captured pertinent responses. Ten percent of the captured data were keyed a second time for quality control. If differences existed between the first keyed value and the second, an adjudicator handled resolution. The decision of the adjudicator was used to grade the performance of the keyers, who were required to maintain a certain accuracy level.

The images and the captured data were transferred to NASS's centralized network and became available to regional field offices and headquarters on a flow basis. The images were available for use in all stages of review. Images were computer generated for reports obtained from the telephone interviews and the Internet.

Data Editing

Captured data were processed through a computer formatting program that verified records were valid. Rejected records were referred to analysts for correction. Accepted records were sent to a complex computer batch edit process. Each execution of the computer edit in batch mode consisted of records from only one State and flowed as the data were received from each data collection source.

The computer edit determined whether a reporting operation met the qualifying criteria to be counted as an in-business record. The edit examined each in-business record for reasonableness and completeness and determined whether to accept the reported value for each data item or to take corrective action. Such corrective actions included removing erroneously reported values, replacing an unreasonable value with a value consistent with other reported data, or providing a value for an item omitted by the respondent. To the extent possible, the computer edit assigned a value deterministically within the edit or marked value for imputation for later resolution. Operations failing to meet the qualifying criteria were categorized as out-of-scope. Out-of-scope records that NASS had reason to believe might be in-business (indications of recent and/or significant horticultural activity reported on NASS surveys, for example) were referred to analysts for verification and action.

The edit systematically checked reported data section-by-section with the overall objective of achieving an internally consistent and complete report. NASS subject-matter experts had previously defined the criteria for acceptable data. Problems that could not be resolved within the edit were referred to an analyst for intervention. Regional field office analysts also participated using an interactive version of the edit program to submit corrected data and subsequently re-edit the record to ensure satisfactory resolution.

Imputation

After the initial edit, an automated imputation program supplied data based on State or national averages. Post-imputation records were run back through the computer edit to ensure imputation actions provided acceptable results. Instances where imputed data failed edit checks were referred to analysts for corrective action.

Data Analysis

The complex edit ensured the full internal consistency of the record. Successfully completing the edit did not provide insight as to whether the report was reasonable compared to other reports in the county. Analysts were provided an additional set of tools to review record-level data across operations. These examinations revealed extreme outliers, large and small, or unique data distribution patterns that were possibly a result of reporting, recording, or handling errors. Potential problems were researched and, when necessary, corrections were made and the record interactively edited again.

ESTIMATION

Nonresponse Weighting

The 2019 Census of Horticultural Specialties is a census of every operation on the NASS Horticulture Sampling Frame with at least $10,000 of horticultural sales indicated. Operations on the frame that had indicators of horticultural sales below the $10,000 threshold were sampled at an average rate of 1 out of 3.

Although much effort was expended to obtain a response from each operation selected for the census, it was not possible to obtain a complete set of responses. Nonresponse can lead to biases in published estimates because the information concerning the horticultural enterprise production on the nonresponding operations could not be factored into the estimates. Such estimates of totals will be biased low. To reduce this bias, NASS made nonresponse adjustments to the initial weights of the responding operations. The nonresponse weight adjustment increases the weight of responding operations to account for the data that would have been reported by the nonresponding operations. This increased the estimates of totals obtained by the respondents and reduced this bias.

Conceptually, each operation on the sample begins the weighting process with an initial weight equal to the inverse of the record's probability of selection. Records with sales of $10,000 or more will have an initial weight of 1 because they are selected with certainty. Records with sales less than $10,000 will have an initial weight of about 3.

If each operation selected for the census provided the requested data, the data could simply be multiplied by each record's initial weight then added up to attain an estimate for the total amount of the item of interest. In the presence of nonresponse, nonresponse adjustments are computed and applied to the initial weights of the responding operations resulting in a nonresponse-adjusted weight greater than the initial weight for these operations. The initial weight of each nonresponding operation is then adjusted to zero. The adjustments are computed in a manner that requires the sum of the nonresponse-adjusted weights across the responding operations on the census to equal the number of records on the sampling frame.

Nonresponse Weight-Adjustment Groups

To compute nonresponse adjustments, each operation on the mail list was placed in a weight-adjustment group. Each operation was assigned to a group based on the characteristics used to define the group. It was necessary that the characteristics that defined the weight-adjustment groups were available for responding and nonresponding operations alike. Therefore, it was not possible to define weight-adjustment groups using data collected via the CHS.

