

2019 NAAA Aerial Application Industry Survey: Operators

Conducted for:

National Agricultural Aviation Association (NAAA)



Conducted by

Tim Struttman and Jackie Zawada

Supported by NAAA

and the Southwest Center for Agricultural Health, Injury Prevention, and Education

IMPORTANT DATES

Survey data was collected among operators from January - April 2018. Questions on the survey asked respondents about operations during 2017. This report was finalized in 2019.

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1. Executive Summary

This web-based survey of Part 137 operators and pilots conducted between January 26, 2018, and April 29, 2018, was supported by the National Agricultural Aviation Association (NAAA) and the Southwest Center for Agricultural Health, Injury Prevention, and Education. This secure-site survey was designed in partnership with NAAA and modeled after a similar paper-based survey conducted in 1992, 1994, 1998, 2004 and a web-based survey in 2012. Careful outreach activities were planned and executed before and during the survey to ensure a high response rate. After testing the questionnaire, it was loaded to a secure site. Although the focus was surveying Federal Aviation Regulations (FAR) Part 137 (hereafter referred to as Part 137) certificate holders, pilots were also asked to complete a survey. Using the census of Part 137 operators, prospective respondents were mailed a letter inviting them to the web survey. The sample size of operators was 1880. For those operators and pilots for whom we had an email address the link was emailed. There were 3,273 email addresses including pilots and operators. The nature of the questions asked of operators differed slightly from the questions asked of pilots. For example, operators were asked “How many airplanes are at the operation during normal operations?” Pilots were not asked this question. Five hundred fifty operators’ and 305 pilots’ responses were received over the 93-day data collection period. In the 2012 survey, we received 508 and 324 responses, respectively.

The response rate among the approximately 1,560 Part 137 operators who conduct agricultural operations was estimated at 35%. The average age was 55 years old for operators and 47 years old for pilots who have been in the business an average of 28 and 19 years, respectively. The largest number of operator responses came from Texas, Minnesota, Arkansas, Louisiana, California, Nebraska and North Dakota. More than half (58%) of the operations are based on private land; 42% are located on public airports. Operators had an average of 2.3 aircraft per operation. Ninety-five percent of all aircraft used had closed cockpits. Eighty-one percent of aircraft used were equipped with smokers to determine wind direction and estimate wind speed. Operators estimated during 18% of the operations, the pilot also loaded product. To minimize spray drift, 88% said they used smokers, 90% said they used drift control additives, 75% said they modified droplet size and 63% changed flight patterns. For swath guidance, 99% of the respondents said they used a GPS device.

The usual acres treated in a single day using a single aircraft were: cotton – 1,125 acres, soybeans – 1,143 acres, corn – 1,165 acres, and rice – 1,033 acres. Maximum acres treated in a single day using a single aircraft averaged 2,119 acres for cotton, 1,958 acres for soybeans, 1,925 acres for corn and 1,579 acres for rice. Overall, most operators treat corn, small grains and soybeans. The results from the 2019 survey were also used to estimate that aerial application treats 127 million acres of cropland annually. The 2017 USDA Census of Agriculture states there are 347 million acres of cropland used for crop production in the United States. Taking into account some crops are treated more than once during a season, aerial application is estimated to treat somewhere between 28 percent to 37 percent of this cropland.

The 2019 survey was the same as in prior years in that the focus was Part 137 certificate holders. However, the 2019 survey, like in 2012, also included pilots who were not Part 137 certificate holders. Three hundred five pilots who were not Part 137 certificate holders responded to the

survey. Results presented here are for Part 137 certificate holders only. Results of the pilot survey are given in another report.

2. Background

Through deliberate planning, the NAAA Executive Director, the Director of Education and Safety, survey researchers and Part 137 certificate holders worked to balance survey length, the need for representative data and the survey's administration time period. A Part 137 operation is defined below.

From Section 137.3 of the Federal Aviation Regulations: Agricultural aircraft operation means the operation of an aircraft for the purpose of (1) dispensing any economic poison, (2) dispensing any other substance intended for plant nourishment, soil treatment, propagation of plant life, or pest control, or (3) engaging in dispensing activities directly affecting agriculture, horticulture, or forest preservation, but not including the dispensing of live insects.

Gathering data from this geographically dispersed population, often working long hours in fairly small operations presented challenges to the team. Although a US postal service mailed letter requesting recipients to go to a web survey often have low response rates, we did not have 100% of Part 137 Operators' email addresses, thus we first used US mail to reach all those who are on the FAA's census of registered Part 137 Certificate holders. The postal mailed letter invited operators to log into a secure site to participate in the survey. No paper responses were collected. Confidentiality was paramount. Assurances were imbedded in the survey outreach promotion campaign assuring respondents their identification along with the information they provided would not be shared; the website was restricted and secure; and the data obtained belonged to NAAA. Emails were sent to operators and pilots for whom we had an email address.

The purpose of the survey was to:

- Gather data from the population of Part 137 operators on demographics, experience, scope of work operations, equipment, standard practices, drift mitigation techniques, crops and acres treated.
- Gather data on risks, safety practices, risk perceptions and health for future training purposes.
- Compare these data with data obtained in prior surveys to identify trends.
- Gather information on the aerial application of crop protection products and provide such data to the EPA and crop protection product manufacturers to aid in registration and reregistration, thereby increasing the availability of those products to the aerial application industry.

The overriding principles were to design a survey that could be answered by operators and pilots alike that was short, precise and gathered only the necessary data in a secure, cost-effective manner. Average response time was 28 minutes.

This survey report only addresses practices of those in the agricultural aviation industry. It does not include Part 137 operations that conduct only firefighting operations. Data collection and analysis was conducted by Tim Struttman and Jackie Zawada and was supported by the Southwest Center for Agricultural Health, Injury Prevention, and Education Tyler, Texas, CAU50-OH07541, and NAAA, Alexandria, Virginia.

3. Methods

The target audience for this web-based survey was FAR Part 137 operators who conduct agricultural operations. Part 137 operations include firefighting operations but these were not the focus of this study. A file of all Part 137 operations was purchased from Airpac, Inc. of Edmond, Oklahoma, containing 1,880 names, addresses, telephone numbers, aircraft and company names. An email roster containing 3,273 email addresses belonging to NAAA was obtained.

In collaboration with NAAA, survey experts crafted questions on demographics, operations, practices, risk perception, injuries and health. Questions were modeled after the 2012 NAAA survey so that comparisons could be made. The questionnaire was pilot tested among operators whose comments were incorporated into the questionnaire to improve question clarity.

The survey was then loaded into the Qualtrics web tool, a statistical analysis tool used for survey authoring and deployment of web surveys, for administration on a secure website and tested. Analysis was conducted in MATLAB and Microsoft Excel.

The final questionnaire was loaded in January 2018. The initial question on the survey asked if the respondent was an operator (Part 137 certificate holder), a pilot employee or other. If the respondent answered ‘Operator,’ the Operator Survey was presented. If the respondent answered ‘Pilot,’ the Pilot Survey was presented. See Appendix A – Operator Survey.

Both the US mailed letter and the initial login web page contained the supporting signatures of the NAAA President, the NAAREF President and the NAAA Executive Director, giving credibility and legitimacy to the survey.

The first postal mailing occurred on January 26 and a follow-up ‘thank you/reminder’ postcard was sent on 2/12. The first email was sent on 2/10 and reminders were sent on 2/23, 3/4, 3/15, 3/23, 3/30, 4/5, 4/12, 4/18, 4/22 and 4/26, each with slightly varying text. The survey was closed on April 29. Respondents who started the survey but did not complete it before April 29 were sent reminder emails and could pick up where they left off.

Among those in the initial list of 1,880 we estimate that 1% are firefighting operations and based on the number of mailed letters returned undeliverable (7%) and business closure rate calculated in 2012 we estimate 17% of the operations on the FAA Census of Part 137 Operations are no longer in business or are firefighting operations. Therefore, the total population of Part 137 operations who conduct agricultural operations were assumed to be 1,560 operators.

The completed surveys were exported from Qualtrics and imported into MATLAB for analysis. These data were screened for missing responses and information believed to be erroneous. A review committee made up of highly experienced aerial applicators conference called in June 2018. This panel of experts included operators from different geographic regions and agricultural

practices, including airplane and helicopter applicators, who agreed on standards to judge the accuracy of the responses submitted. When extreme values suggested a misunderstanding of the question or deliberately misleading responses, these values were removed. The panel set upper limits on the number of acres that can be treated in a single day with a single aircraft.

Additionally, when a respondent completed fewer than 10% of the questions the data were removed because the respondent failed to provide critical information. One hundred nine respondents completed less than 10% of the questions. Cases where the respondent said they were neither a Part 137 operator nor a pilot were deleted. There were 37 respondents who said they were neither operators nor pilots.

4. Results

There were 550 operators and 305 pilots whose responses were considered for the survey, a total of 857 responses. Assuming there were 1,560 operators who conduct agricultural operations, this was a 35.2% response rate for operators. Two hundred eleven responded to the survey as a result of the US mailed letter and 339 responded via a link in an email. Seventy-six percent of the respondents completed the survey and of those who did not complete it (dropouts) they completed an average of 54% of the questions. Most dropouts occurred when asked about specific crops and acres treated.

Although the data were collected in 2018 and respondents were asked to report their experiences relative to 2017, these results are presented as 2019 to coincide with the report release date. These results are referred to as the '2019 survey'. Where specific questions asked about 2017, the results are presented as 2017 to show the reader exactly how the survey question was asked.

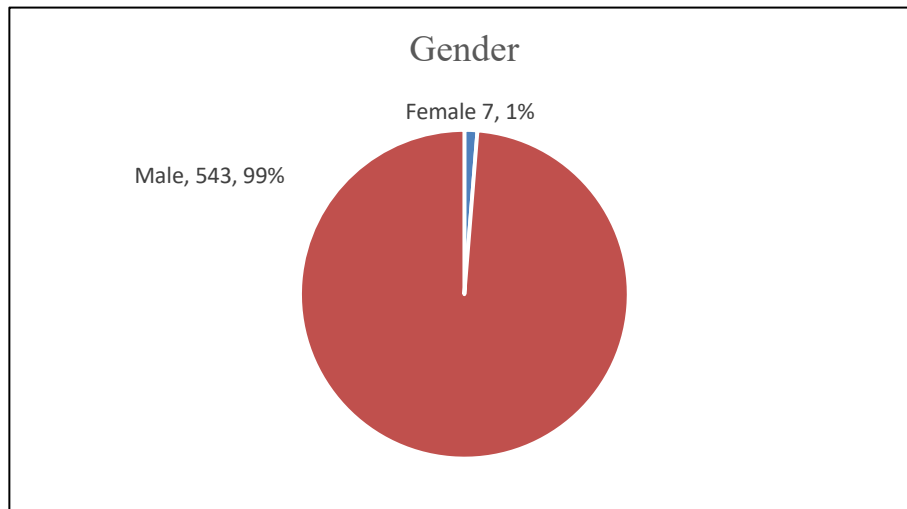
Results are presented here for 550 operators. Where appropriate, comparisons to the 2012 NAAA surveys are made.

4.1. Result Details

Results are presented in seven subsections: Demographics, Equipment and Standard Practices, Operations, Risk Perception, Injury, Operator Workload, and finally, Health.

4.1.1. Demographics

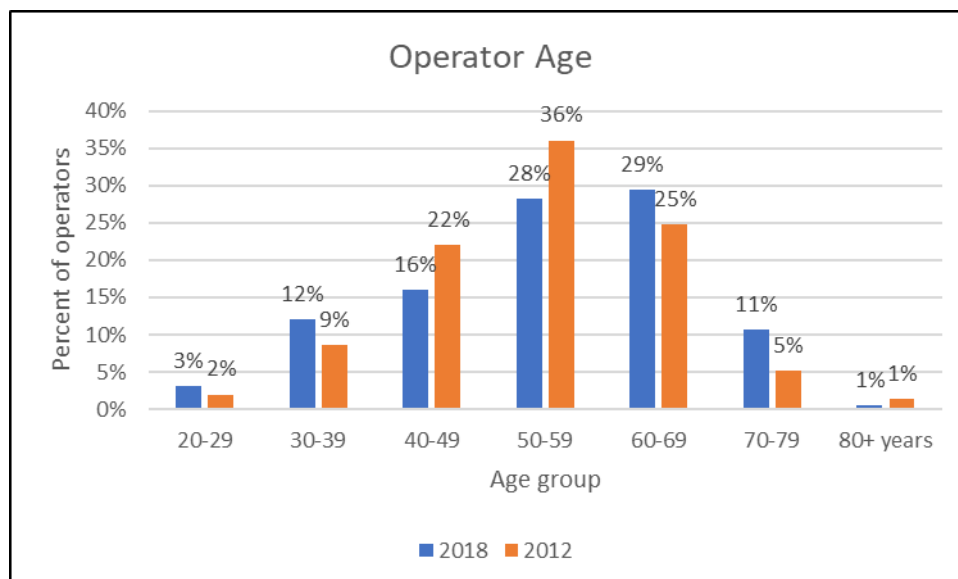
Figure 1 – Gender of Operator



*550 responses

Ninety-nine percent, all but seven of the operators, identified as male. In 2012, all but three (99%) were male, so there has been more than a doubling of female agricultural aviation operators in that time.

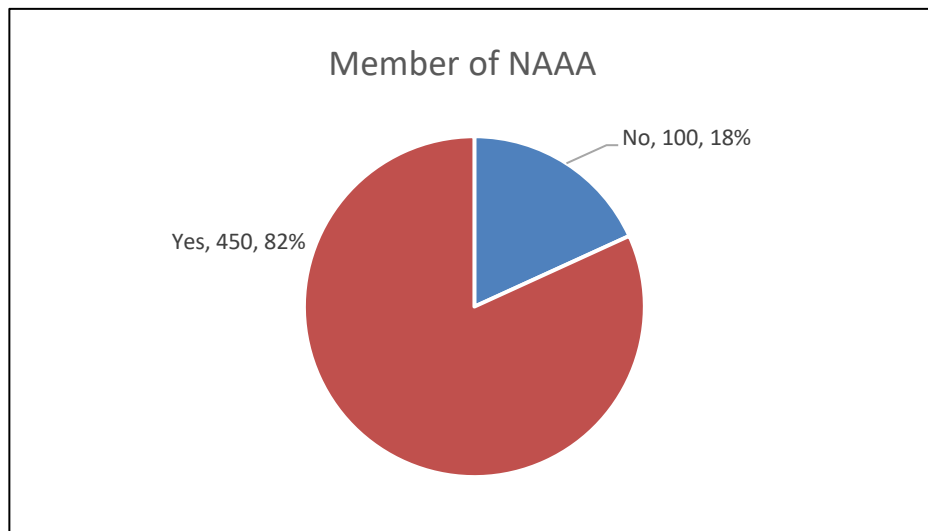
Figure 2 – Operator Age



*550 responses in 2019 and 508 in 2012

Respondents' age ranged from 20 to 82. The average respondent age was 55 (53 years old in 2012). Five hundred three (91%) of the 550 operators were also pilots. The population of operators under 40 years of age grew from 11% in 2012 to 15% in 2019.

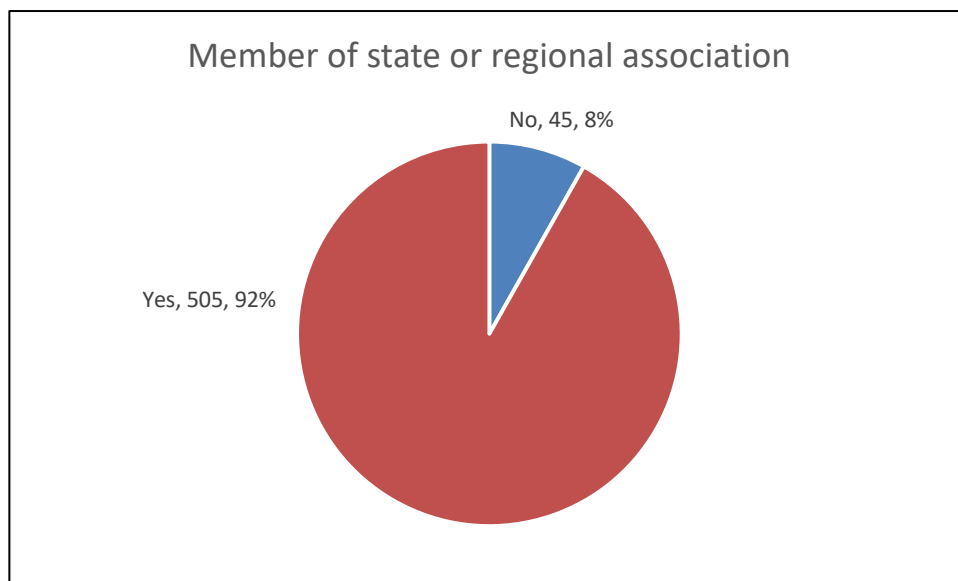
Figure 3 – Members of NAAA



*550 responses

Eighty-two percent of those operators surveyed were members of NAAA. For comparison, the 2019 pilot survey found that 54% of pilots were NAAA members.

Figure 4 – Members of a state or regional agricultural aviation association

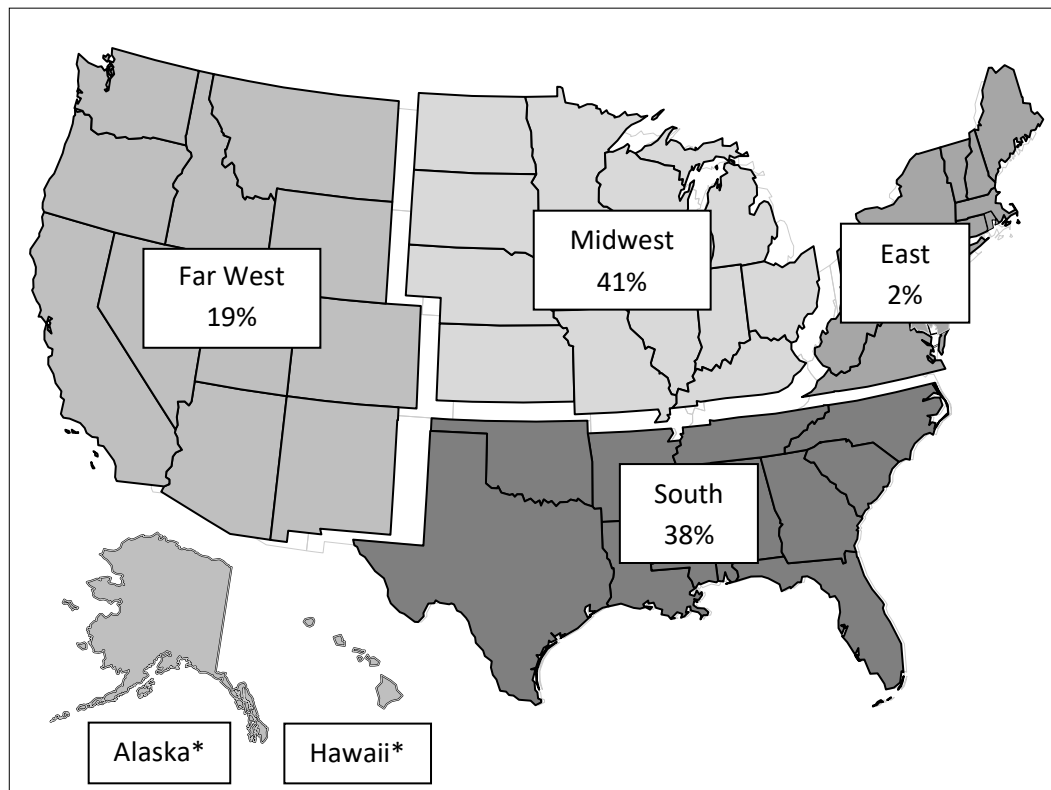


*550 responses

Ninety-two percent of those surveyed were members of a state/regional agricultural aviation association. Membership in state/regional associations and NAAA in the 2019 survey were nearly identical to data collected in the 2012 survey. The 2019 pilot survey found that 83% of pilots were members of a state/regional agricultural aviation association.

NAAA's membership data indicated 48% of the nation's operators were members of the Association as of the end of 2017 based on the fact that there were 748 operator members of NAAA and an estimated 1,560 total operators in the U.S. For pilots, NAAA's membership data indicated 490 or 24% of the 2,028 hired ag pilots in the US were members of the Association.

Figure 5 – Map with percentage of responding operators by region



*Note: Alaska and Hawaii are considered to be part of the Far West Region

Regional distribution of respondents and their membership status is shown in Table 1. Figure 5 above illustrates the regional divisions referenced in Table 1 and gives the overall response of regional distribution.