The information on the sampling frame was used to create the weight-adjustment groups and was a measure of the horticultural economic size (HES). The basic definition of the weight-adjustment groups is given below:

Definition

HES<$10,000
$10,000<=HES<$50,000
$50,000<=HES<$150,000
$150,000<=HES<$250,000
$250,000<=HES<$500,000
$500,000<=HES
Must Group (varies by State)

All records that were considered likely to be very large horticultural operations for a given State were considered “must” cases and put in a special group. For all records in a must group, nonresponse adjustment was not allowed and data were imputed for any of these records that did not respond. Must group definitions varied by State.

Nonresponse-Adjustment Computation

A separate nonresponse adjustment was calculated within each weight-adjustment group. All responding records within each group received the same nonresponse adjusted weight. The nonresponse-adjustment was obtained by dividing the sum of the initial weights across all the records in the group by the sum of the initial weights of the responding operations in the group. If the sum of the initial weights across all records in the group was 50 and the sum of the initial weights of all responding operations in the group was 40, the nonresponse-adjustment for the responding operations was 50/40 or 1.25. The nonresponse-adjusted weight for all responding operations in the group was the product of the initial weight and the nonresponse adjustment of 1.25. This was simply (1 x 1.25). Note that 1.25*40=50, the sum of the initial weights for all records in the group.

The assumption made when computing nonresponse adjustments in this way was that within each weight-adjustment group, the data that the nonrespondents would have provided had they responded were collectively similar to the data provided by the respondents. This assumption was made somewhat more plausible because operations in the same group shared similar characteristics with respect to the information used to define the group - the HES.

Coverage Weighting Adjustments

The target population for the 2019 CHS was all operations that had at least $10,000 of commercial horticultural production in 2019. Unfortunately, it is impossible to compose a list of operations that is complete. Due to this incompleteness of the mail list, data produced from it, even if perfectly corrected to account for nonresponse, will still have a tendency to be biased downwards because operations not on the list would not have any representation. This bias due to list incompleteness is called coverage bias, or more specifically, bias due to undercoverage of the sampling frame.

To reduce the amount of this bias, an additional adjustment was calculated and applied to the nonresponse-adjusted weight for each responding operation. This was called the coverage adjustment.

Coverage Adjustment Computation

The majority of CHS respondents were also respondents on the 2017 Census of Agriculture. Operations that were respondents to both censuses were assigned the census of agriculture coverage adjustment computed for the operation in the 2017 Census of Agriculture. The coverage adjustment for

CHS respondents that did not match the census of agriculture were calculated using records with similar information that did match the census of agriculture.

The coverage adjustment was then applied to nonresponse weight for each CHS respondent record. This resulted in a fully-adjusted weight. The fully-adjusted weight attempts to correct for nonresponse bias, as well as coverage bias.

Summary Weights

Most of the fully-adjusted weights for the 2019 Census of Horticultural Specialties were not whole numbers (integers). Using these weights to create the estimates published in the tables would result in fractional values. These would be difficult to read and cause consistency problems between related tables. To avoid some of these problems, summary weights were created by randomly moving the fully-adjusted weights up or down to an integer in a way that preserved the overall sum of the fully adjusted weights. This process is called weight integerization. The resulting summary weights were used to produce the numbers published in the tables.

Census Response Rate

The response rate is an indicator of the quality of data collection. It is generally assumed that if a response rate was close to 100 percent, the potential for nonresponse bias is small. Because this census contains both farm and nonfarm records, the response rate is an indicator of replying to the census data collection effort, but does not reflect whether those responding met the farm definition or had the items of interest for the census. Using the fourth response rate formula (RR4) from the American Association of Public Opinion Research's Response Rate Standard Definitions manual the response rate for the 2019 Census of Horticulture Specialties survey is 66.3 percent. This compares to 68.9 percent for the 2014 Census of Horticulture Specialties Survey.

MEASURES OF PRECISION

Under the guidance of the Statistical Policy Office of the Office of Management and Budget (OMB), NASS provides data users with quality metrics for its published data series. 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 (CV) for each estimated item. Nonsampling error is evaluated by response rates and the percent of the estimate from respondents.

Coefficient of variation is a measure of the relative amount of error associated with a sample estimate. Specifically, it is the standard error of a point estimate divided by that estimate, generally multiplied times 100 so that it can be reported as a percentage. This relative measure allows the reliability of a range of estimates to be compared. For example, the standard error is often larger for large population estimates than for small population estimates, but the large population estimates may have a smaller CV, indicating a more reliable estimate. Every estimate for the 2019 Census of Horticultural Specialties has a corresponding CV published with it. NASS has identified the following index to use when evaluating coefficient of variation for the 2019 Census of Horticultural Specialties. The coefficient of variation is used as an indicator of the precision in the census estimates and is reported for some census items in Table A.