Table 1 – Business headquarters by region and by NAAA membership

	Far West No. (%)	Midwest No. (%)	East No. (%)	South No. (%)	Total No.	Percent of total
Members	82 (76%)*	190 (85%)	10 (91%)	168 (82%)	450	82%
Non-Members	25 (24%)	36 (15%)	1 (9%)	38 (18%)	100	18%
Total	107 (19%)**	226 (41%)	11 (2%)	206 (38%)	550	100%

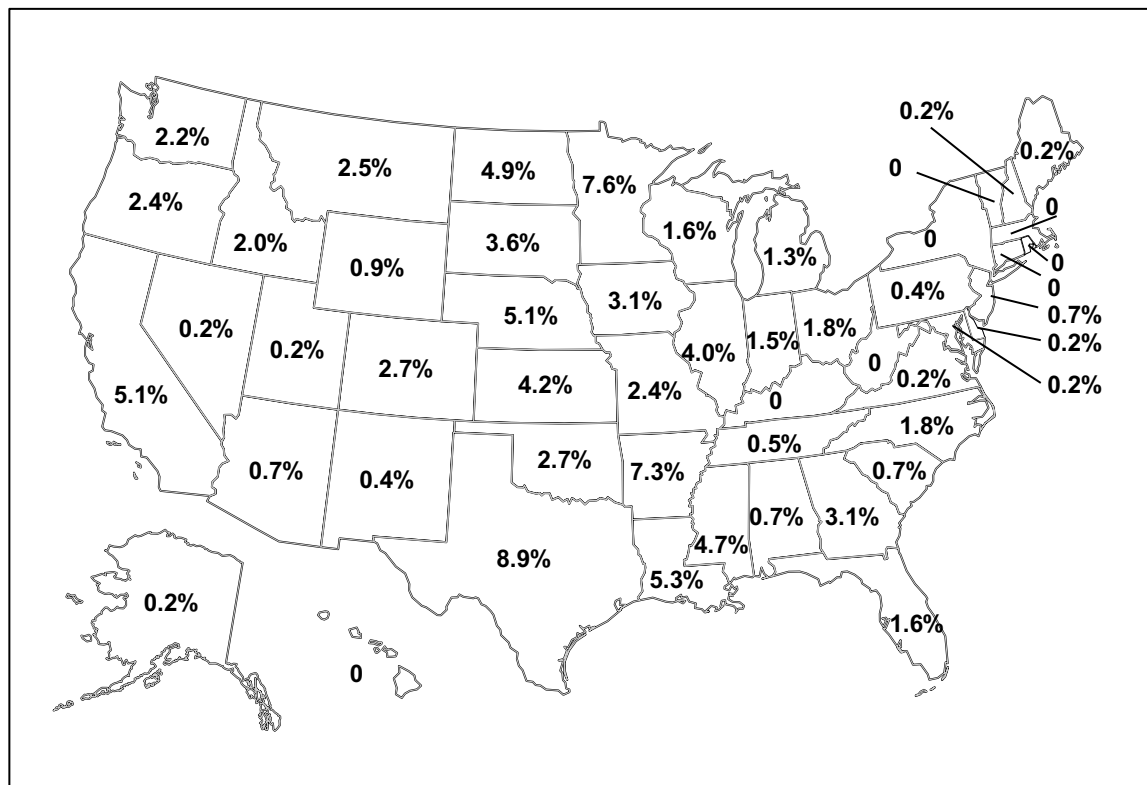
*Percent of respondents in the region **percent of total respondents

Survey question: In which state is your aerial application business headquartered?

Table 2 – Business headquarters by state

State	Number of Operations	Rank	Percent	State	Number of Operations	Rank	Percent
Alabama	4	22	0.7%	Montana	14	13	2.5%
Alaska	1	25	0.2%	Nebraska	28	5	5.1%
Arizona	4	22	0.7%	Nevada	1	25	0.2%
Arkansas	40	3	7.3%	New Hampshire	1	25	0.2%
California	28	5	5.1%	New Jersey	4	22	0.7%
Colorado	15	12	2.7%	New Mexico	2	24	0.4%
Connecticut	0		0.0%	New York	0		0.0%
Delaware	1	25	0.2%	North Carolina	10	17	1.8%
District of Columbia	0		0.0%	North Dakota	27	6	4.9%
Florida	9	18	1.6%	Ohio	10	17	1.8%
Georgia	17	11	3.1%	Oklahoma	15	12	2.7%
Hawaii	0		0.0%	Oregon	13	14	2.4%
Idaho	11	16	2.0%	Pennsylvania	2	24	0.4%
Illinois	22	9	4.0%	Rhode Island	0		0.0%
Indiana	8	19	1.5%	South Carolina	4	22	0.7%
Iowa	17	11	3.1%	South Dakota	20	10	3.6%
Kansas	23	8	4.2%	Tennessee	3	23	0.5%
Kentucky	0		0.0%	Texas	49	1	8.9%
Louisiana	29	4	5.3%	Utah	1	25	0.2%
Maine	1	25	0.2%	Vermont	0		0.0%
Maryland	1	25	0.2%	Virginia	1	25	0.2%
Massachusetts	0		0.0%	Washington	12	15	2.2%
Michigan	7	20	1.3%	West Virginia	0		0.0%
Minnesota	42	2	7.6%	Wisconsin	9	18	1.6%
Mississippi	26	7	4.7%	Wyoming	5	21	0.9%
Missouri	13	14	2.4%	Total	550		100.00%

Figure 6 – Map of headquarters by state



Respondent business headquarters were in 42 states. Respondent headquarters' state is shown in Table 2 and Figure 6. In the 2012 survey, responses were received from businesses in 45 of 50 states.

No responses were received from Rhode Island, West Virginia, New York, Kentucky, Massachusetts, Connecticut, Vermont, District of Columbia or Hawaii. States with the most responses were Texas - 49 (8.9%), Minnesota - 42 (7.6%), Arkansas - 40 (7.3%), Louisiana - 29 (5.3%), California - 28 (5.1%), Nebraska - 28 (5.1%), and North Dakota - 27 (4.9%).

States with the most responses in the 2012 survey were Texas - 57 (11.2%), Arkansas - 40 (7.9%), Minnesota - 34 (6.7%), Kansas - 26 (5.1%), and California - 26 (5.1%) States lacking responses in 2012 were Rhode Island, West Virginia, Nevada, Connecticut, Vermont and Hawaii.

Survey question: Please list the states in which you do aerial application.

Table 3 – Table of states where operators report making applications

State	Number of Operations doing business in state	Percent	Rank	State	Number of Operations doing business in states	Percent	Rank
Alabama	21	3.8%	21	Montana	29	5.3%	17
Alaska	3	0.5%	31	Nebraska	73	13.3%	5
Arizona	10	1.8%	27	Nevada	13	2.4%	25
Arkansas	64	11.7%	6	New Hampshire	0	0.0%	
California	36	6.6%	13	New Jersey	5	0.9%	30
Colorado	42	7.7%	10	New Mexico	18	3.3%	23
Connecticut	0	0.0%		New York	7	1.3%	29
Delaware	5	0.9%	30	North Carolina	26	4.7%	19
District of Columbia	0	0.0%		North Dakota	57	10.4%	7
Florida	30	5.5%	16	Ohio	19	3.5%	22
Georgia	35	6.4%	14	Oklahoma	46	8.4%	9
Hawaii	1	0.2%	33	Oregon	27	4.9%	18
Idaho	27	4.9%	18	Pennsylvania	10	1.8%	27
Illinois	80	14.6%	2	Rhode Island	0	0.0%	
Indiana	32	5.8%	15	South Carolina	10	1.8%	27
Iowa	80	14.6%	2	South Dakota	53	9.7%	8
Kansas	79	14.4%	3	Tennessee	18	3.3%	23
Kentucky	12	2.2%	26	Texas	77	14.1%	4
Louisiana	41	7.5%	11	Utah	8	1.5%	28
Maine	5	0.9%	30	Vermont	1	0.2%	33
Maryland	7	1.3%	29	Virginia	23	4.2%	20
Massachusetts	2	0.4%	32	Washington	23	4.2%	20
Michigan	19	3.5%	22	West Virginia	7	1.3%	29
Minnesota	88	16.1%	1	Wisconsin	15	2.7%	24
Mississippi	42	7.7%	10	Wyoming	19	3.5%	22
Missouri	40	7.3%	12	Total	1385	100.0%*	

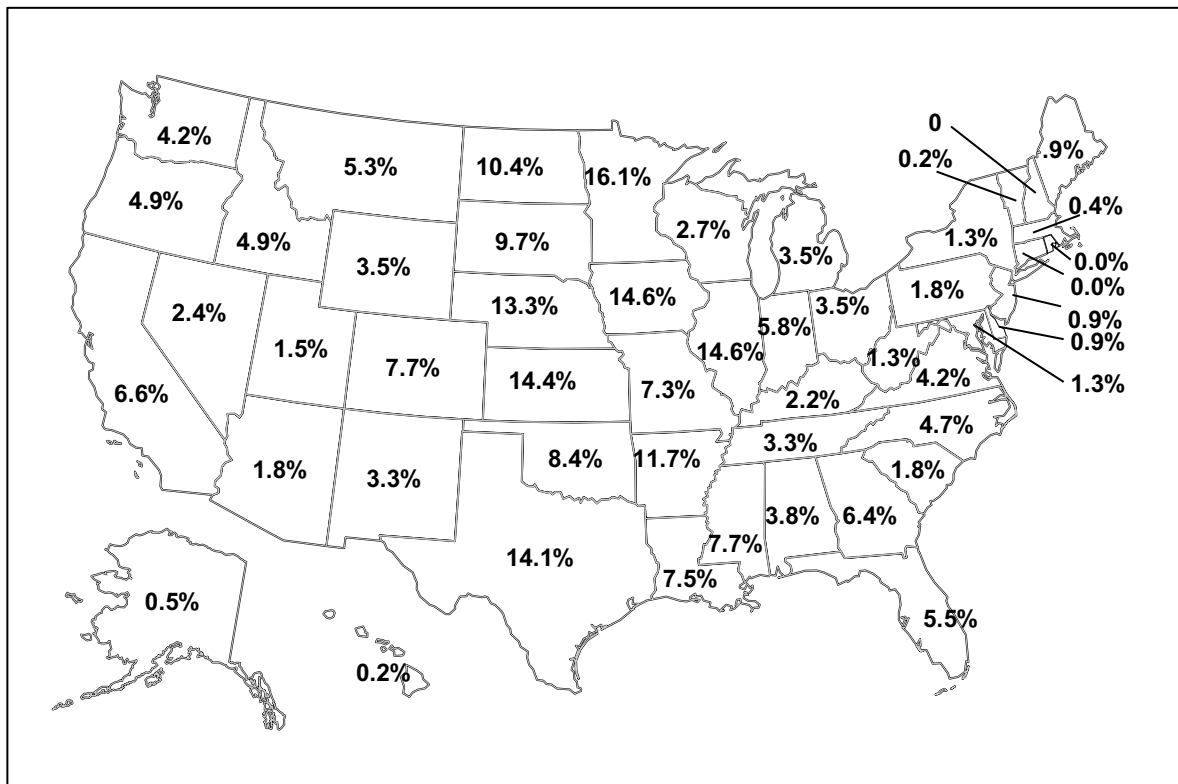
*percent of 548

Respondents were asked to list the states in which they conducted operations and the results are given in the Table 3 and Figure 7. The majority of operations conducted business in two or more states. Percentages are calculated based on 548 responses.

States where the greatest number of operators reported performing applications were Minnesota - 88 (16.1%), Illinois - 80 (14.6%), Iowa - 80 (14.6%), Kansas - 79 (14.4%), Texas - 77 (14.1%), Nebraska - 73 (13.3%), and Arkansas - 64 (11.6%). Operators reported no activity in Connecticut, District of Columbia, New Hampshire and Rhode Island.

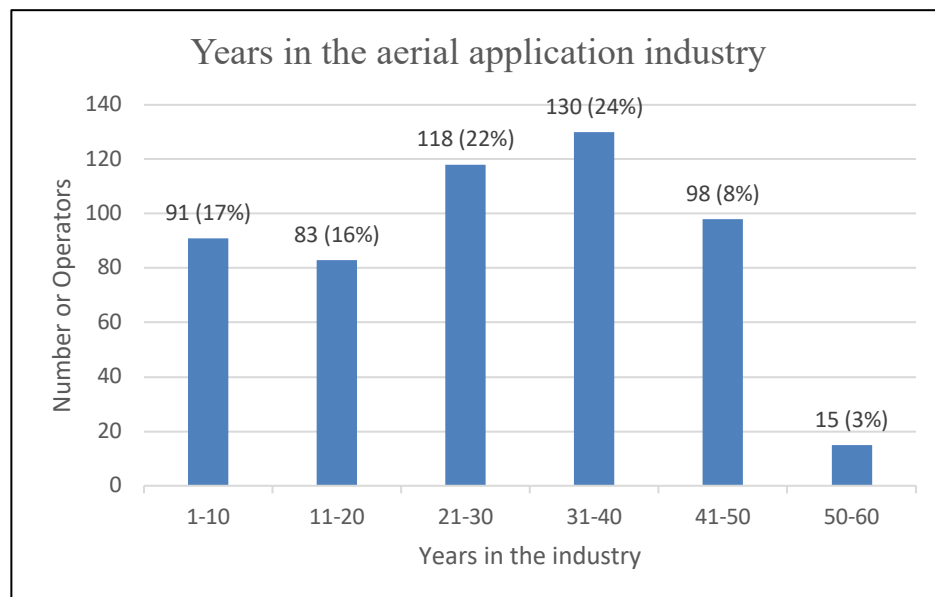
In 2012, the leading states were Iowa - 88 (17.3%), Texas - 80 (15.7%), Minnesota - 75 (14.8%), Arkansas - 67 (13.2%), Illinois - 62 (12.2%), and Nebraska - 60 (11.8%). In 2012, operators reported no activity in Connecticut, District of Columbia, Hawaii and New Hampshire.

Figure 7 – Map of states where operators report making applications



Survey question: How long have you been in the aerial application industry? ____ years.

Figure 8 – Years in the aerial application industry

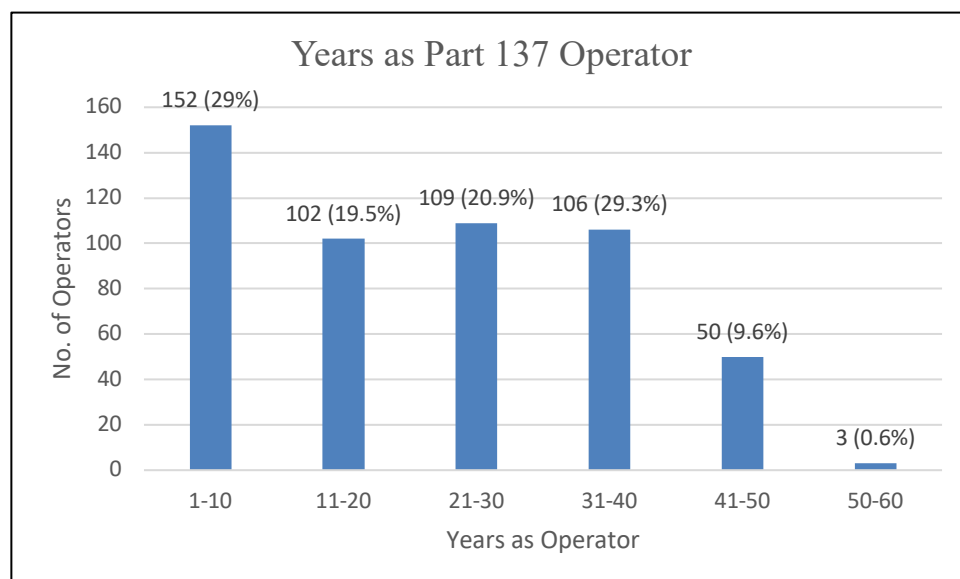


*535 responses

Respondents have been in the industry an average of 27.9 years (27.4 years in 2012). See Figure 8. Nearly a quarter of the respondents have been in the industry 30 to 40 years. Over one-half (57%) have been in the industry 21 years or more.

Survey question: How long as an operator? ____ years.

Figure 9 – Number of years as a Part 137 Operator

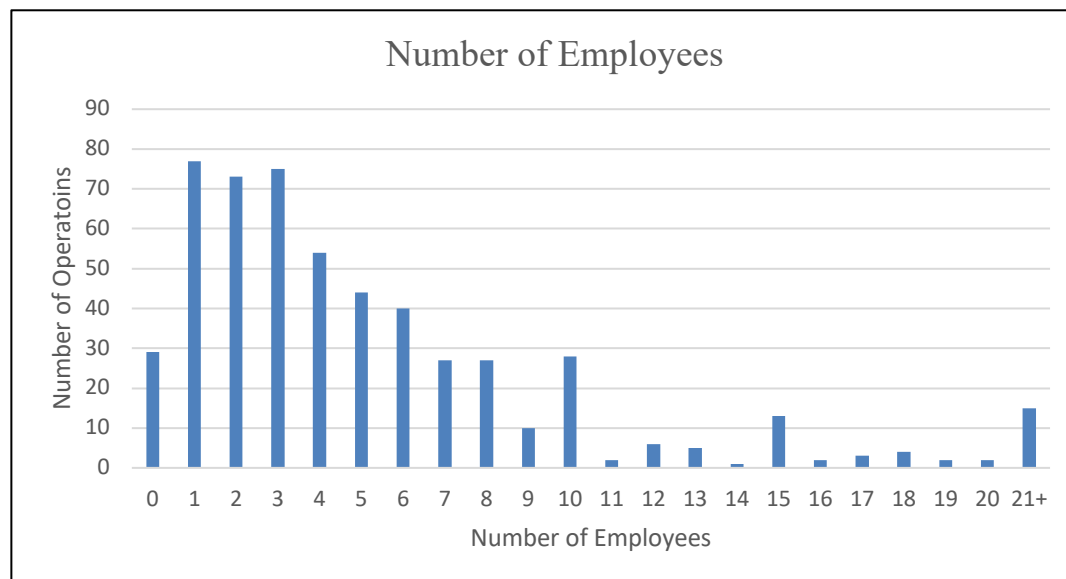


*522 responses

Respondents have been in business as the **operator** for an average of 21.9 years (21.7 years in 2012) and ranged from one year to 54 years as an operator.

Survey question: How many people do you employ in your application business?

Figure 10 – Number of employees in the operation

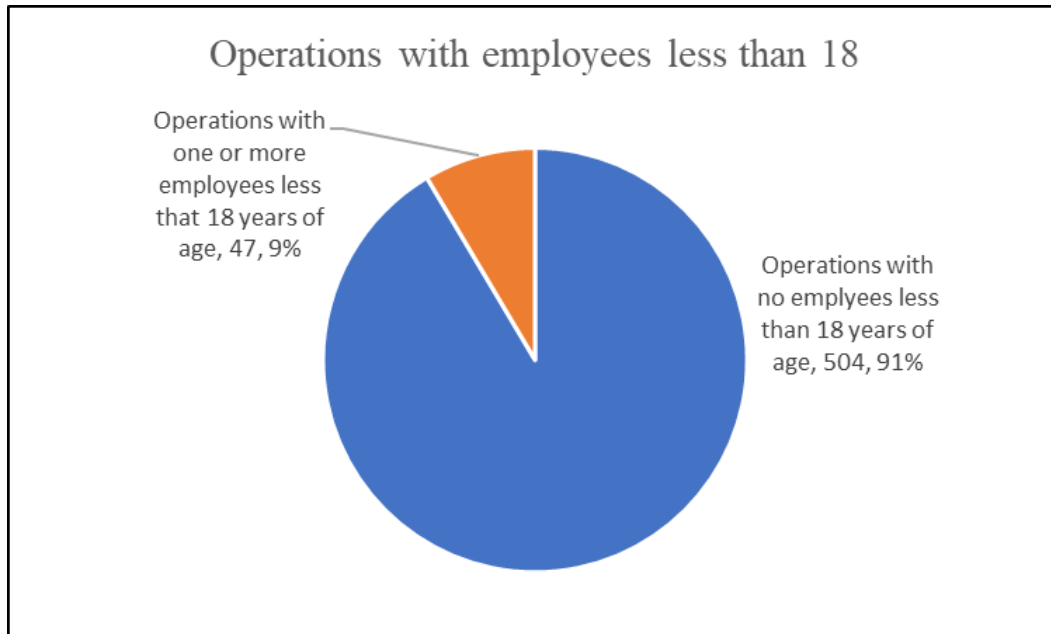


*548 responses

Size of the operation in terms of the number of employees is shown in Figure 10. Median (midpoint of the distribution) number of employees is 4. Twenty-nine operations had no employees, 77 operations had one employee and 73 had two employees compared to 27, 79 and 82 respectively in 2012. Nearly one-half of the operations (46%) had 3 or fewer employees. Operations had an average of 6.2 employees. In 2012 operators reported, on average, 5.1 employees per operation.

Survey question: How many of your employees are under age 18?*

Figure 11 – Number of employees under age 18



*549 responses

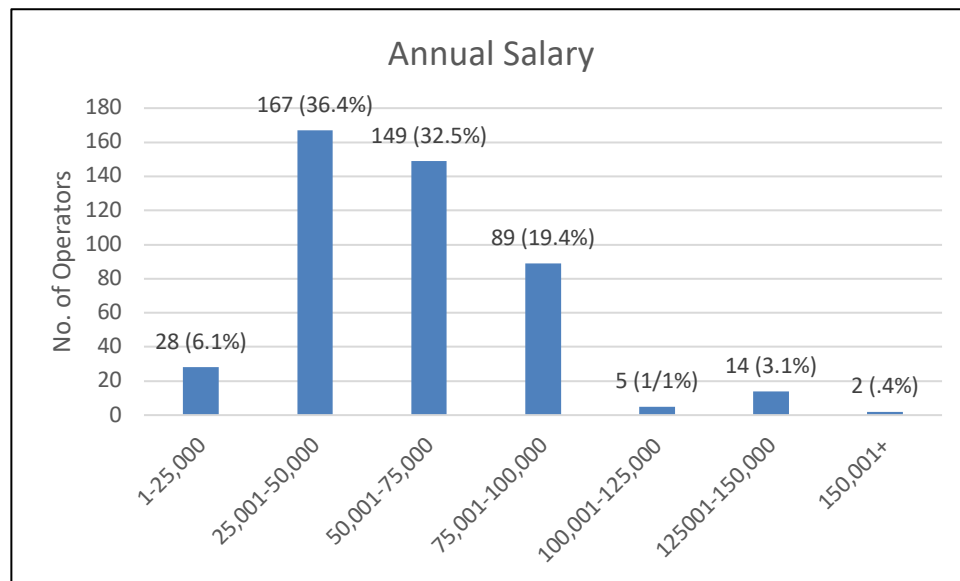
The vast majority (91%) had no employees younger than 18 years of age, while 47 operations (9%) had at least one person younger than 18 years of age. See Figure 7.

Survey question: Of all employees under 18, how many are your immediate or extended family?

Forty-seven operations (9%) reported they had employee(s) under 18 years of age and of these 47, about one-half (23) employed immediate or extended family under 18.

Survey question: If you were to hire a full-time pilot in 2018 with 1,000 hours ag application time and two years of experience, what would you pay him or her annually?

Figure 12 – Annual salary estimate for pilots with 1,000 hours of ag time and two years of experience



*459 responses

Average salary estimates for a pilot with 1,000 hours of ag time was \$63,540 and ranged from \$10,000 to \$200,000. Four hundred fifty-nine operators responded to the question. Half of the responses were greater than \$60,000 and half were less than \$60,000. Over two thirds (68%) said they would pay between \$25,001 and \$75,000. See Figure 12.