- **Low Reliability Estimate**. Coefficient of Variation (CV) 30 percent or higher. Caution should be used when using this estimate in any form. Please consult NASS for more information or guidance.

- **Medium Reliability Estimate.** Coefficient of Variation (CV) between 15 percent and 29.9 percent.

- **High Reliability Estimate.** Coefficient of Variation (CV) less than 15 percent. Table A provides statistical precision estimates for the number of farms, total sales, wholesale sales, retail sales for the U.S. and for each State. Table B provides statistical precision estimates for the total value of sales by size and operations by type of crop for the U.S.

Table A. **Reliability Estimates of Operations and Value of Sales of All Horticultural Specialty Crops – United States and States: 2019**

[For meaning of abbreviations and symbols, see introductory text.]

Geographic area	Operations		Total sales		Wholesale sales		Retail sales	
	Number	Coefficient of variation (percent)	Value ($1,000)	Coefficient of variation (percent)	Value ($1,000)	Coefficient of variation (percent)	Value ($1,000)	Coefficient of variation (percent)
United States	20,655	1.1	13,778,944	4.7	11,851,387	5.2	1,927,557	5.5
Alabama	233	4.3	273,072	20.3	251,090	22.1	21,982	35.9
Alaska	107	13.0	14,520	25.1	5,798	37.8	8,722	34.9
Arizona	100	12.0	235,234	41.9	203,019	37.6	32,215	94.5
Arkansas	122	10.5	67,624	35.0	40,236	33.9	27,388	79.5
California	1,331	2.4	2,629,146	11.6	2,459,682	12.3	169,464	21.9
Colorado	258	13.1	189,890	19.5	146,476	25.8	43,415	27.7
Connecticut	300	8.7	229,956	29.8	194,798	32.6	35,158	27.5
Delaware	48	19.8	23,148	53.6	16,006	66.3	7,143	50.5
Florida	1,689	4.0	1,932,182	11.9	1,857,411	12.5	74,771	16.3
Georgia	425	7.8	353,954	15.2	314,622	19.5	39,332	38.2
Hawaii	530	10.2	89,206	10.4	72,708	11.5	16,498	24.0
Idaho	254	17.3	80,485	30.1	61,408	28.0	19,077	47.0
Illinois	509	5.1	225,894	12.2	170,545	14.4	55,349	19.7
Indiana	471	5.0	104,889	23.1	70,595	34.2	34,294	10.9
Iowa	321	5.2	100,954	28.4	72,183	38.7	28,770	25.8
Kansas	142	11.2	55,189	22.3	34,030	22.9	21,159	42.6
Kentucky	337	7.0	48,139	26.3	21,349	60.9	26,790	22.5
Louisiana	239	7.7	107,795	17.7	97,168	20.0	10,627	42.9
Maine	248	8.2	66,412	49.8	21,898	43.8	44,514	57.5
Maryland	297	12.9	244,870	16.4	226,943	18.0	17,927	31.7
Massachusetts	408	6.3	136,599	20.9	85,472	24.6	51,127	18.6
Michigan	1,092	2.7	695,386	13.4	566,304	16.5	129,081	12.3
Minnesota	380	7.0	255,940	38.7	201,706	46.5	54,234	19.4
Mississippi	106	11.8	39,621	21.8	27,589	26.9	12,032	38.5
Missouri	335	10.9	74,440	35.6	55,058	44.2	19,382	42.8
Montana	150	14.0	26,614	17.1	12,494	38.1	14,120	20.0
Nebraska	155	7.9	43,584	27.2	29,225	36.8	14,359	26.7
Nevada	12	35.1	10,244	59.9	6,464	69.2	3,780	73.6
New Hampshire	194	18.7	48,567	40.7	34,082	61.9	14,485	26.8
New Jersey	555	5.1	505,129	17.2	432,646	21.5	72,483	33.4
New Mexico	61	20.3	25,975	37.9	19,353	52.6	6,622	54.5
New York	978	4.1	309,779	17.4	222,034	24.9	87,745	9.4
North Carolina	885	3.5	555,928	21.8	498,262	24.1	57,666	11.4
North Dakota	35	33.6	7,069	31.8	3,801	42.7	3,268	53.3
Ohio	854	3.3	468,978	27.8	387,305	32.4	81,673	16.8
Oklahoma	143	11.0	153,465	51.9	135,852	59.5	17,613	36.1
Oregon	1,124	4.9	1,015,784	12.5	950,631	13.6	65,153	17.1
Pennsylvania	1,365	5.2	309,893	14.0	235,841	20.9	74,051	12.9
Rhode Island	91	12.1	22,552	26.1	12,756	30.4	9,796	41.8
South Carolina	230	12.9	175,136	39.7	158,214	43.8	16,921	47.6
South Dakota	50	21.5	15,057	56.3	8,820	(H)	6,237	35.4
Tennessee	501	6.1	227,221	25.0	180,758	25.5	46,464	35.4
Texas	614	6.7	598,812	11.4	495,362	11.3	103,450	43.5
Utah	94	10.7	130,933	30.6	99,396	36.8	31,537	30.8
Vermont	199	9.3	21,346	23.0	8,208	20.5	13,137	27.0
Virginia	465	6.9	271,128	19.4	235,891	22.7	35,237	26.8
Washington	699	5.7	299,518	15.4	258,957	18.3	40,561	12.5
West Virginia	103	15.6	26,165	70.3	20,185	78.5	5,980	44.2
Wisconsin	789	8.5	231,373	16.8	129,882	24.6	101,492	20.9
Wyoming	27	27.1	4,151	33.6	873	65.2	3,278	32.7