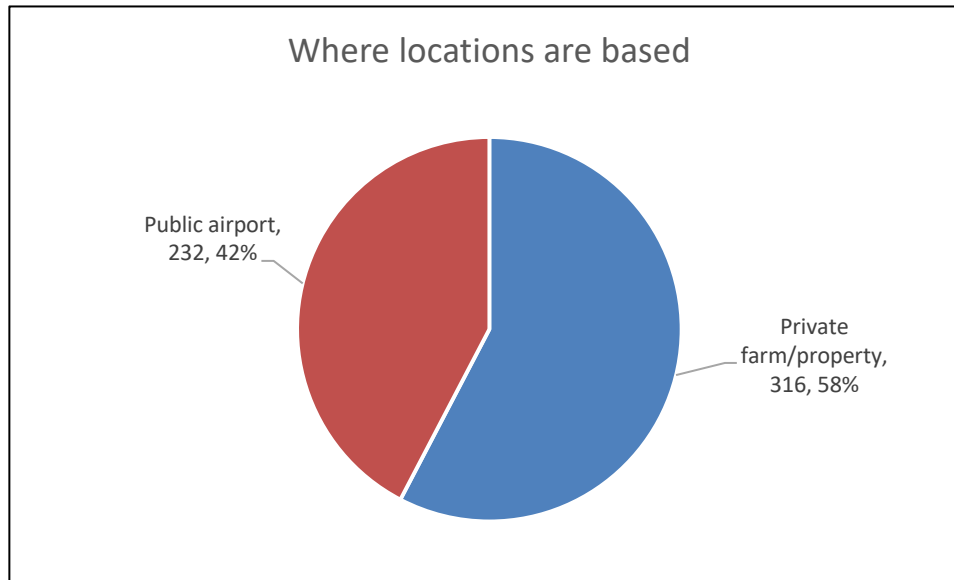
Average salary and salary range by region are given in the table below.

Table 4 – Average salary by region for 1,000 hours of ag time and two years of experience

Region	Average	Range	Responses
East	\$64,500	\$30,000-\$85,000	10
South	\$67,566	\$10,000-\$200,000	169
Midwest	\$57,565	\$10,000-\$200,000	184
Far West	\$67,968	\$10,000-\$150,000	95

Survey question: Where is your operation based? On a public (tax supported) airport or on a private farm or on private property (not publicly funded).

Figure 13 – Location of operation, public or private property



*548 responses

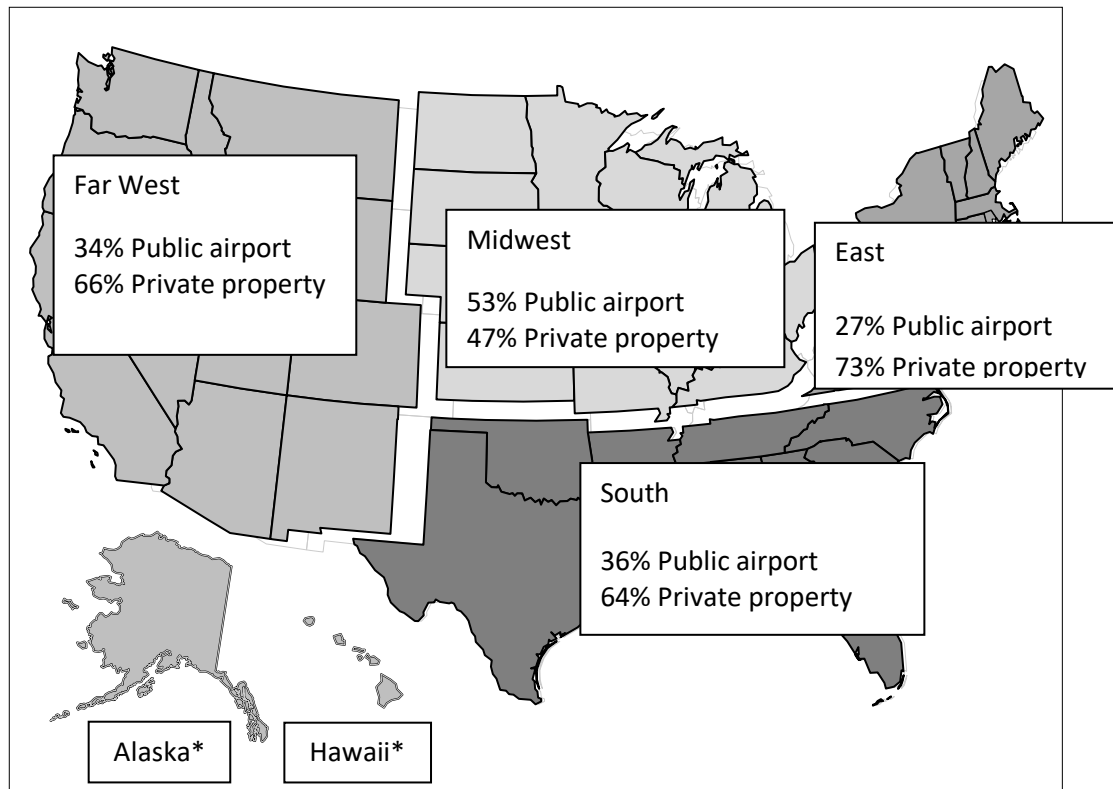
More than half (58%) of the operations are based on private property. See Figure 13. Regional distribution in which operations are based are provided in Table 5 below.

Table 5 – Regions and airport types

	East	Midwest	South	Far West	Total
On Private property	8 (73%)	106 (47%)	132 (64%)	70 (66%)	316 (58%)
On Public Airport	3 (27%)	120 (53%)	73 (36%)	36 (34%)	232 (42%)
Total reporting	11	226	205	106	548

A higher proportion of the operations in the Midwest are on public airports compared to other regions. Regions are shown in Figure 14.

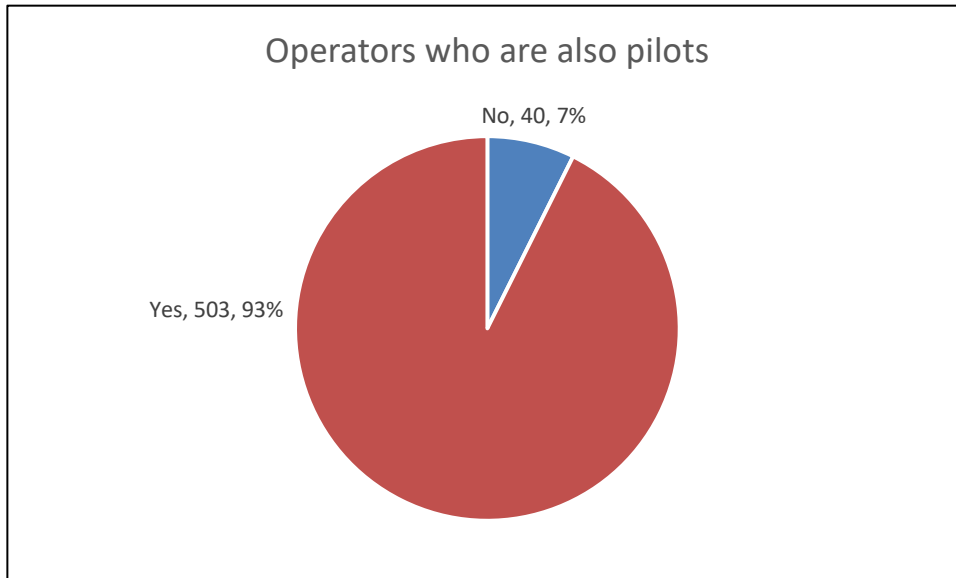
Figure 14 – Location of operation by region, public or private property



*Alaska and Hawaii are part of the Far West

Survey question: Are you a pilot?

Figure 15 – Operators who are also pilots

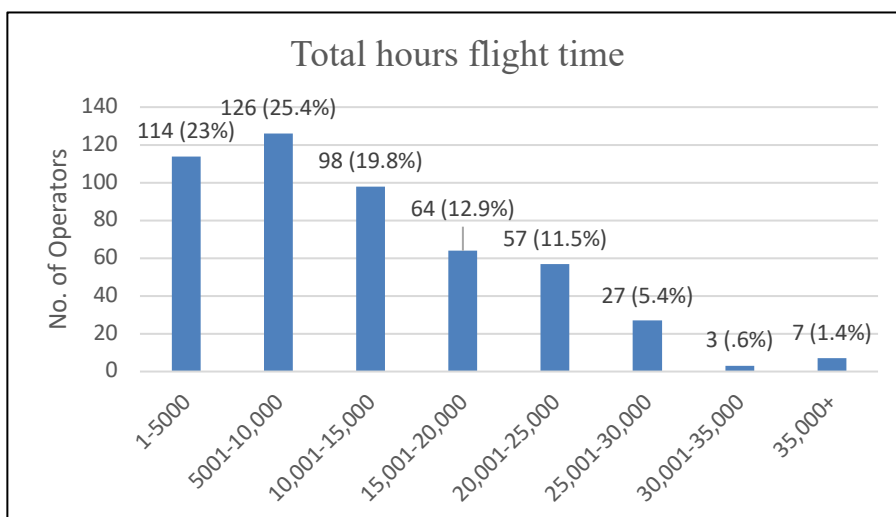


*543 responses

The majority (93%) of the operators are also pilots. In 2012, 94% of the operators were also pilots. If the Operator is also pilot, they were asked questions about flight hours. This survey did not ask if the Operator was one of the ag pilots at the operation.

Survey question: How many hours of total flight time do you have?

Figure 16 – Operator Total Flight Time

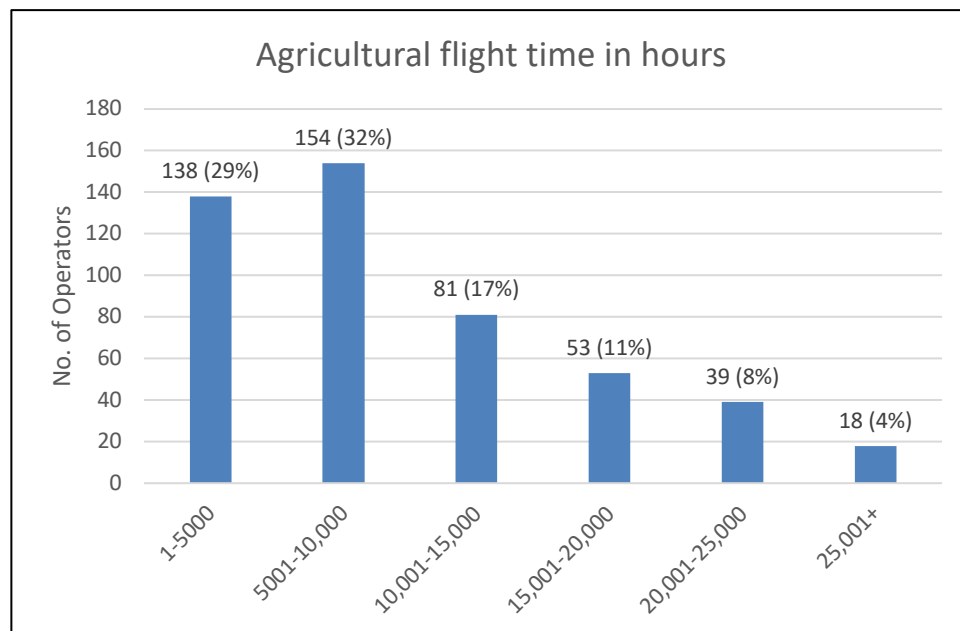


*496 responses

The average total flight time for operators is 12,404 hours. In 2012, the average total flight time was 12,336 hours. Reported hours ranged from 200 to 44,000. Half the operators have more than 10,500 hours. See Figure 16.

Survey question: How many hours of ag time do you have?

Figure 17 – Operator total ag time

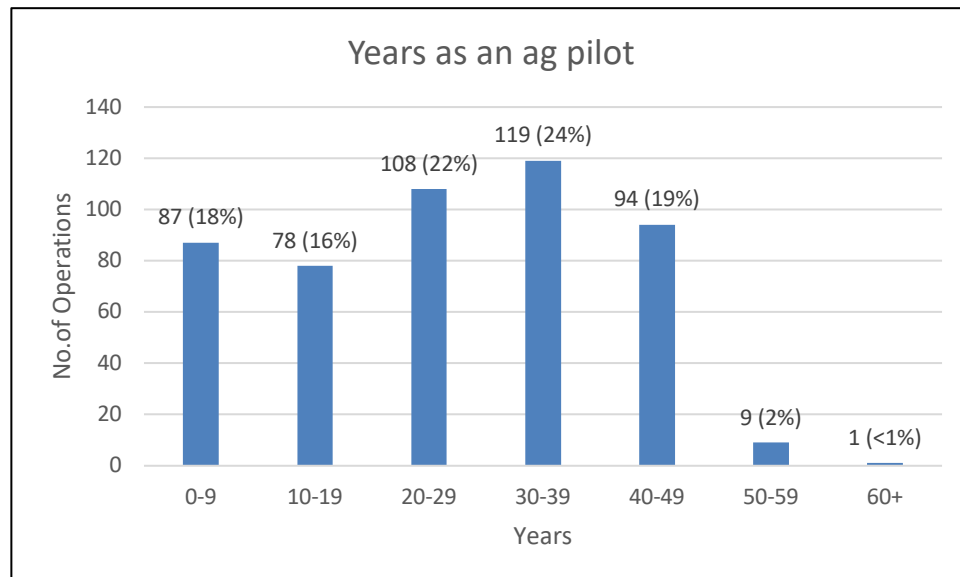


*483 responses

Average ag time among operators is 10,242 hours and half of the 483 operators who are also pilots have more than 9,000 hours. Ag hour flight time ranged from 5 to 35,000 hours. In 2012, operator respondents had an average of 9,946 hours as an agricultural pilot. See Figure 17. The 2019 pilot survey showed that hired pilots have an average ag time of 7,450 hours. Fifty (16%) of the pilots reported having less than 1000 ag hours.

Survey question: How many years have you been an agricultural pilot?

Figure 18 – Total years as an ag pilot



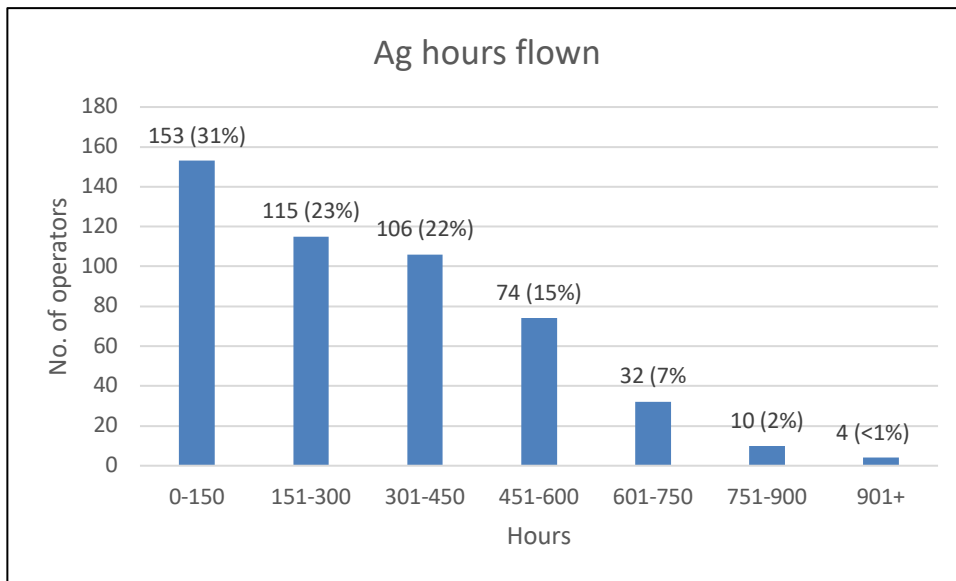
*496 responses

The average number of years operators have been ag pilots is 25.7. Responses ranged from 0 to 60. In 2012, the average operator-pilot had been an agricultural pilot for 25.5 years and responses ranged from 2 to 60 years. Eighty-seven respondents in the 2019 survey have less than 10 years' experience as an ag pilot whereas in 2012, fifty-nine respondents had been an agricultural pilot less than 10 years. See Figure 18. For pilots, the average number of years as an agricultural pilot is 17.2 years, with nearly one half (46.7%) have been an ag pilot for ten or fewer years.

Survey question: How many agricultural hours did you fly in 2017?

Hours ranged from 0 to 1,020. Operators who flew ag averaged 344 hours. Half of the Operators flew more than 299 hours. Results from the 2012 survey showed operator-pilots flew an average of 333 hours as an agricultural pilot ranging from 0 hours up to 1,127 hours. See Figure 19.

Figure 19 – Total Ag hours flown

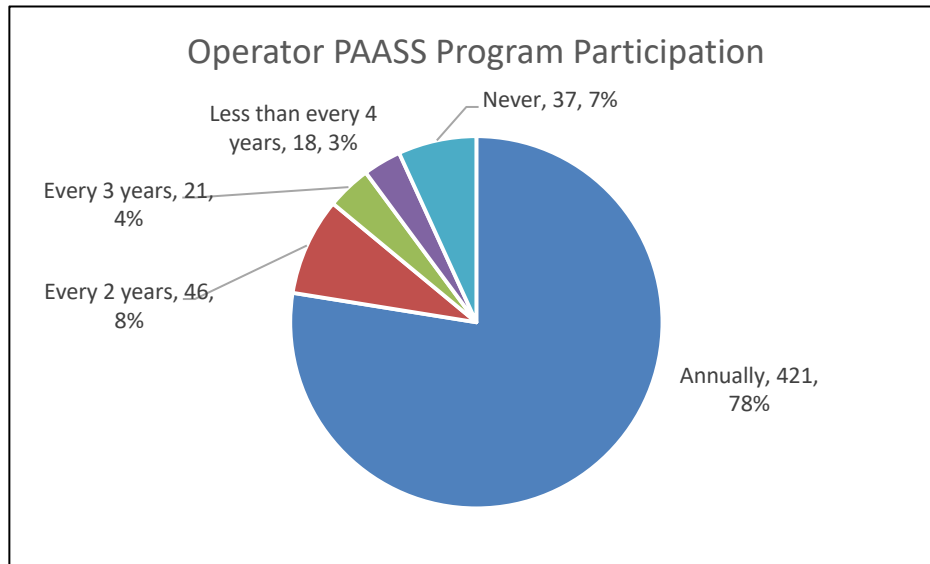


*494 responses

Fifty operators (10%) flew zero hours and all of these 50 reported having at least one pilot who made applications.

Survey question: How often do you attend the PAASS Program? Annually, Never, Less than every 4 years, Every 3 years, Every 2 years.

Figure 20 – PAASS Program attendance by operators

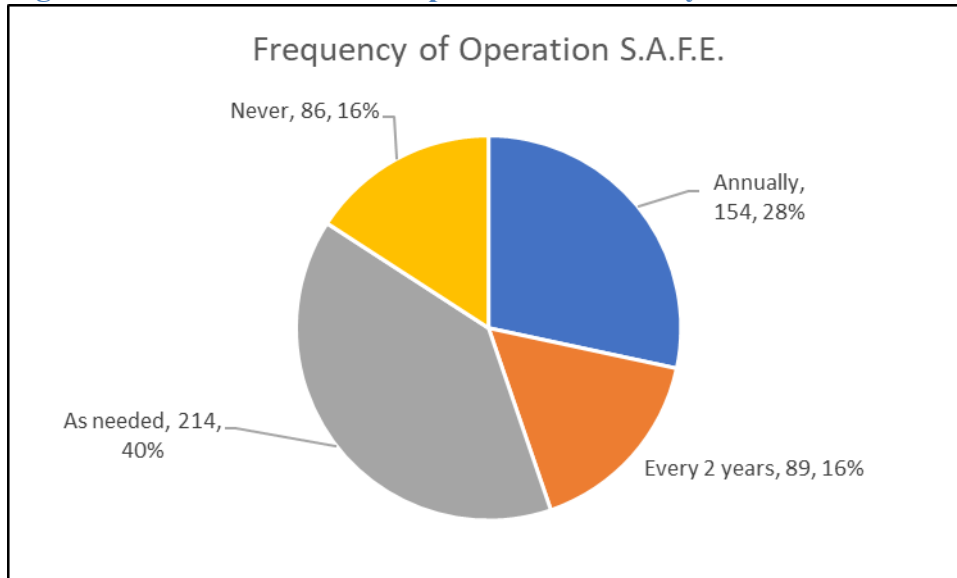


*543 responses

The majority of operators (78%) attend the PAASS program annually and another 8% attend every two years. See Figure 20.

Survey Question: How often do the aircraft used at your operation get tested at Operation S.A.F.E. fly-in clinics?

Figure 21 – Aircraft tested at operation S.A.F.E fly-in clinics



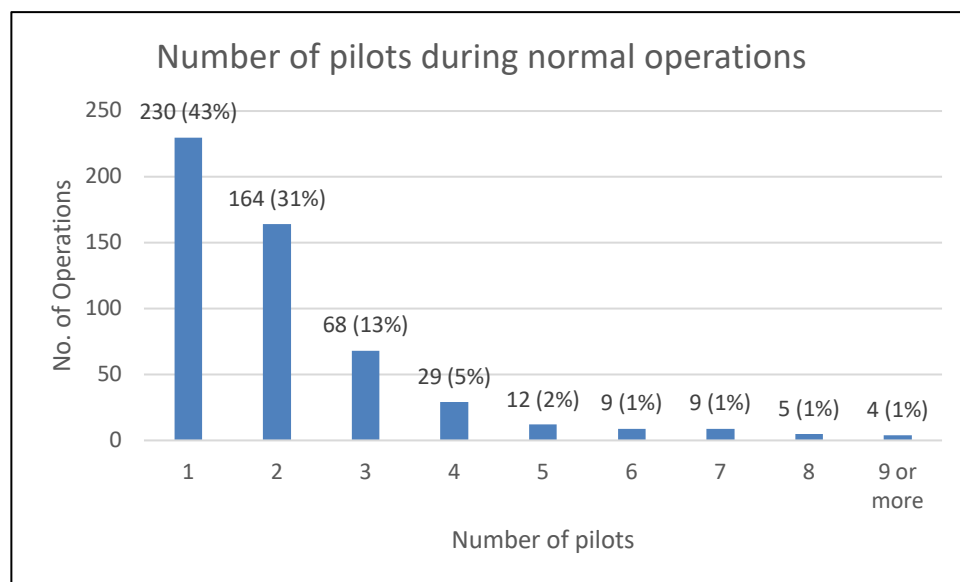
*543 responses

Forty-four percent of the operators said they participate in Operation S.A.F.E fly-in clinics either annually or every two years.

Survey question: How many pilots fly during normal operations?

*Note from survey: The next questions are about the airplanes and helicopters at your operation during **normal operations** during **non-peak times**. **Normal operations** are defined as routine day-to-day operations not including backup or spare aircraft.*

Figure 22 – Number of pilots during normal operations



*530 responses

Operators have an average of 2.17¹ pilots during normal flight operations. Most (74%) of operations have two or fewer pilots. Forty-three percent of operations have one pilot during normal operations. Median number of pilots per operation is 2. See Figure 22.

¹ One operation reported 25 pilots. If this is removed from the average calculation, the average number of pilots at an operation during normal operations is 2.13.

To estimate the number of hired agricultural pilots in the US, we start with the estimated 1,560 number of operations actively engaged in the industry. Our survey found that 434 (87 %) of the operators also flew more than 10 hours indicating they likely counted themselves when responding to the question about how many pilots fly during normal operations. Therefore 87% (1,357) of the 1,560 operations in the US are operations where the operator is also a pilot making applications. If each operation has 2.17 pilots during normal operations as our survey found, there are 3,385 agricultural pilots and subtracting the 1,357 who are also operators, we conclude there are 2,028 hired ag pilots in the US.

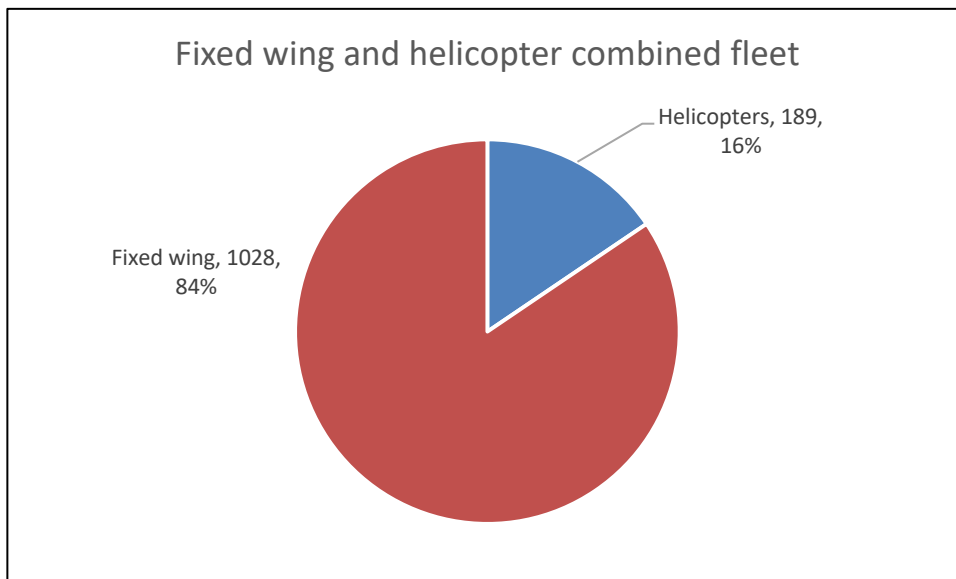
4.1.2. Equipment and Standard Practices

This section describes the operations including number and type of aircraft, equipment, standard practices and crops treated.

Survey question: How many airplanes fly during normal operations?

Survey question: During normal operations, how many helicopters does your business use?

Figure 23 – Fleet makeup of airplanes and helicopters



An analysis of the combined fleet of airplanes and helicopters is presented on the following pages. Based on the data, fixed-wing aircraft account for 84% of the fleet and helicopters make up the remaining 16%. See Figure 23. These are comparable to the 2012 survey when the proportion of fixed-wing aircraft and helicopters was 87% and 13%, respectively, showing a slight increase in the use of helicopters from the 2012 to the 2019 survey.

During normal operations, calculations based on the respondent's data showed they had an average of 2.3 aircraft per operation. In the 2012 survey, the average number of aircraft was 2.1. Size of responding operations as defined by the number of aircraft owned is shown in Table 6.

Table 6 – Number of aircraft compared to past surveys, percent of operations.

Number of aircraft	2019*	2012	2004	1998	1994	1992
One	42%	42%	36%	40%	34%	32%
Two	30%	31%	37%	34%	36%	42%
Three	13%	13%	15%	14%	16%	15%
Four and over	14%	14%	12%	12%	14%	11%
Average	2.3	2.1	2.2	2.1	2.3	2.2

***dates refer to survey publication dates**

Survey question: During normal operations, how many helicopters are turbine powered?

Survey question: During normal operations, how many airplanes are turbine powered?

Survey question: During normal operations, how many airplanes have a closed cockpit?

Survey question: During normal operations, how many helicopters have a closed cockpit?

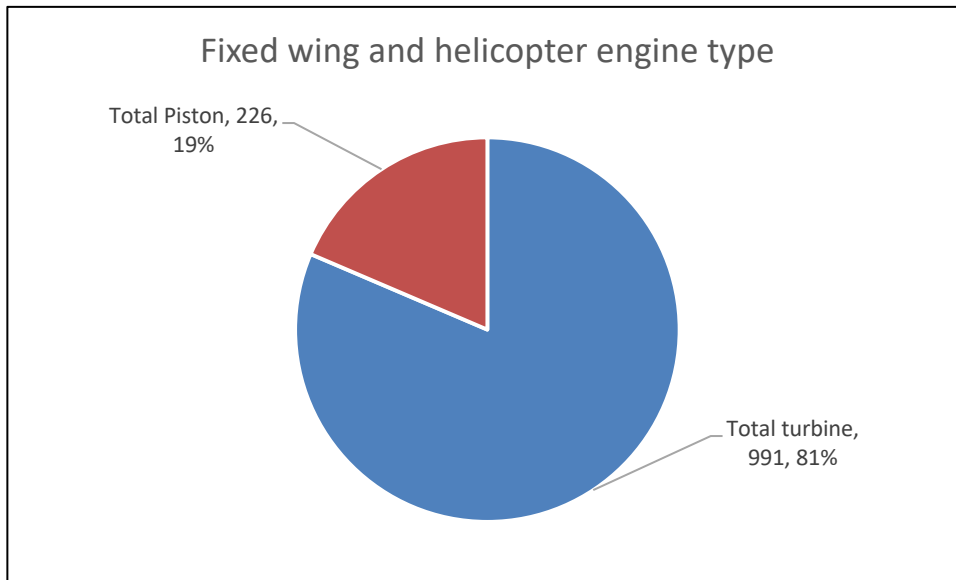
Table 7 – Fixed wing and helicopter characteristics

Aircraft type	Turbine powered	Reciprocating	Closed cockpit	Open cockpit
Fixed wing	856 (83%)	172 (17%)	1028 (100%)	0
Helicopter	135 (71%)	54 (29%)	130 (69%)	59 (31%)

Eight-hundred fifty-six of the fixed-wing aircraft (83.3% of the 1,028 aircraft) are turbine powered. One hundred thirty-five of the helicopters (71.4% of the 189 helicopters) are turbine powered.

Of the combined fleet of airplanes and helicopters, 81% were powered by turbine engines and 19% used piston engines. In 2012, 67% of the combined fixed wing and helicopter fleet were turbine powered. See Figure 24.

Figure 24 – Combined airplane and helicopter engine type



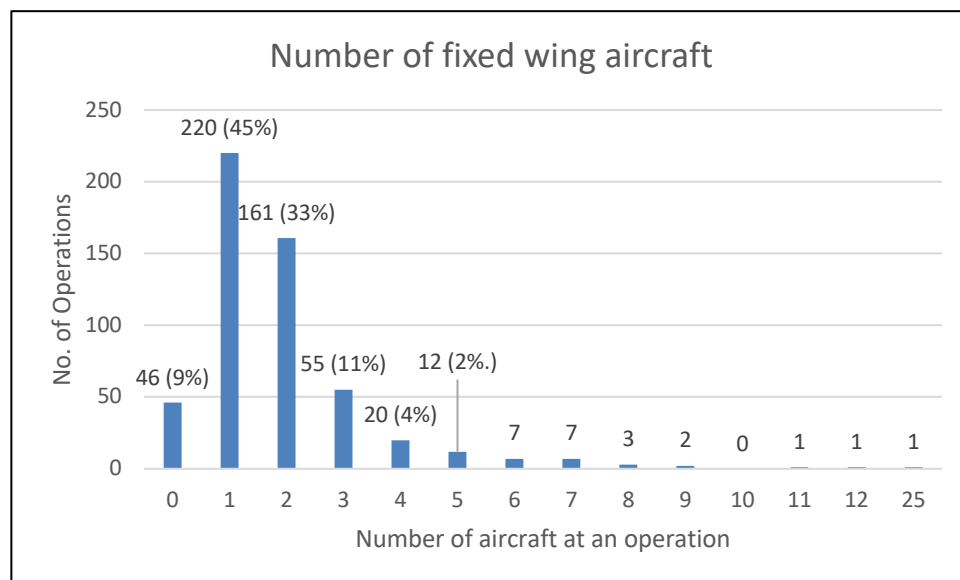
Of the fixed wing aircraft, 100% had a closed cockpit and 69% of the helicopters had a closed cockpit. Overall in this survey, of the 1,217 combined fixed-wing aircraft and helicopters, all but 59 helicopters were equipped with closed cockpits. Those helicopters without closed cockpits can be configured to have closed cockpits by refitting the doors on the helicopter. The doors are removed in order to moderate temperature within the cockpit and reduce heat stress.

In the 2012 survey, 99% of fixed-wing aircraft had closed cockpits and 87% of helicopters used during normal operations had closed cockpits.

Ninety-seven operations reported using at least one helicopter and 24 operations reported using helicopters alone. In 2012, sixty-six operations reported using at least one helicopter and 33 operations reported using helicopters exclusively.

Survey question: How many airplanes at the operation during normal operations?

Figure 25 – Number of fixed-wing aircraft per operation during normal operations



*536 responses

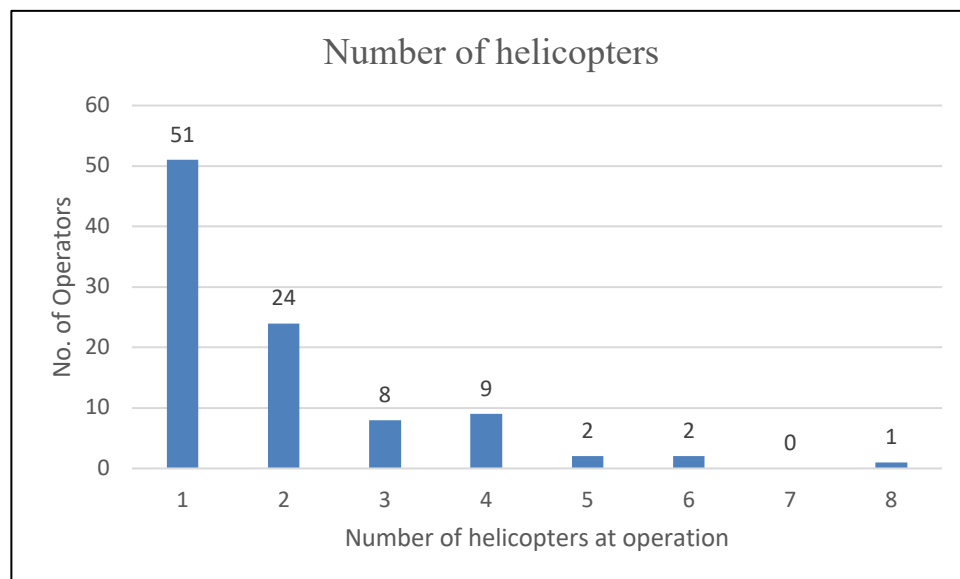
Among operations that have fixed-wing aircraft, they had an average of 2.0 fixed wing aircraft. Forty-six operators reported they do not have any fixed-wing aircraft at their operation. Of those that do have fixed-wing aircraft, 44.9% of these have just one. One third of those who have fixed-wing aircraft have two planes at their operation during normal operations.

Operators reported they used a total of 1,028 fixed-wing aircraft. Of the 536 operators reporting, 490 (91%) used only fixed-wing aircraft in their operation while 47 (9%) reported using both fixed-wing aircraft and helicopters. By contract, in 2012, operators reported they used a total of 938 fixed-wing aircraft. Of the 502 operators reporting in 2012, 436 (87%) used only fixed-wing airplanes in their operation while 33 operators (7%) reported using both fixed-wing and helicopters. In the 2019 survey, 220 operations reported having one fixed-wing aircraft during normal operations. One operation reported they had 25 fixed-wing aircraft.

Survey question: How many helicopters at the operation during normal operations?

The majority (53%) of operations that use helicopters have just one in operation. See Figure 26. Among operations that have helicopters, each operation has an average of 1.9 helicopters. Seventy-one percent of these helicopters are turbine powered. In 2012, 65% of the helicopters in use were turbine powered.

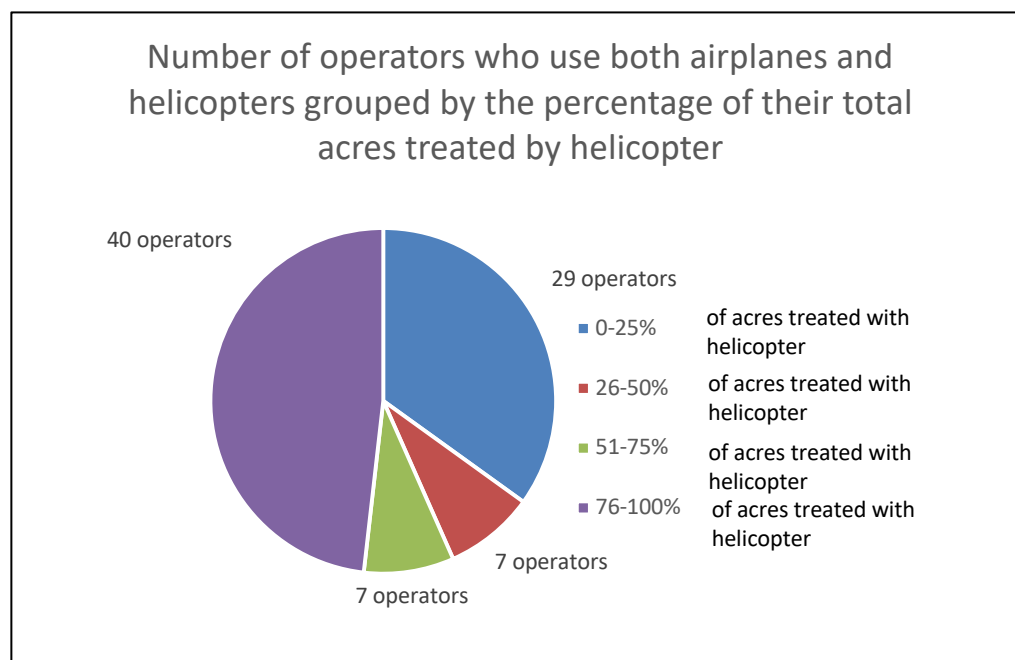
Figure 26 – Number of helicopters per operation during normal operations



Survey question: If you use both airplanes and helicopters at your operation in 2017, what percentage of the total acres were treated using helicopters?

In the 83 operations that have both fixed-wing and helicopters, an average of 59% of the acres treated are with helicopters.

Figure 27 – Operations with both fixed wing and helicopters- proportion of acres treated with helicopters



Forty operators (48%) of those who use both airplanes and helicopters in their business said that they use helicopters on more than 75% of the acres they treat.

Survey question: How many of the aircraft (planes and helicopters) during normal operations have the following equipment?

- **A GPS swath guidance system**
- **An on-board wind/meteorological measurement system that displays wind speed and direction in the cockpit (e.g. Aircraft Integrated Meteorological Measurement System, AIMMS)**
- **A single boom shutoff valve**
- **A method for reducing effective boom length such as valves or shutoffs that can be adjusted on the ground or in flight**
- **Electrostatic aerial spray technology system**
- **A smoker to determine wind direction while performing aerial applications**
- **The STC necessary to perform operations using night vision goggles**
- **Inflatable seat restraints**
- **ADS-B out**
- **ADS-B in**

Survey question: How many aircraft have equipment for making constant rate applications (applies constant application rate regardless of speed) or making variable rate applications (varies the application rate across the field according to a prescription map of soil or crop conditions) for dry applications?

Survey question: How many aircraft have equipment for making constant rate applications (applies constant application rate regardless of speed) or making variable rate applications (varies the application rate across the field according to a prescription map of soil or crop conditions) for liquid applications?

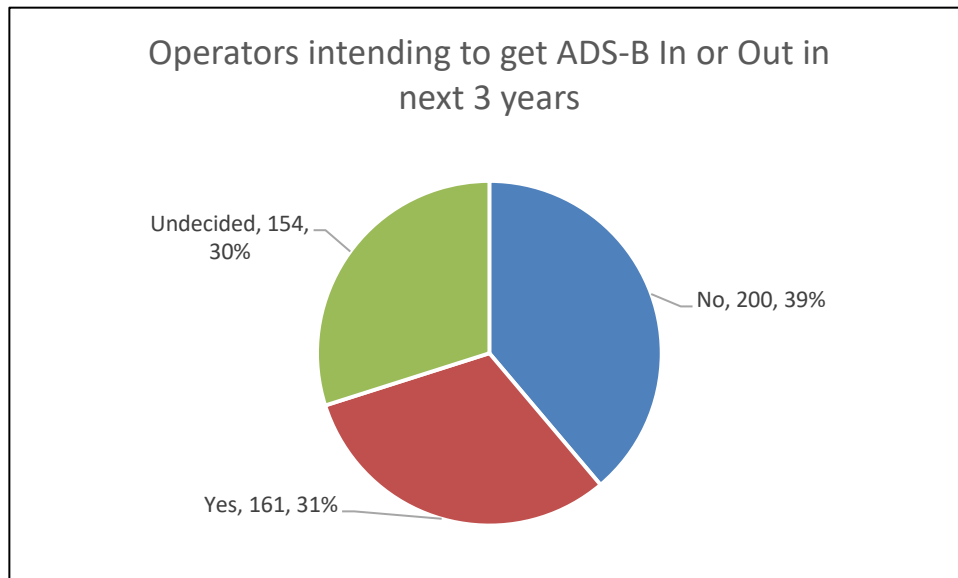
Table 8 – Equipment in aircraft 2019 and 2012 Surveys

Equipment	2019 survey Number of aircraft	2019 survey Percent of aircraft*		2012 survey Number of aircraft	2012 survey Percent of aircraft**
GPS swath guidance system	1208	99.3%		1066	99%
On-board weather measurement system (AIMMS ¹)	94	7.7%		73	7%
Single boom shut off valve	572	47.0%		489	45%
Boom length reduction system	742	61.0%		Not asked	
Electrostatic spray system	51	4.2%		53	5%
Smoker to determine wind direction and speed	981	80.6%		918	85%
STC for night vision goggles	27	2.2%		Not asked	
Inflatable seat restraints	338	27.8%		Not asked	
ADS-B out	129	10.6%		Not asked	
ADS-B in	111	9.1%		Not asked	
Dry flow control equipment	362	29.7%		Not asked	
Liquid flow control equipment	780	64.1%		Not asked	

*1,217 aircraft **1,076 aircraft ¹ Aircraft Integrated Meteorological Measurement System

Survey Question: Do you intend to add ADS-B In or Out during the next three years?

Figure 28 – Intention to get ADS-B-In or Out

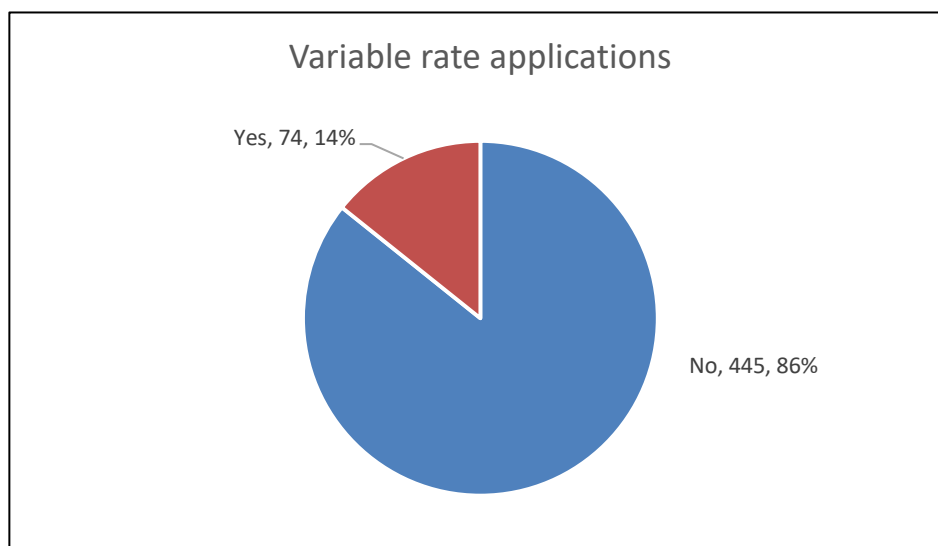


*515 responses

About one-third of operators intend to get ADS-B In or Out in the next three years. See Figure 28 above.

Survey Question: In 2017, did you make any variable rate applications either liquid or dry?