Table B. **Reliability Estimates of Operations and Value of Sales for Selected Horticultural Specialty Items – United States: 2019**

[For meaning of abbreviations and symbols, see introductory text.]

Item		Total	Coefficient of variation (percent)
TOTAL VALUE OF SALES BY SIZE			
$10,000 - $19,999	operations	3,744	4.1
	$1,000	53,098	4.6
$20,000 - $24,999	operations	1,220	3.0
	$1,000	26,936	3.1
$25,000 - $39,999	operations	2,536	3.9
	$1,000	79,378	4.0
$40,000 - $49,999	operations	1,144	4.1
	$1,000	50,558	4.1
$50,000 - $99,999	operations	3,254	3.4
	$1,000	230,035	3.4
$100,000 - $249,999	operations	3,266	4.1
	$1,000	517,609	3.7
$250,000 - $499,999	operations	1,773	3.2
	$1,000	617,180	3.8
$500,000 - $999,999	operations	1,430	4.7
	$1,000	999,900	4.5
$1,000,000 - $2,499,999	operations	1,274	3.8
	$1,000	2,029,890	4.0
$2,500,000 or more	operations	1,014	2.7
	$1,000	9,174,361	6.9
OPERATIONS BY TYPE OF CROP			
Annual bedding/garden plants	operations	6,687	1.8
	$1,000	2,244,460	12.1
Potted herbaceous perennial plants	operations	5,108	1.8
	$1,000	922,616	10.2
Potted flowering plants for indoor or patio use	operations	3,977	1.2
	$1,000	1,200,387	10.0
Foliage plants for indoor or patio use	operations	2,336	2.5
	$1,000	691,472	20.0
Cut flowers and cut lei flowers	operations	2,035	3.6
	$1,000	385,668	23.5
Cut cultivated greens	operations	644	3.7
	$1,000	99,984	14.3
Nursery stock sold (see text)	operations	6,458	2.4
	$1,000	4,545,276	6.9
Propagative horticultural materials, bareroot, and unfinished materials	operations	1,038	6.8
	$1,000	720,448	21.3
Sod, sprigs or plugs sold	operations	1,068	4.8
	$1,000	1,271,561	8.8
Dried bulbs, corms, rhizomes, and tubers	operations	263	9.4
	$1,000	60,072	34.0
Food crops grown under protection	operations	2,994	3.9
	$1,000	703,469	18.4
Transplants for commercial vegetable and strawberry production	operations	491	6.6
	$1,000	369,864	20.6
Vegetable seeds	operations	335	9.3
	$1,000	127,198	61.2
Flower seeds	operations	166	14.4
	$1,000	43,927	64.7
Aquatic plants	operations	238	14.0
	$1,000	25,034	40.5
Cultivated Christmas trees sold (see text)	operations	2,857	3.4
	$1,000	357,190	12.9
Short rotation woody crops sold (see text)	operations	18	42.2
	$1,000	5,090	84.9
Tobacco transplants	operations	99	20.0
	$1,000	5,228	19.8