Figure 29 – Variable Rate Applications



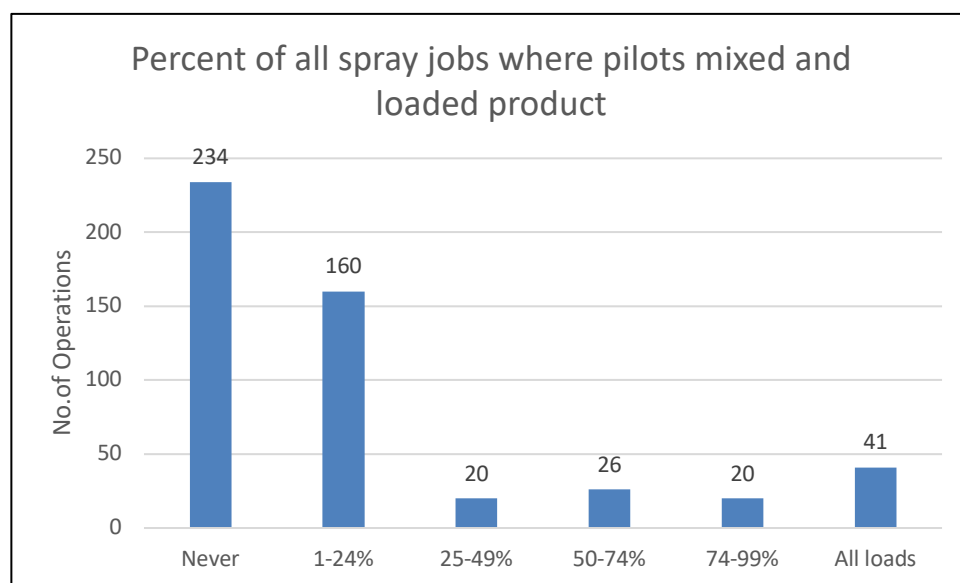
*519 responses

Responses from 519 operators indicated that only 14% of the operators performed either liquid or dry variable rate application. See Figure 29.

Of the 74 operators who did variable rate applications, 55% are located in the South Region.

Survey question: At your operation, what percent of all spray jobs does the pilot also mix and load product?

Figure 30 – Pilot also Mixes and Loads Product



*501 responses

Responses varies from zero to 100 with an average of 18% of the loads mixed by the pilot. Forty-seven percent (234/501) of the operations reported that the pilot never mixes and loads. At 8% of the operations, the pilot always mixes and loads the product. Nearly 4 out of 5 operations (79%) said the pilot mixes and loads less than 25% of the time or not at all. In 2012, 14% of the pilots mixed and loaded. Results for the 2019, 2012 and 2004 surveys are shown in Table 9. The trend is that the pilot is doing less mixing and loading.

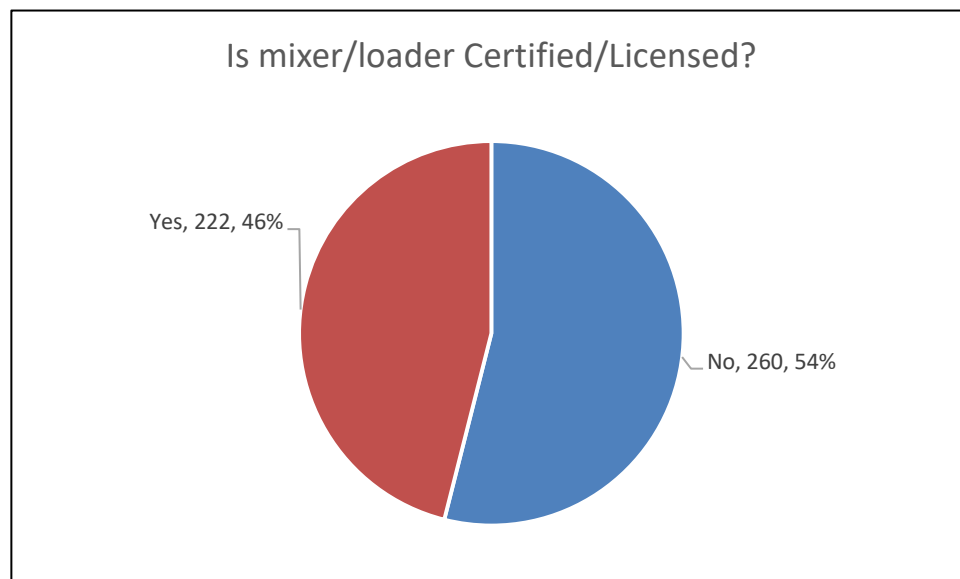
Table 9 – Percentage of all spray jobs mixed and loaded by the pilot

Percentage of loads mixed/loaded by the pilot performing the application								
Percent Range	2019*	2012**	2004***		Percent Range	2019*	2012**	2004***
0%	47%	35%	32%		51-60%	1%	6%	1%
1-10%	27%	40%	29%		61-70%	<1%	6%	.7%
11-20%	5%	6%	4%		71-80%	2%	7%	4%
21-30%	2%	5%	4%		81-90%	1%	2%	3%
31-40%	2%	1%	.3%		91-100%	10%	2%	15%
41-50%	4%	1%	8%					

*percent of 501, **percent of 488, *** percent of 569

Survey question: At your operation, if the mixer/loader is not also a pilot, is this person certified or a licensed applicator?

Figure 31 – Certified or Licensed Applicator



*482 responses

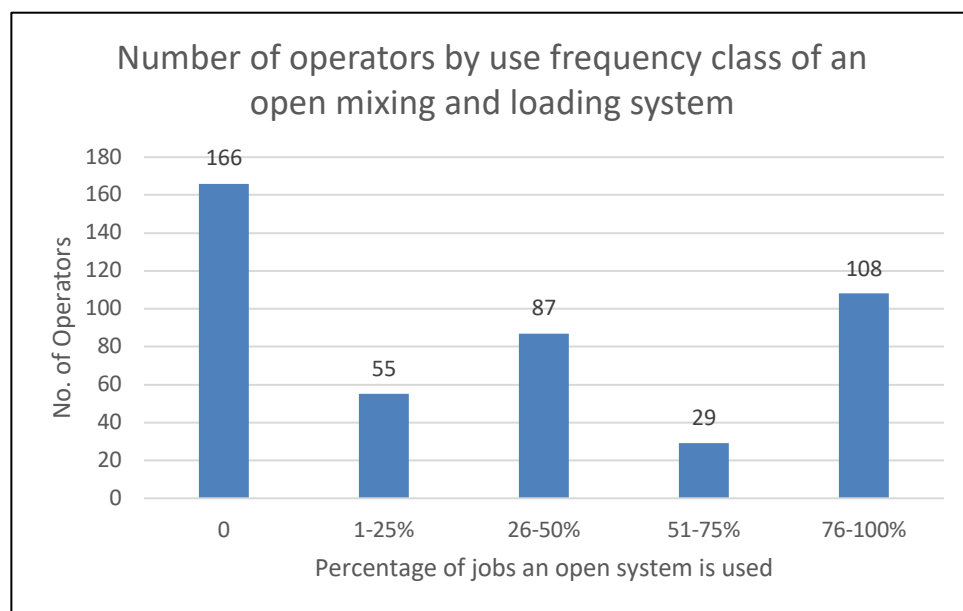
In a little less than half of the operations where the mixer/loader is not the pilot, that person is certified/licensed.

Survey question: At your operation, when pesticides are mixed and loaded for spray application, what percentage of the total mixing/loading jobs use the following practices?

- A closed transfer system is a mechanism that moves pesticide into a spray tank without applicator coming in contact with the pesticide.
- Open transfer (system that allows a mixer/loader to come in contact with pesticide)

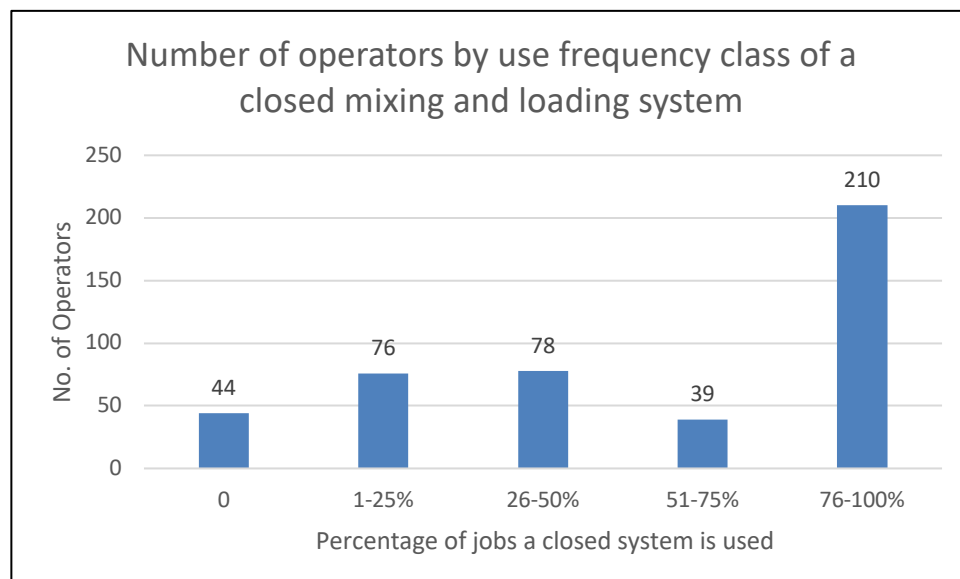
Fifty operations (11%) reported using an open system 100% of the time. Conversely, 37% of the operations said they never use an open system. On average, 38% of the transfers use an open system. An open transfer system allows the mixer/loader to potentially come in contact with the pesticide. See Figure 32.

Figure 32 – Percent of total mixing jobs that use an open transfer system



*445 responses

Figure 33 – Percent of total mixing jobs that use a closed transfer system

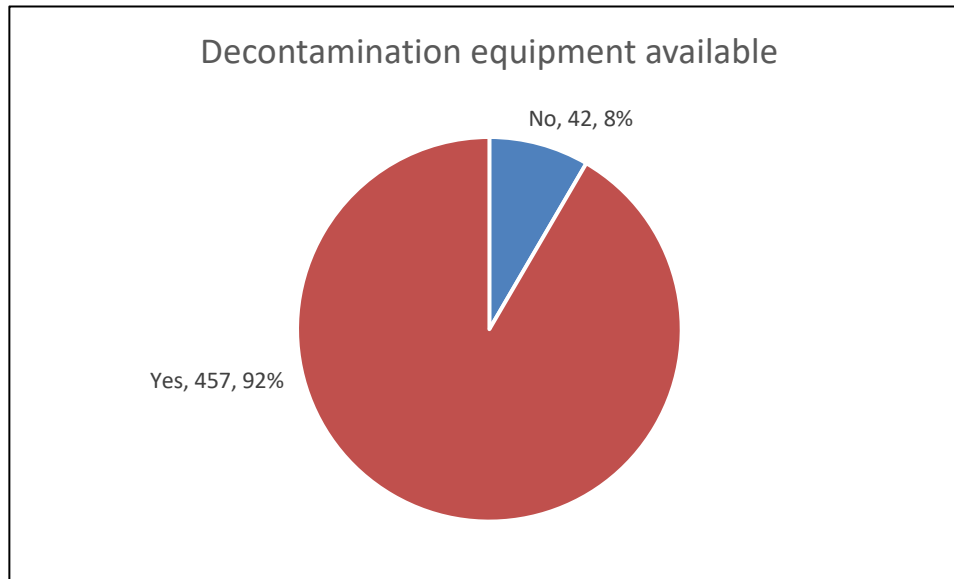


*447 responses

One hundred seventy-four operators (39%) said they use a closed system 100% of the time while 10% never use a closed system. Among those who use a closed system, it is used for an average of 70% of the loads. A closed system does not allow a mixer/loader to come in contact with the pesticide. The difference between the 50 operations who reported using an open system 100% of the time should and the 44 operations that never use a closed system (these would be expected to be equal) is due to either a slight difference in those who responded to the two separate questions or respondent error.

Survey question: Does your operation have decontamination equipment such as a shower available on the airfield?

Figure 34 – Availability of decontamination equipment



*499 responses

When asked if the operation has decontamination equipment, such as a shower, 499 operators responded; 92% responded in the affirmative that decontamination equipment was available at the operation. Of the 42 operators who said they do not have decontamination equipment, 57% are on private farms or private property and 43% are on public (tax supported) airports. The proportion of operations with decontamination facilities in 2019 survey is the same as it was in 2012 survey.

Survey question: Which of the following do you use to control spray drift? (Please check all that apply.) a) Drift control additives, b) Wind detectors on the ground, c) Smoker to monitor wind speed and direction, d) Smoker to monitor inversions, e) Modify droplet size by changing pressure, f) Modify droplet size by changing the nozzle orifice size, g) Modify droplet size by changing nozzle type, h) Modify droplet size by changing nozzle angle, i) Modify droplet size by changing airspeed, j) Change in-flight patterns, k) Right or left boom shut off, l) Reduce effective boom length, on the ground or in-flight, using adjustable valves or shut-offs, m) Buffer zones on the downwind side of the field, n) On-board wind/meteorological measurement system (e.g. AIMMS)

Table 10 – Methods used to control drift reported by 499 Operators

Operators*	Methods used to control spray drift
90.4%	(a) Drift control additives
90.2%	(m) Buffer zones on the downwind side of the field
88.4%	(c) Smoker to monitor wind speed and direction
75.4%	(f) Modify droplet size by changing the nozzle orifice size
69.3%	(d) Smoker to monitor inversions
63.7%	(h) Modify droplet size by changing nozzle angle
63.7%	(j) Change in-flight patterns
59.5%	(e) Modify droplet size by changing pressure
53.9%	(b) Wind detectors on the ground
53.5%	(l) Reduce effective boom length, on the ground or in-flight, using adjustable valves or shut-offs
39.5%	(i) Modify droplet size by changing airspeed
39.3%	(k) Right or left boom shut off
36.9%	(g) Modify droplet size by changing nozzle type
5.2%	(n) On-board wind/meteorological measurement system (e.g. AIMMS)

* 499 operators

The leading three methods used to control spray drift as reported by operators are drift control additives, buffer zones and smokers to monitor wind speed and direction. These are the same three reported by pilots. Overall, the drift control methods reported by operators is greater than reported by pilots. Operators reported using an average of 8.3 methods and pilots an average of 6.9 methods. Twenty-six operations (5.2%) said they use on-board AIMMS, yet 42 operations said they had at least one aircraft equipped with an on-board wind/meteorological measurement

system. The difference between the 88.4% of operations who reported using a smoker to monitor wind speed and direction and the 80.6% of aircraft reported to have a smoker to determine wind speed and direction (table 8) is likely due to either a difference in those individuals who responded to the two separate questions, respondent error, or a the fact that one question is based on the number of operators while the other is based on number of aircraft. For example, one operation could have and report in the survey on two aircraft, one with a smoker and the other without a smoker. They would likely answer that they used a smoker to monitor wind speed and direction as a means to reduce drift for their operation even though only 50% of their aircraft have a smoker.

AIMMS (Aircraft Integrated Meteorological Measurement System) is an on-board system that measures real-time, site-specific atmospheric data, including wind speed, direction, altitude, humidity and temperature. AIMMS enables pilots to line up their swath in a manner that considers wind direction and speed to mitigate drift. Meteorological data is collected and synced with the GPS latitudinal and longitudinal coordinates. Smokers are mechanical devices that inject oil into the aircraft's exhaust system. The smoke produced aids the pilot in determining many factors such as wind direction and velocity and the existence of an inversion.

Those who attend PAASS annually and responded to the drift control technologies question (n=397) reported using more methods to control drift than those who did not attend annually and responded to the drift control question (n=102). Those who attend annually reported an average 8.4 methods whereas those who did not attend annually reported 7.9. Although not statistically significant, the differences do point to the value of the PAASS Program.

Trends in methods to control spray drift are given in the next table. Some questions on this topic in this survey were slightly different compared to previous NAAA surveys, thus direct comparisons cannot be made. Where direct comparisons cannot be made 'n/a' appears in the table. See Table 11.

Table 11 – Trends in methods used to minimize spray drift

Drift Control Method	2019 Survey*	2012 Survey**	2004 Survey
Drift control additives	90%	82%	86%
Wind detectors on the ground	54%	47%	72%
Smokers	n/a	83%	n/a
Smokers to monitor inversions	69%	n/a	n/a
Smoker to monitor wind speed & direction	88%	n/a	n/a
Modify droplet size	n/a	79%	n/a
Modify droplet size-change nozzle angle	64%	n/a	n/a
Modify droplet size-change nozzle orifice size	75%	n/a	n/a
Modify droplet size by changing nozzle type	37%	n/a	n/a
Modify droplet size by changing airspeed	40%	n/a	n/a
Modify droplet size by changing pressure	60%	n/a	59%
Special nozzles	n/a	55%	85%
Right of left boom shut off	39%	n/a	n/a
Reduce effective boom length	54%	n/a	n/a
Changes in flight patterns	64%	73%	82%
On Board AIMMS	5%	4%	n/a
Diluting formulations	n/a	n/a	28%
Appropriate buffer zone on downwind side	90%	n/a	n/a

*percent of 501 respondents ** Percent of 508 respondents

Survey Question: For swath guidance when applying pesticides by air, the operation uses: (check all that apply.) Human flaggers, Automatic flaggers, GPS, Other.

Results and trends are shown in the Table 12 below.

Table 12 – Swath guidance used

Method	2019 Survey*	2012 Survey**	2004 Survey***	1998 Survey****	1994 Survey*****
Human Flaggers	2% ¹	1%	4%	15%	38%
Automatic Flaggers	16%	19%	28%	58%	73%
GPS	99%	93%	92%	60%	25%
Other	<1%	1%	4%	n/a	n/a

*percent of 496, ** percent of 508, *** percent of 596, **** percent of 574, ***** percent of 844

¹ 89% of these respondents also use GPS – only 1 respondent used human flaggers alone.

Other responses given for swath guidance were pivot tracks, pre-placed flags at field edge, years of experience, and human spotter on the ground. For swath guidance when applying pesticides, the majority of respondents most often relied on GPS and rarely used human or automatic flaggers. Nine operators reported they use human flaggers; of these, 8 (89%) also use GPS. Only 0.2% reported using human flaggers alone.

The use of GPS for swath guidance has increased dramatically from 25% in the 1994 survey to 99% in the 2019 survey. Over those same years the use of human flaggers has decreased significantly. In 1994, 38% of operations used human flaggers. In 1998, 15%; in 2004, 4%; and in 2012, just 1% of operations relied on human flaggers for swath guidance. Over the same period and the use of automatic flaggers has also decreased. In 1994, 73% reported use of automatic flaggers; in 1998, 58% used automatic flaggers; in 2004, 28% used automatic flaggers; and in 2012, only 19% of operations reported using automatic flaggers. In the 2019 survey, just 16% of the operations used automatic flaggers.

Survey question: If your aircraft are equipped with smoker(s) to determine wind direction while performing aerial applications, how often are these used?

Table 13 – How often a smoker is used

Frequency of smoker use	No.	%
Before an application near a sensitive area	333	68.4%
Every load	184	37.8%
Every 2-4 swath runs	128	26.3%
Every 5-7 swath runs	102	20.9%
Do not use aircraft equipped with a smoker	49	10.1%
Every swath	36	7.4%
As needed	29	6.0%
Anytime we need to check wind/spray conditions	4	0.8%
When around sensitive areas	2	0.4%
Before and during applications	1	0.2%
1 time per field	1	0.2%
2-3 times	1	0.2%

*485 operator responses

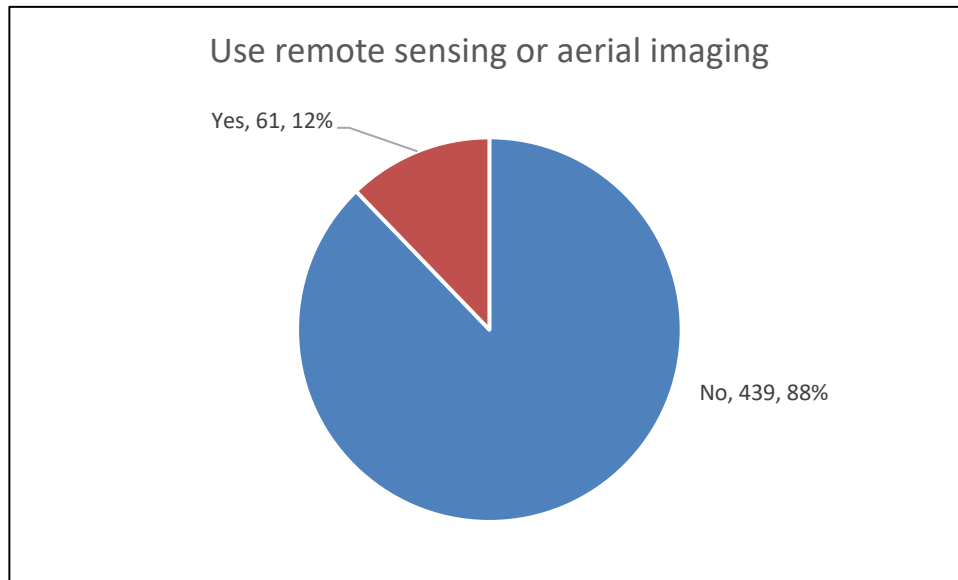
Direct comparisons to the 2012 survey cannot be made because the choices were different and the 2019 survey questionnaire was “select all that apply” instead of choose only one. “Select all that apply” was added because aerial applicators might use smokers differently, depending on the products being applied, the target crop, weather conditions, and surrounding areas.

Survey question: At your operation, do you conduct remote sensing or aerial imaging?

Five hundred two operators responded and 61 (12%) indicated they use remote sensing in their operation. See Figure 35.

When asked if they use UAS (drones) in their operation, 503 operators responded and just 20 operators said they use drones. See Figure 36.

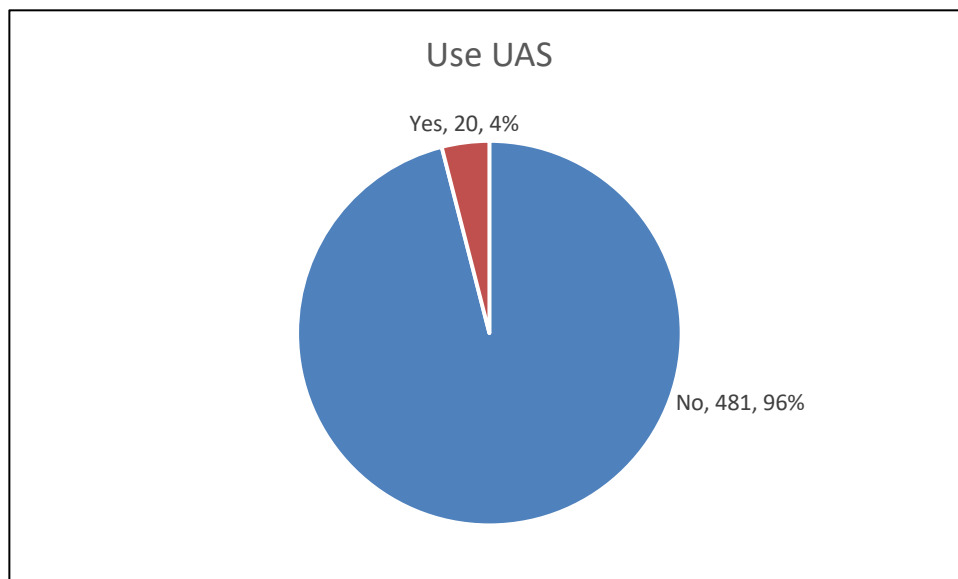
Figure 35 – Remote sensing as part of the operation



*500 responses

Survey question: Do you use UAS (drones) in your operation?

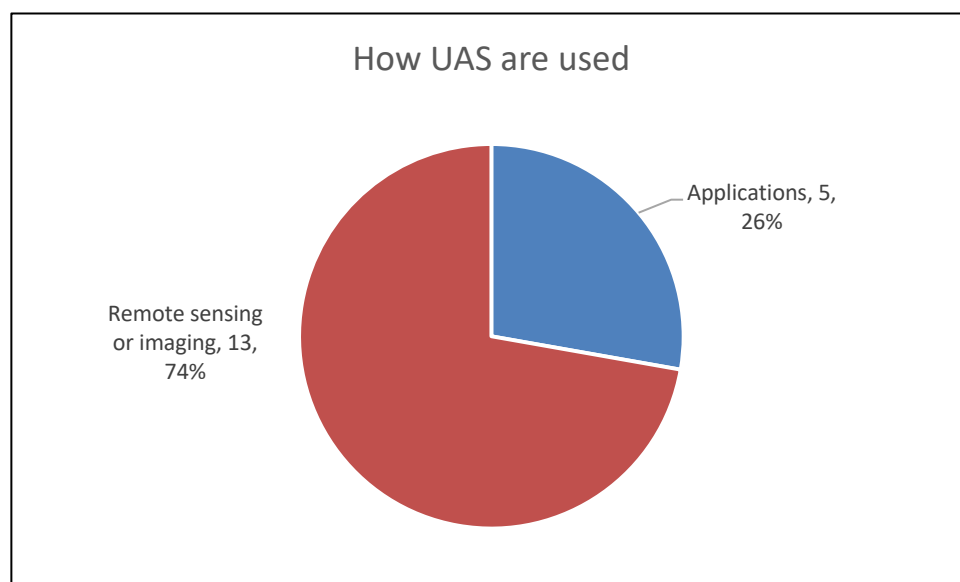
Figure 36 – Use UAS as part of the operation



*501 responses

Survey question: How do you use UAS at your operation? – Applications, Remote sensing or imaging

Figure 37 – Uses of UAS



*19 operators responded

Thirteen of the 19 respondents (74%) said they use UAS for remote sensing or imaging, 26% said the use UAS for applications. Other uses stated were 'fog surveillance,' 'to take photos of test plots' and 'for surveillance' which are included in 'remote sensing or imaging' above.

Survey Question: To identify and track sensitive areas, I use: (Please check all that apply.)

a) A sensitive crop registry (i.e FieldWatch, b) Data I collect myself, c) Data stored and given to pilots digitally, d) Data stored and given to pilots on hand-drawn maps, e) Other, please specify.

Table 14 – How sensitive areas are tracked

Methods to track sensitive areas	Responses	Percent
Data I collect myself	416	83%
Data stored and given to pilots on hand-drawn maps	302	60%
Sensitive crop registry (i.e.FieldWatch)	191	38%
Data stored and given to pilots digitally	143	29%

*499 responses

Most (83%) track sensitive areas by using self-collected data. Four choices were given as well as an ‘other’ category. Responses to the ‘other’ methods are given in Table 15.

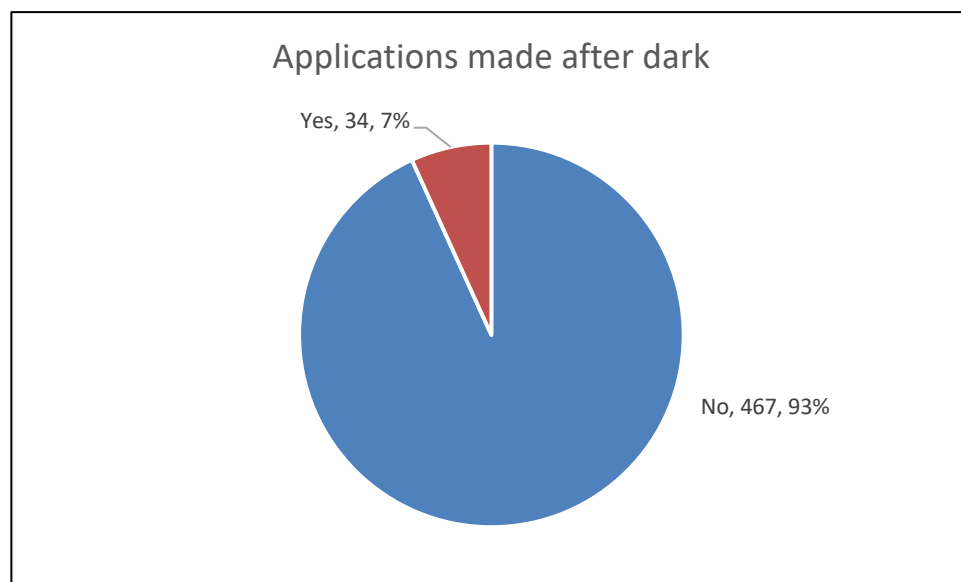
Table 15 – Other methods to track sensitive areas

All customers annually provide farm maps and crops planted or to be planted	Flight plan on line
Ask the customer about surroundings, call the neighbor	Google earth maps
Ask the grower if any sensitive crops/areas nearby.	Growers’ information
Computer generated maps	I just spray my own fields
Contact owner of sensitive crop myself	Information from customers
County derived maps of every field farmed in CA. Each map shows field numbers, etc. and surrounding crops for that growing season, even if multi-cropped. We will not make any application unless there is a map supplied showing target fields and all surrounding crops.	On the requisition from grower, PCA, on permit.
Crop associations’ digital maps	Oral briefing
Customer supplied Crop status	Sensitive areas marked on mapping system.
Data given on computer generated maps	Spotter on field
Discussion with primary farmer and adjacent farmers, and homeowners.	Verbally discuss with the grower

Survey question: Do you make applications during the hours of darkness?

Operators were asked if they conduct operations during hours of darkness. Responses are shown in Figure 38 below. Seven percent of the operations (n=34) conduct operations after dark. Seventy-four percent of these operations are in the far west region of the US. Refer to Figure 5.

Figure 38 – Treatments after dark

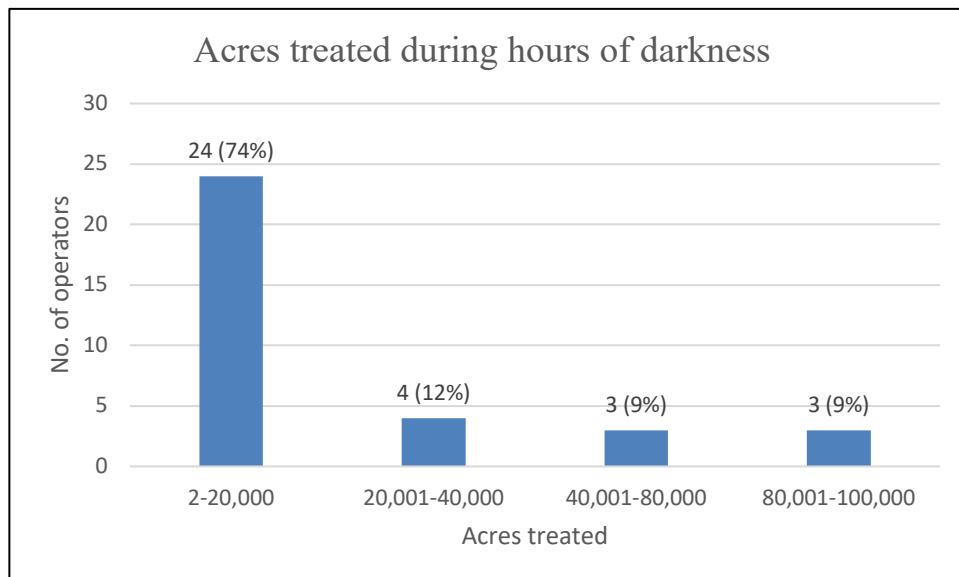


*501 responses

Survey question: Please estimate the total number of acres you treated during hours of darkness in 2017

Operators were asked to estimate the number of acres treated during hours of darkness. Results are given in Figure 39 below. Thirty-three operators responded to the question. Acres ranged from two to 100,000 with an average of 18,000 across the 33 operations. The majority of responses were between 1 and 20,000 acres.

Figure 39 – Number of acres treated during hours of darkness

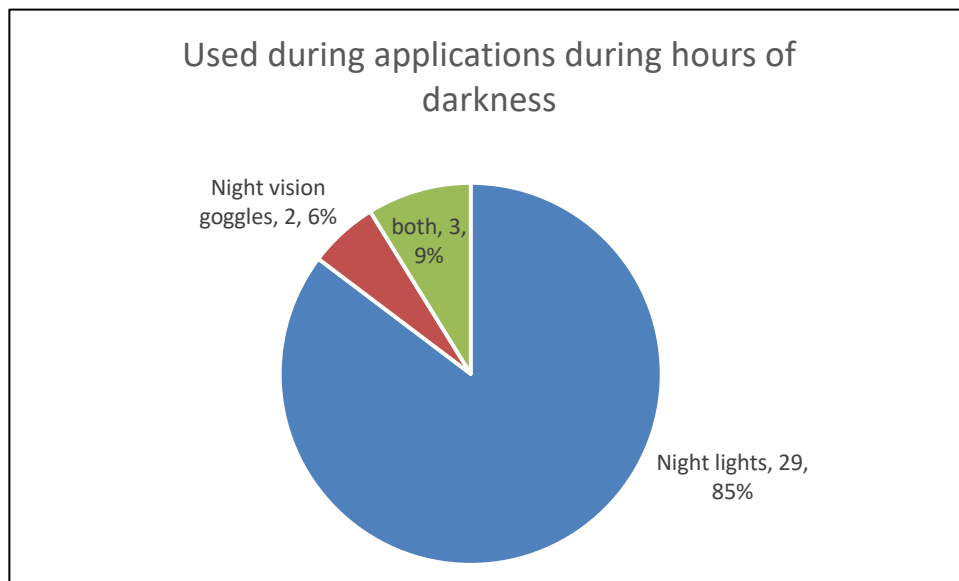


*33 responses

Survey question: During applications conducted after dark, we use: Night vision goggles, Night lights, both.

Operators were asked if they used night lights or night vision goggles when conducting operations at night. Results are shown in Figure 40. In most cases, night lights are used.

Figure 40 – Methods used during dark applications



*34 responses

Survey question: Please rank the reasons for doing applications during hours of darkness. (Drag and drop the reasons into the appropriate order where 1 is the primary reason.)

_____ To protect pollinators

_____ Because of cooler temperatures

_____ Because there's less wind

_____ Because field workers are not present

The primary reason reported by operators for making applications after dark is to protect pollinators, followed by field workers not present, cooler temperatures, and finally less wind. Average rankings are shown in Table 16.

Table 16 – Ranking of reasons for doing applications during hours of darkness

Reason	Mode	Average*
To protect pollinators	1	1.82
Because field workers are not present	2	3.00
Because of cooler temperatures	3	2.63
Because there's less wind	4	3.15

*34 operator responses

Other reasons operators gave for conducting operations during hours of darkness are shown in Table 17 below.

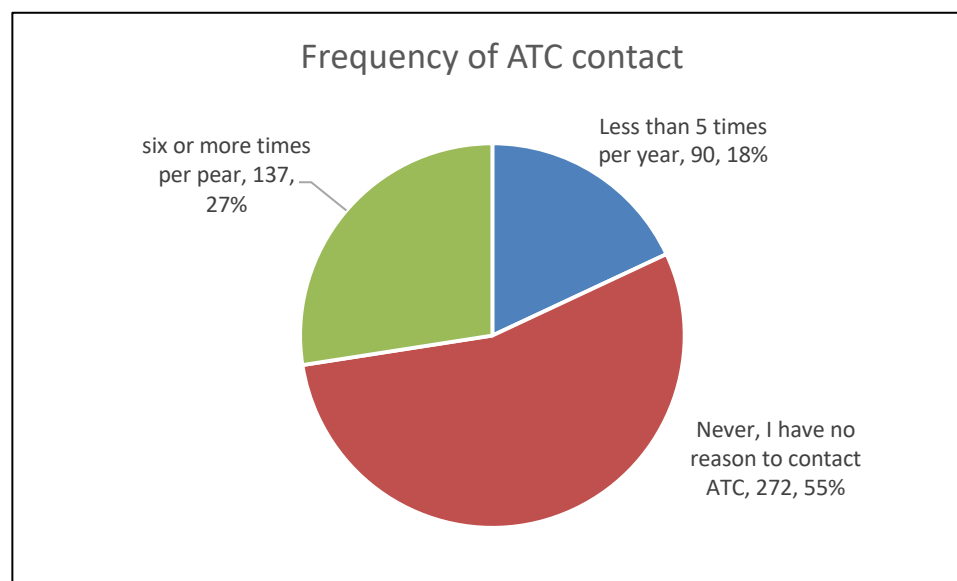
Table 17 – Other reasons for conducting operations after dark

Other reasons given
When mosquitoes are active
To get work done
Interaction with local public, schools, etc.
Weather issues
Avoid joggers/bikers
To complete job

Survey question: During normal ag operations, how often do you contact Air Traffic Control (e.g. operating near controlled air space) Never. I have no reason to contact ATC, six or more times per year, less than 5 times per year.

When asked about the frequency of contact with ATC, the majority of operators (55%) said they do not use ATC services.

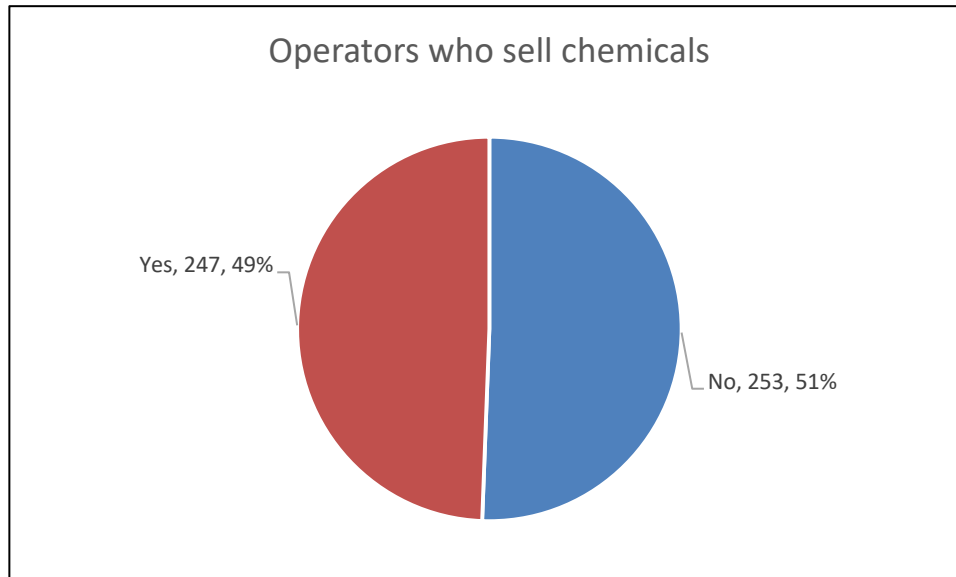
Figure 41 – Contact with Air Traffic Control (ATC)



*499 responses

Survey question: Do you sell some or all of the chemicals used for aerial applications?

Figure 42 – Proportion of operators who sell chemicals

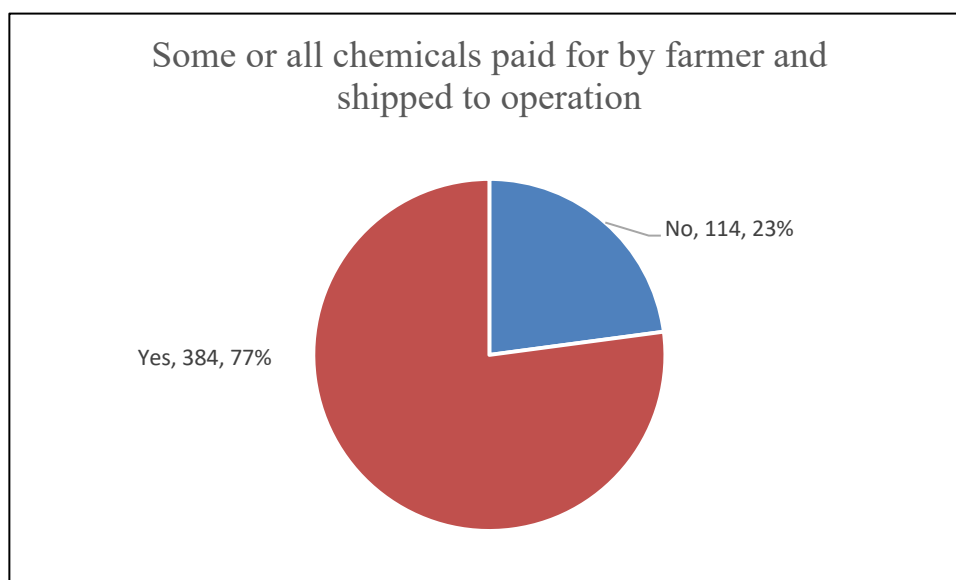


*500 responses

Nearly half (49%) of the operators sell some or all of the chemicals used for aerial applications. In 2012, 74% said they sold chemicals.

Survey question: Are some or all of the chemicals paid for by the farmer/rancher and shipped directly to your operation?

Figure 43 – Some or all paid for by farmer/rancher and shipped

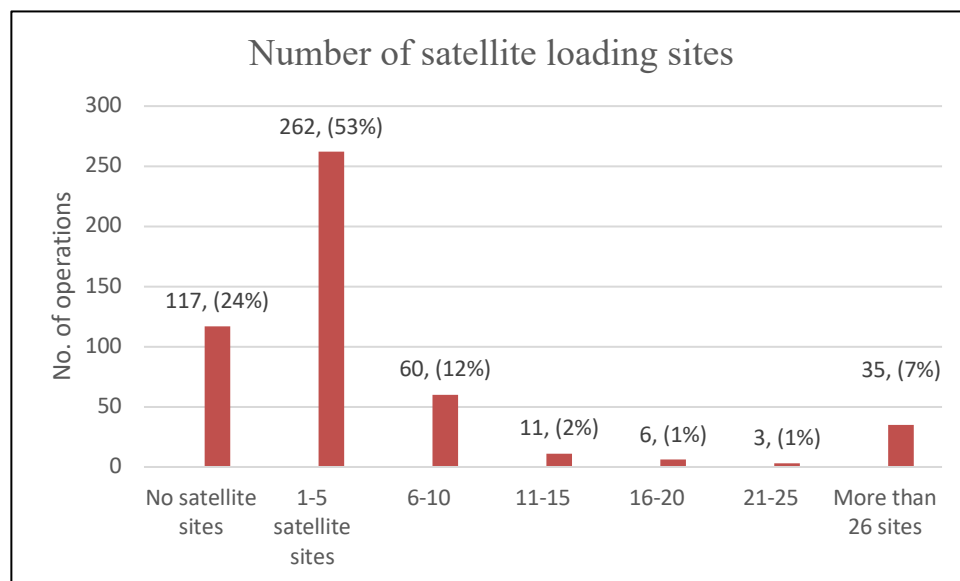


*498 responses

When asked if some or all of the chemicals are paid for by the farmer and sent directly to the operation, 77% said farmers pay for some of the product and have it sent to the operation. In 2012, 67% said the chemicals are paid for by the farmer and shipped directly to the operation. Twenty three percent of operations in the 2019 survey retail their chemicals.

Survey question: At your operation in 2017, how many satellite loading sites did you use?

Figure 44 – Number of loading sites



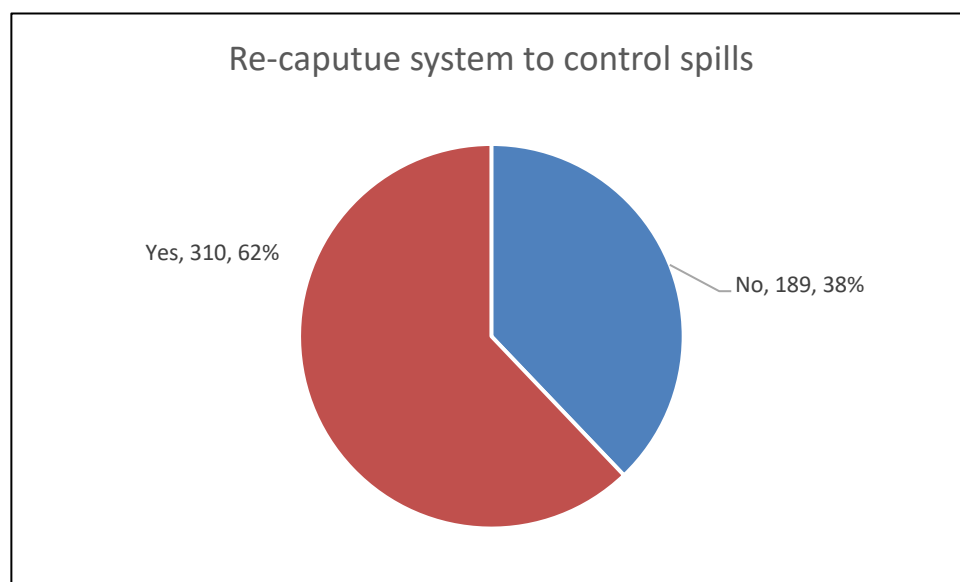
*494 responses

Nearly one quarter of the operations have no satellite sites. The majority (53%) of operations had five or fewer sites. Of those who had at least one satellite site, the average number of sites was 8.3 sites. Twenty-four operators report 50 satellite sites.

The wording of the question in the 2019 survey was: At your operation in 2017, how many satellite loading sites did you use? In 2012 operators were asked: **At your operation, on average how many loading sites do you use in a typical year?** To which they responded, on average, operators used 2.8 loading sites. The wording suggests asking respondents to report an average may yield erroneous results. Future surveys should ask for the number of sites, not an average.

Survey question: Does the loading area you usually use have a re-capture system (loading pad) to control spills?

Figure 45 – Normally used loading site and re-capture systems



*499 responses

In 62% of the operations, the site normally used for operations has a re-capture system. In 2012, 65% of the sites reported they had re-capture systems at the sites normally used. Additionally, operators were asked if the loading site was covered and 24% of the 499 who responded said it was. In 2012, 19% said it was covered. The usual location where operations take place is compared with the site being covered or not covered in Table 18. More than half of the covered sites are on private property or a private farm.

Table 18 – Usual loading site type and covered or not covered

	Usual site configuration	
	Covered	Not covered
Private farm or private property	74 (26%)	212 (74%)
Public (tax supported) airport	47 (22%)	163 (78%)
Combined public and private	121 (24%)	375 (76%)

Thirty-six percent of the operations have a method for rainfall re-capture and 83% said they have a method to clean the loading pad at their operation. Ninety-one percent have a fire extinguisher at the loading area and this is the same as reported in 2012.

4.1.3. Operations

Survey question: Please select the crops you treated in 2017.

Operators were asked to select the crops they treated. Four hundred ninety-nine operators responded. Most operators treat corn, small grains and soybeans. See Table 19 below. Percent is based on 499 operations.

Table 19 – Crops treated

Crop	No. of Responses	Percent
Corn	417	83.6%
Small grains (Wheat/Barley)	366	73.3%
Soybeans	349	69.9%
Pastures and range land	299	59.9%
Cover crop work	259	51.9%
Alfalfa	226	45.3%
Cotton	170	34.1%
Sorghum	158	31.7%
Roots and Tubers (includes potatoes, beets, onions and bulbs)	134	26.9%
Organic crops	119	23.8%
Rice	110	22.0%
Leafy Vegetables	106	21.2%
Other	91	18.2%
Orchards (Fruit/Nut)	88	17.6%
Aquatic weed and algae control	65	13.0%
Forests	65	13.0%
Mosquito Control (non-aquatic)	65	13.0%
Small fruits (Grapes/Berries)	46	9.2%
Mosquito Control (aquatic)	38	7.6%
Right-of-Way	34	6.8%
Other Public Health Pest Control	12	2.4%

*499 responses

Survey question: You selected the following crops in the previous question. Please complete the table below with your best estimate. For each crop or use, indicate the number of acres that your company treated during 2017 with your entire fleet.

Operators were asked to estimate the total number of acres for each crop treated by their company, using their **entire fleet**. Table 20 shows the average number of acres treated per operation, minimum, maximum, the sum of all acres treated for all respondents and the number of responses. Comparing Table 19 to Table 20 you will see that several operators did not provide the number of acres treated in their responses. For example, 417 operators reported they treat corn crops, yet only 320 provided the acres treated.

Table 20 – Average and total acres treated

Crop	Average acres treated	Min.	Max.	Total acres treated	Total Responses
Cotton	38,350	160	1,176,500	4,817,413	123
Corn	29,538	43	525,000	9,481,701	320
Mosquito Control (aquatic)	26,683	5	200,000	773,811	28
Rice	25,215	50	180,000	1,966,784	77
Forests	25,131	100	350,000	1,306,821	51
Roots and Tubers (includes potatoes, beets, onions and bulbs)	21,696	25	200,000	2,147,931	98
Soybeans	20,862	50	200,000	5,716,053	273
Small grains (Wheat/Barley)	14,512	50	320,000	4,106,871	282
Other	12,119	400	150,000	1,100,489	52
Orchards (Fruit/Nut)	11,645	80	225,000	733,639	62
Mosquito Control (non-aquatic)	9,759	5	125,000	458,692	46
Pastures and range land	8,473	49	130,000	1,982,743	233
Alfalfa	5,071	30	60,000	882,415	173
Leafy Vegetables	5,071	100	60,000	370,244	72

Cover crop work	4734	30	80000	956,274	201
Sorghum	4,689	31	100,000	515,766	109
Small fruits (Grapes/Berries)	4,056	100	30,000	125,738	30
Aquatic weed and algae control	3,298	5	40,000	158,316	47
Right-of-Way	1,630	30	10,000	35,860	21
Organic Crops	1,591	50	10,000	141,585	88
Other Public Health Pest Control	641	10	3,000	3,846	5

Other crops treated are shown in Table 21.

Table 21 – Other crops treated

aerial seeding only	Peanuts	crawfish
asparagus	Peppermint	dry beans
canola	pinto beans and kidney beans	green beans
canola,	potato sugar beets	hops
chickpeas	pulse Crops	lentils
Christmas Trees	pumpkins	sweet corn
citrus	sesame	tobacco
conifers trees	sugar cane	tomatoes
cow peas Canola	sunflowers	watermelons

Where possible average acres by crop treated as reported in the 2012 and 2019 surveys are shown in Table 22. Because the crops listed on the surveys were not exactly the same between the two surveys, complete comparisons cannot be made. However, where specific crops treated matched, the data show that the average number of corn acres treated in the 2019 survey has increased by 27% and the average acres of sorghum treated decreased by 41%.

Table 22 – Average acres treated and reported in 2012 and 2019 surveys

Application	2019 average acres treated	2012 average acres treated	Percent change
Aquatic weed & Algae control	3,298	6,200	-47%
Alfalfa	5,071	4,686	8%
Corn	29,538	23,200	27%
Cotton	29,525	36,242	-19%
Forests	25,131	19,967	26%
Leafy vegetables	5,071	8372	-39%
Mosquito control	36,442	28,884	26%
Orchards-Fruit/nut trees	11,645	13,831	-16%
Pastures, rangeland	8,473	11,330	-25%
Rice	25,215	40,646	-38%
Right of way	1,630	961	70%
Roots and Tubers	21,696	22,225	-2%
Small fruits, Grapes/berries	4,056	3,932	3%
Small grains Wheat/barley	14,512	16,146	-10%
Sorghum	4,689	7951	-41%
Soybeans	20,862	16,788	24%
Cover crop work	4734	n/a	n/a
Organic crops	1591	n/a	n/a
Other public health pest control	641	n/a	n/a
Other	14871	n/a	n/a

*n/a not asked in 2012 survey

Survey question: You selected the following crops in the previous question. For each crop, please enter the usual and maximum number of acres treated in a single day in a single aircraft

Operators were asked to estimate the usual number of acres they treat in a single day with a single aircraft. They were also asked to estimate the maximum number of acres treated with a single aircraft in a single day. Responses from 2004, 2012 and 2019 surveys are given in Table 23. Where direct comparisons were not possible, n/a is shown. Data shown in Table 23 are averages.

Table 23 – Single aircraft usual and maximum daily acres treated as reported in the 2019, 2012 and 2004 surveys

Application	Usual number of usual daily acres with one aircraft	Usual number of usual daily acres with one aircraft	Usual number of usual daily acres with one aircraft		Number of maximum daily acres with one aircraft	Number of maximum daily acres with one aircraft	Number of maximum daily acres with one aircraft
	2019 Survey	2012 survey	2004 survey		2019 Survey	2012 survey	2004 survey
Alfalfa	490	442	322		878	1,065	785
Corn	1,165	959	541		1,925	1,820	1,281
Cotton	1,125	1,122	1,080		2,119	1,993	2,145
Forests	1,149	829	587		2,159	1,523	1,491
Leafy vegetables	370	288	389		761	566	811
Orchards-Fruit/nut trees	333	381	277		653	948	598
Pastures, rangeland	709	774	549		1,371	1,546	1,238
Rice	1,033	946	725		1,579	1,701	1,344
Roots and Tubers	775	578	593		1,216	1,112	1,191
Small fruits, Grapes/berries	202	260	339		393	564	514

Small grains Wheat/barley	869	770	597		,1510	1,608	1,307
Soybeans	1,143	1,111	591		1,958	1,953	1,282
Aquatic weed Algae control	343	n/a	n/a		711	n/a	n/a
Mosquito Control (aquatic)	5,232	n/a	n/a		8,774	n/a	n/a
Mosquito Control (non-aquatic)	1,584	n/a	n/a		2,401	n/a	n/a
Other Public Health Control	113	n/a	n/a		169	n/a	n/a
Organic Crops	362	n/a	n/a		545	n/a	n/a
Right of Way	164	n/a	n/a		352	n/a	n/a
Sorghum	562	n/a	n/a		1,030	n/a	n/a
Cover crops	498	n/a	n/a		821	n/a	n/a

The greatest number of acres treated in a single day, with a single aircraft was application to cotton, soybeans, corn, and rice. In most cases, the average acres treated per day in the 2019 survey were higher than in the 2012 survey.

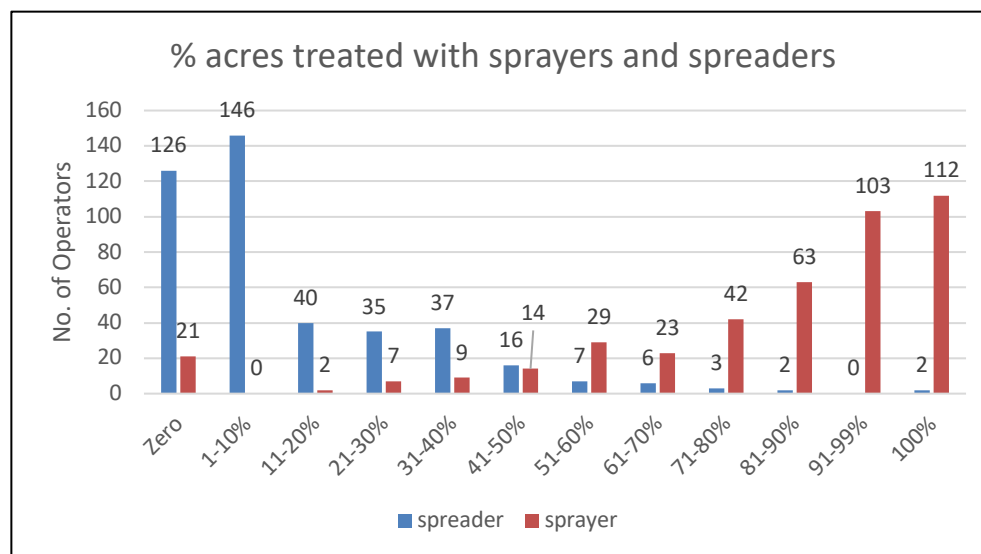
The results from the 2019 survey were also used to estimate that aerial application treats 127 million acres of cropland annually. This estimate was derived by summing the total acreage for all of the crops from all of the respondents and then weighting this value up to the population based on the number of respondents and the 1,560 operators. The 2017 USDA Census of Agriculture states there are 347 million acres of cropland used for crop production in the United States. Taking into account some crops are treated more than once during a season, aerial application is estimated to treat somewhere between 28 percent to 37 percent of this cropland.

The next few questions are about sprayers and spreaders used in Dry and Liquid applications.

Survey Question: Please tell me the percentage of all acres you treated in 2017 using sprayers or spreaders. Percent treated using a sprayer.

Survey Question: Please tell me the percentage of all acres you treated in 2017 using sprayers or spreaders. Percent treated using a spreader.

Figure 46 – Percent of acres treated using a sprayer or spreader

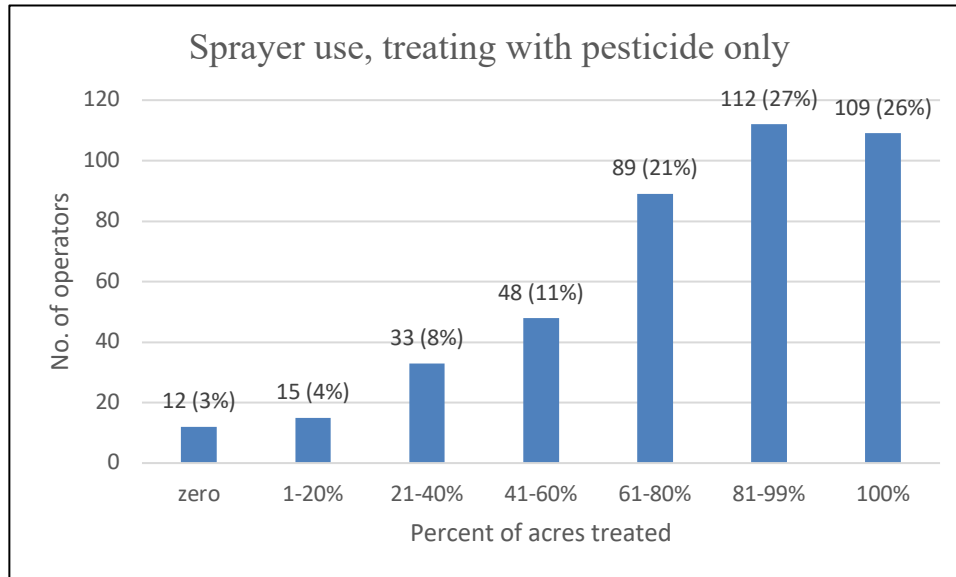


*426 responses on sprayer question and 421 responses on spreader question

One hundred twenty-six operators (30%) said they never use a spreader and 112 operators (26%) said they use a sprayer 100% of the time. Forty-four percent of the operators said they use a spreader for 20% or less of the acres they treat. The majority of operators (75%) said they use a sprayer for more than 70% of the acres they treat.

Survey question: If you used a sprayer in 2017, what percent of these acres treated were pesticide only?

Figure 47 – Percent of acres treated using a sprayer that were pesticide only

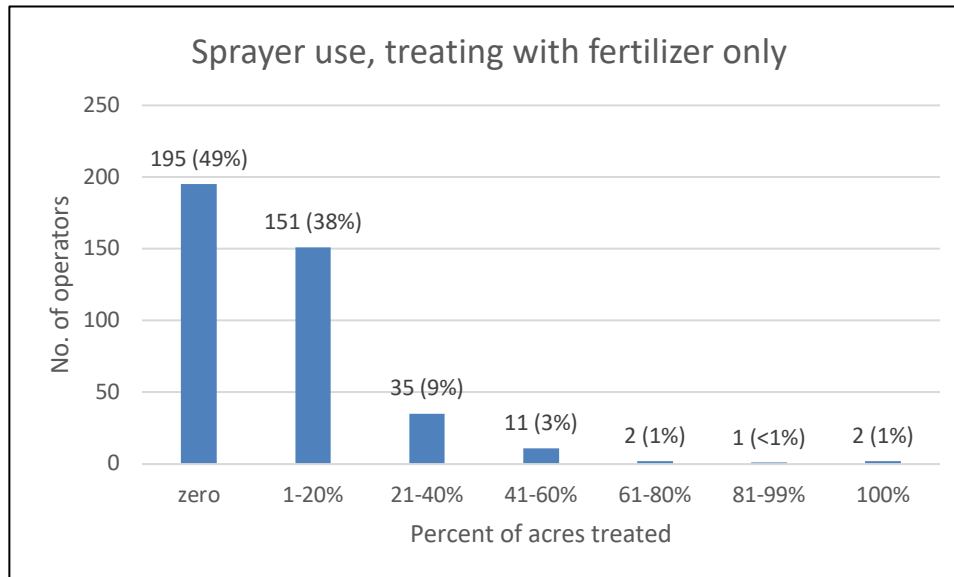


*418 responses

Over one-half (53%) of the operators reported using a sprayer applying pesticides alone on more than 80% of the acres treated. Just 12 operators (3%) said none of the acres treated with a sprayer were pesticides alone. Twenty-six percent said when they use a sprayer, it is to apply pesticides alone.

Survey question: If you used a sprayer in 2017, what percent of these acres treated were fertilizer alone?

Figure 48 – Percent of acres treated with a sprayer that were fertilizer only

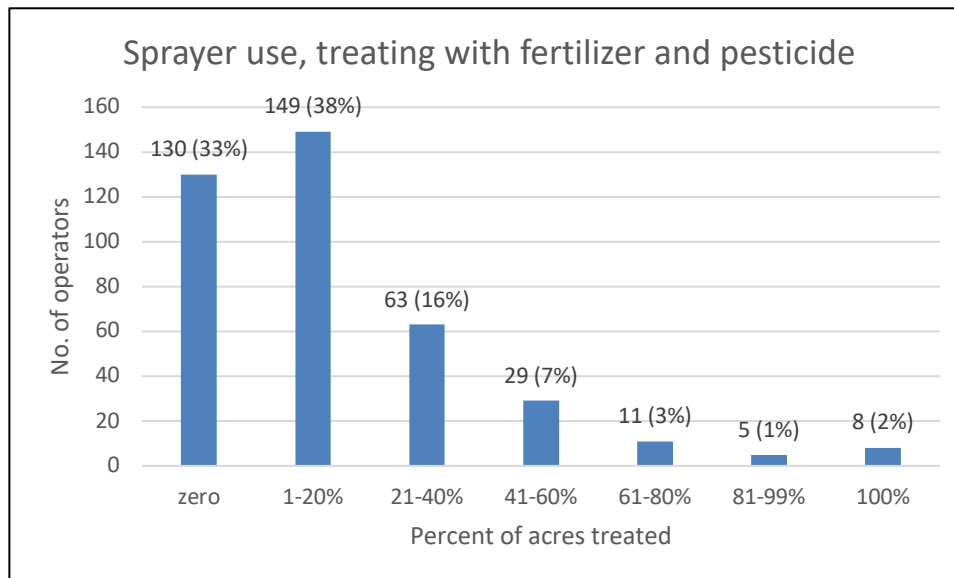


*397 responses

Among those who use a sprayer, 49% did not apply fertilizer alone and 38% said that 20% or less of the acres treated were fertilizer alone applications.

Survey question: If you used a sprayer in 2017, what percent of these acres treated were a mixture of both pesticide and fertilizer?

Figure 49 – Percent of acres treated with a sprayer with a mixture of pesticide and fertilizer

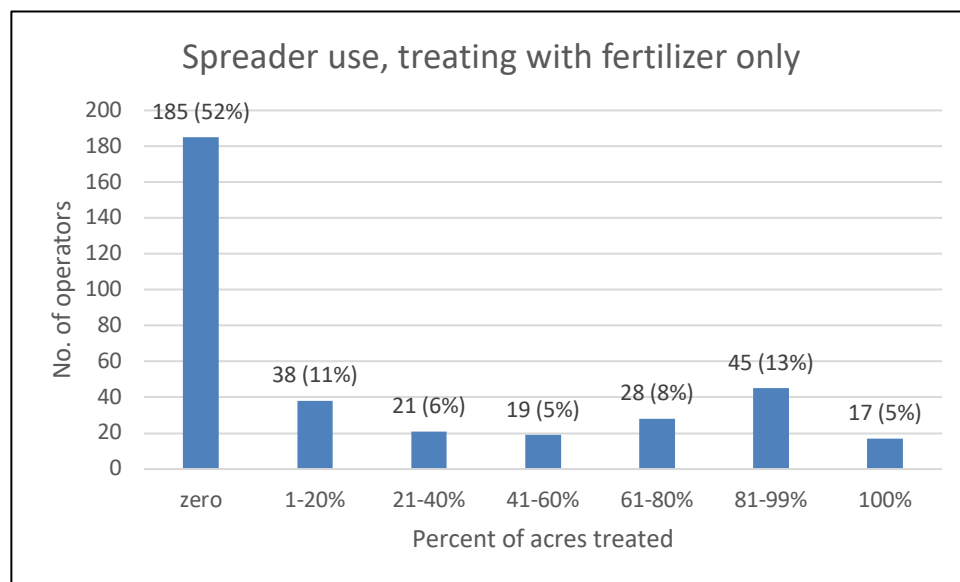


*395 responses

A third of the operations said they do not apply a combination of pesticides and fertilizers using a sprayer.

Survey question: If you used a spreader in 2017, what percent of these acres treated were fertilizers? (Leave blank if you only use a sprayer)

Figure 50 – Percent of acres treated using a spreader applying fertilizer only

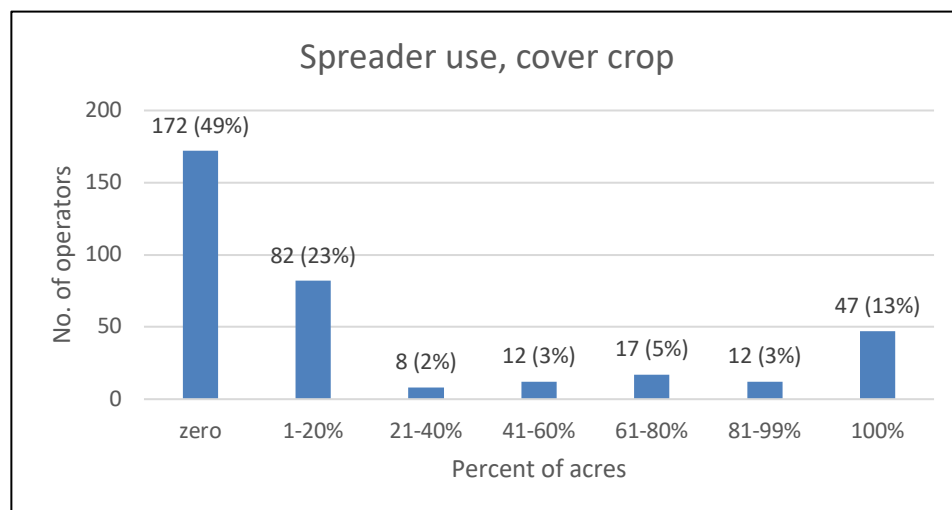


*353 responses

Over half of operations do not use a spreader to apply fertilizer.

Survey question: If you used a spreader in 2017, what percent of these acres treated were cover crop(s)? (Leave blank if you only use a sprayer)

Figure 51 – Percent of acres treated using a spreader applying to cover crops

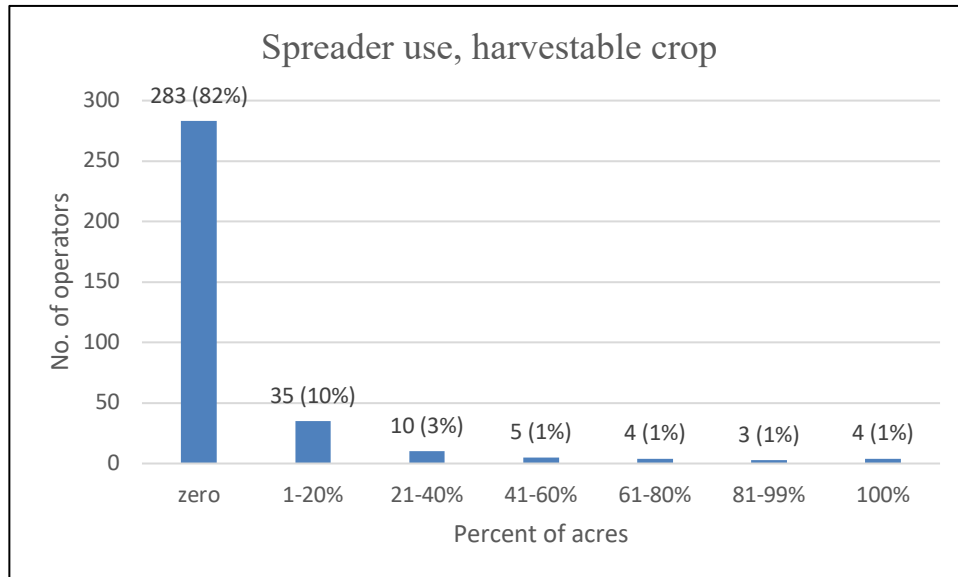


*350 responses

Thirteen percent of the operators said that when using a spreader, it is only used to apply to cover crops.

Survey question: If you used a spreader in 2017, what percent of these acres treated were harvestable crop seeding such as rice? (Leave blank if you only use a sprayer)

Figure 52 – Percent of acres treated using a spreader to conduct harvestable crop seeding such as rice.

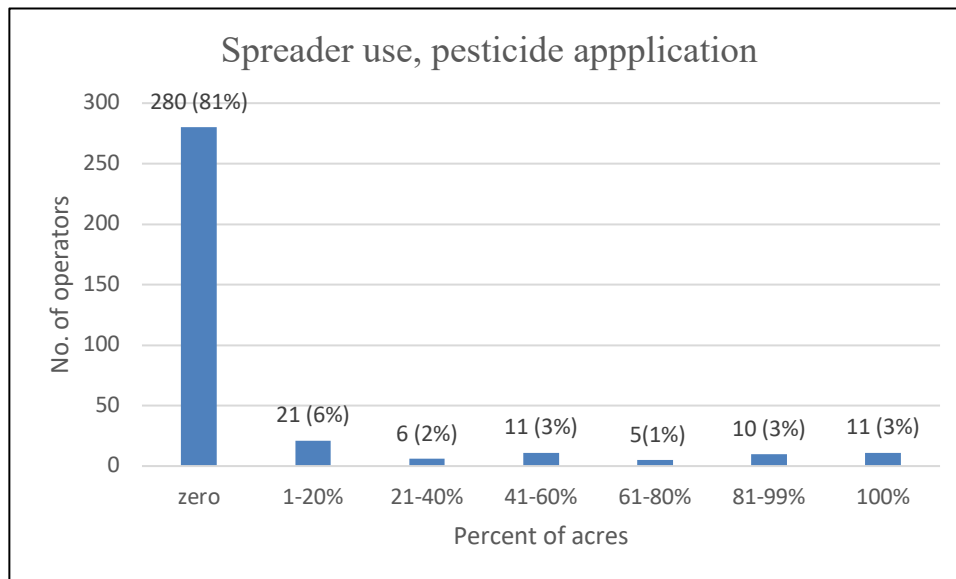


*344 responses

Most operators (82%) said they do not use a spreader to apply harvestable crop seedings.

Survey question: If you used a spreader in 2017, what percent of these acres treated were pesticide applications? (Leave blank if you only use a sprayer)

Figure 53 – Percent of acres treated using a spreader for applying pesticides

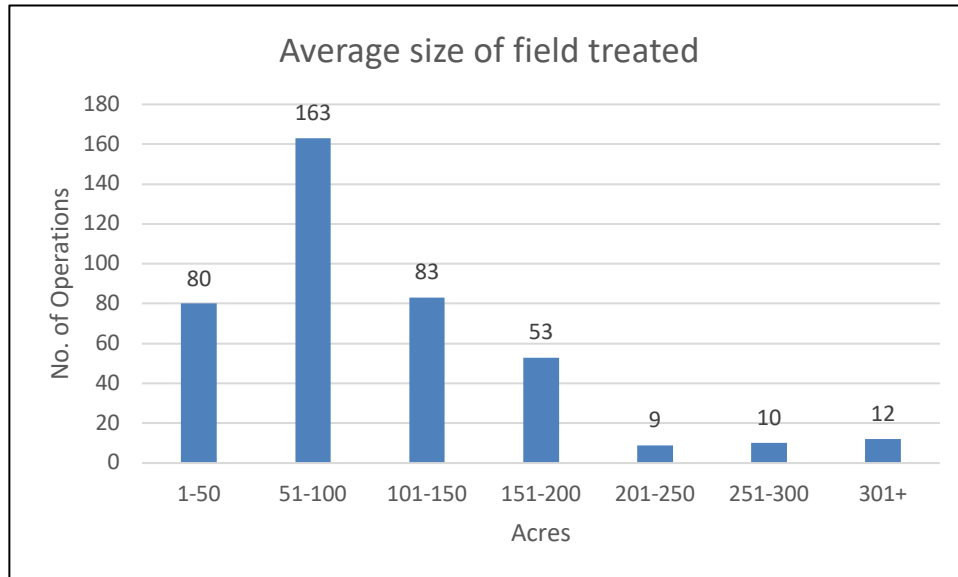


*344 responses

Most operators (81%) do not use a spreader for pesticide applications. For 11 operations, all of the acres treated with a spreader are pesticide treatments.

Survey question: At your operation, estimate the average size of the field (in acres) you treated in 2017.

Figure 54 – Average field size treated

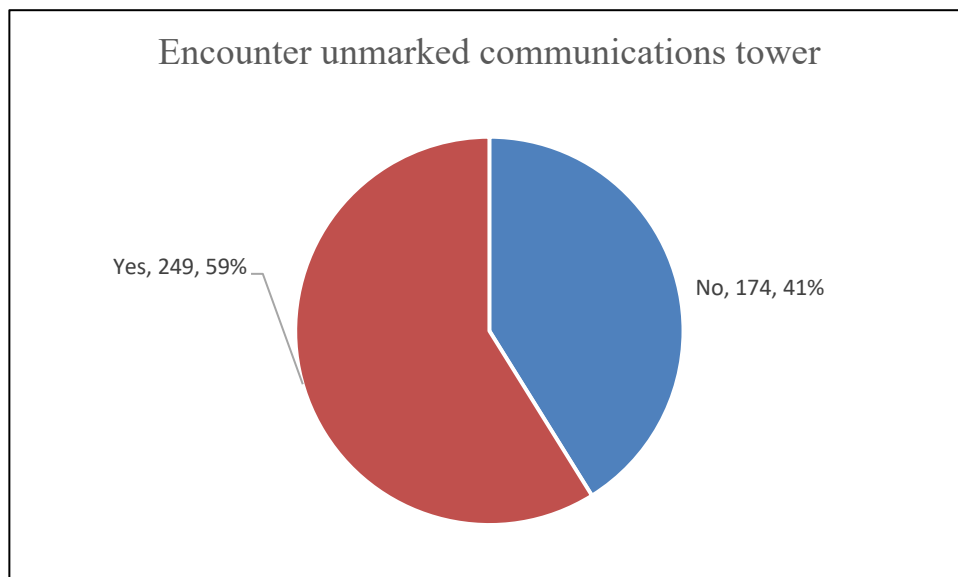


*410 responses

The average field size treated ranged from 5 to 801 acres and averaged 166 acres. The median is 100 acres.

Survey question: In 2017 did you encounter unmarked communication tower(s) when making aerial applications?

Figure 55 – Encounters with unmarked communications towers



*423 responses

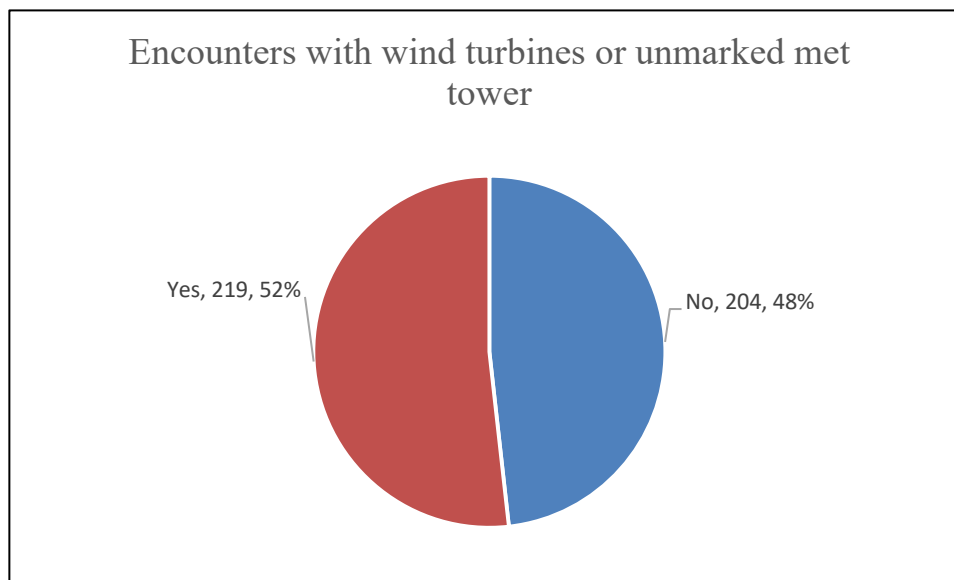
More than half (59%) of the operators encountered an unmarked communication tower. Regional distribution (refer to Figure 5) of encounters with unmarked communication towers is shown in Table 24 below.

Table 24 – Regional distribution of unmarked communication towers

	East	Midwest	South	Far West
Yes	4 (29%)	99 (56%)	96 (64%)	50 (58%)
No	10 (71%)	79 (44%)	53 (36%)	36 (42%)
Total	14	178	149	86

Survey question: In 2017, did you encounter any wind turbine(s) and/or unmarked meteorological tower(s) when making aerial applications?

Figure 56 – Encounters with wind turbines or unmarked meteorological tower

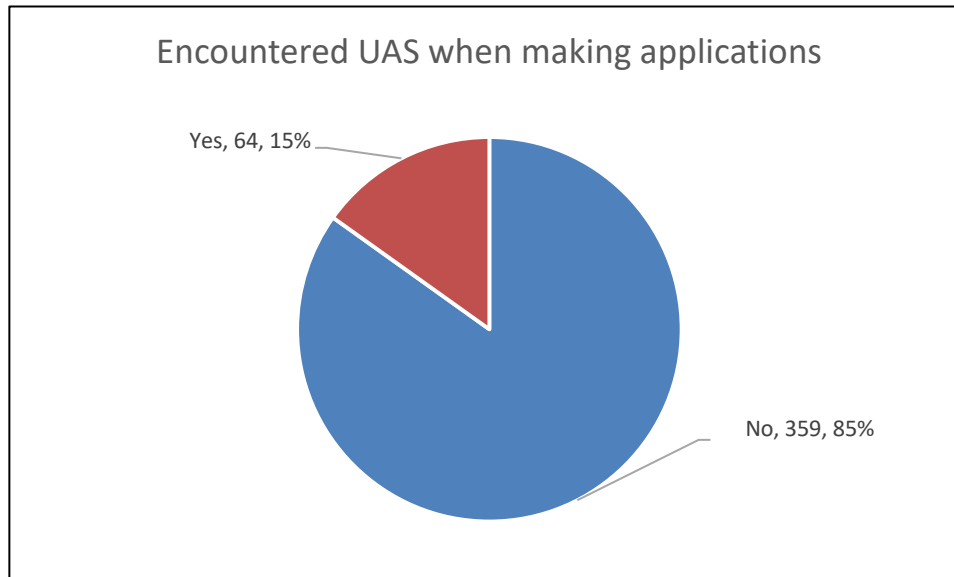


*423 responses

Over half (52%) of the operators reported they had encountered wind turbines or unmarked meteorological towers.

Survey question: In 2017, did you encounter Unmanned Aircraft Systems (UAS or drones) when making aerial applications?

Figure 57 – Encounters with unmanned aircraft systems (drones)



*423 responses

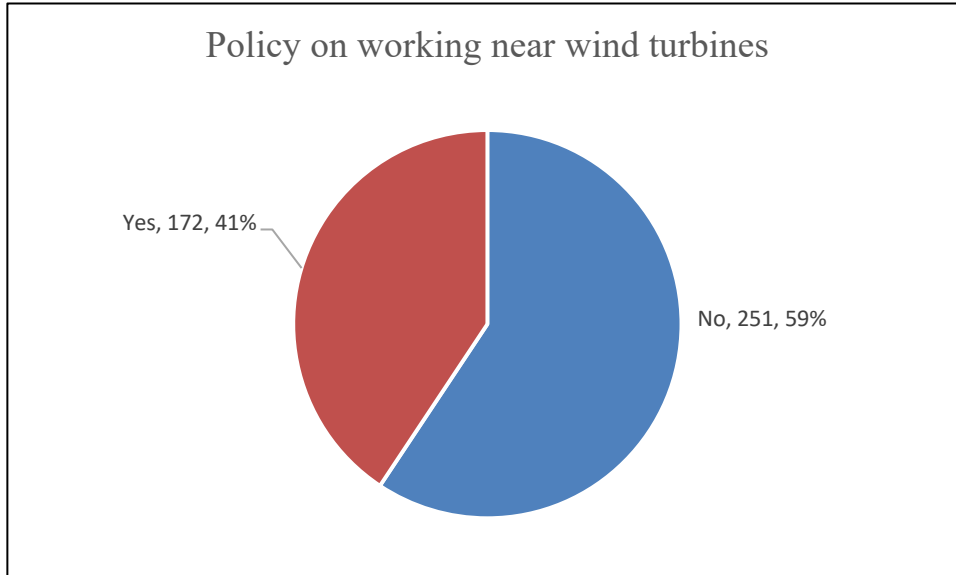
Sixty-four operators, or 15%, reported that they had encountered a UAS while making aerial applications. Regional breakdown of UAS encounters is shown in Table 25 below. The most encounters happened in the Midwest, followed by the South.

Table 25 – Regional distribution of UAS encounters

Region	Operations	Percent
East	2	3.1%
South	21	32.8%
Far West	15	23.4%
Midwest	26	40.6%

Survey question: At your operation, have you established a policy about working in the vicinity of wind turbines?

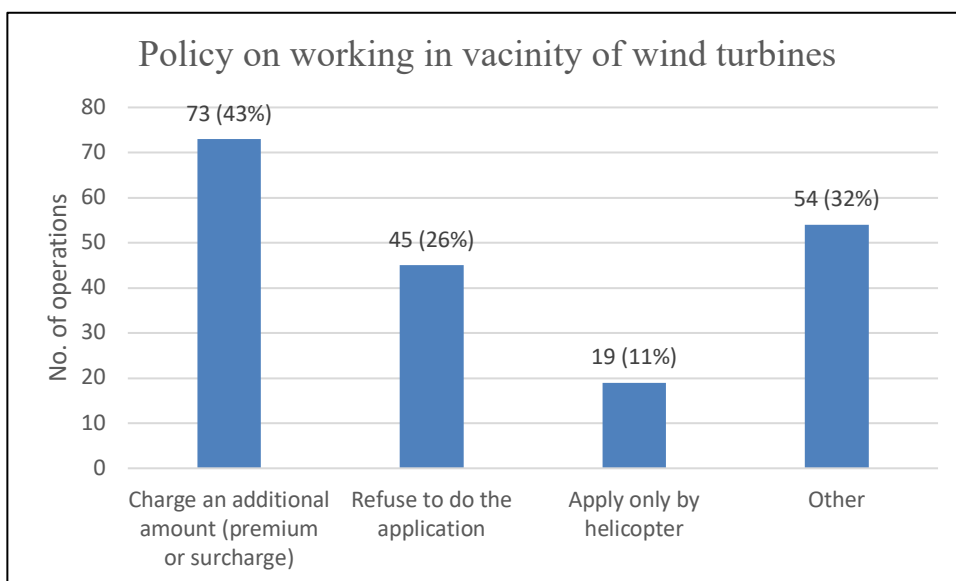
Figure 58 – Policy on working near wind turbines



*423 responses

Less than half (41%) of the operators have a policy at their operation regarding working in the vicinity of wind turbines. In the 2012 survey 35% of the operators reported having a policy about working in the vicinity of wind turbines. The nature of the policy for the 172 operators in the 2019 survey who indicated they had a policy about working near wind turbines are given in

Figure 59. Figure 59 – Nature of the policy on working near wind turbines



*170 responses

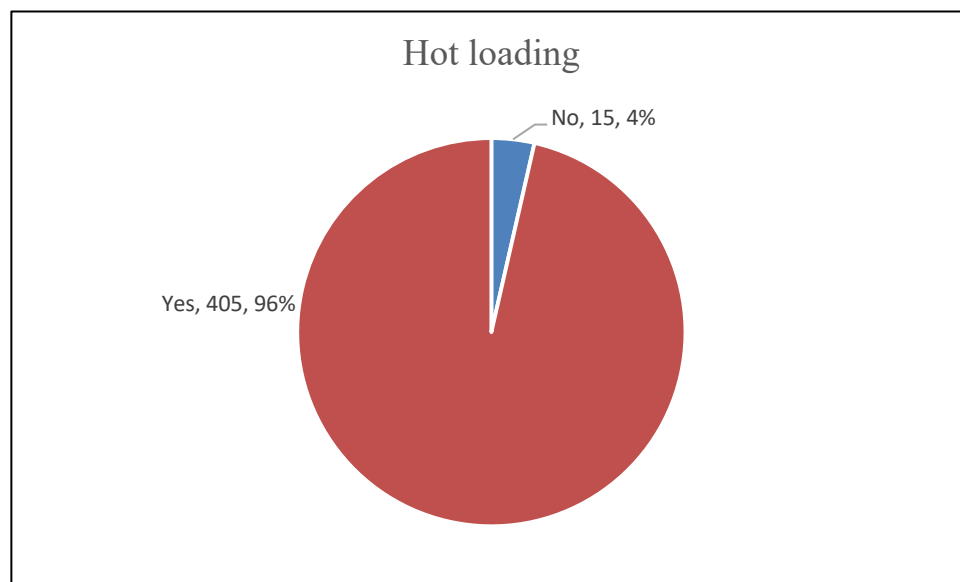
Other responses included:

- Address in a case by case basis.
- Apply only for longtime customers if application can be made safely.
- Avoid collision.
- Be careful. Not at sun up or sun down.
- Be careful and leave yourself an out.
- Be safe and professional. I do many fields with wind turbines.
- Be safe as possible. Communicate to grower that I do not guarantee any work done.
- Be very cautious.
- Conduct a pre-flight briefing with the assigned applicator and utilize computer software to observe the area prior to take off.
- Contact the owners to stop rotation has worked well.
- Contact wind farm manager to shut down wind turbines during application.
- Risk assessment before each job.
- If it can be safely and properly done.
- Leaving the final decision to individual pilots.
- Make a plan and stick to it-do not work around towers if there is another plane within a mile.
- Make decision based on proximity of wind turbines.
- Policy is about safety. Pilots are briefed on safety techniques when working around wind turbines.
- Spray the field as best as we can.
- Survey area before taking the job.
- Take extra time and be careful.

Forty-three percent of the operations (73/170) said they charge an additional amount to do the application; 26% said they refuse to do the application; 11% said they only do the application using a helicopter. In 2012 43% of operators refused to do the application, 28% said they charge more and 6% said they use a helicopter. Other responses offered by operators are listed below.

Survey question: In your operation, do your loaders load chemicals while the engine(s) are running ('hot' fueling or 'hot' loading)?

Figure 60 – Load chemicals while engine is running



*420 responses

Ninety-six percent of the operators said they do hot fueling and 94% reported hot fueling to be a requirement for conducting their operations. In 2012, 92% of operators did hot fueling and 88% considered it a requirement for conducting applications.

4.1.4. Risk Perceptions

Operators were asked to rate occupational risks and/or hazards. On a scale of one to ten, where one means 'presents no risk' and ten means 'presents great risk,' operators were asked to evaluate the danger level of the agricultural chemicals, rotating prop, engine noise, cockpit clutter, birds, power lines, communications towers, mechanical failures, adverse weather, wind turbines, meteorological towers, drones, being shot at and night applications. For example, respondents could rate two items with a rating of 4 indicating they perceived the items to have the same level of risk.

Survey Question: During the active spray seasons your employees/contractors may be exposed to many hazards. Score each item below where 1 is considered 'not a risk' and 10 is 'extremely risky'.

Example:

Crossing the street without looking 7

Mowing lawn with bare feet 7

Running with scissors 2

Table 26 – Risk perception as reported by Operator

Risk	2019 Average	2019 Responses	2012 Average	2012 Responses	Change ‘12 to ‘19
Power lines	7.1	405	6.5	438	+0.6
Communication Towers	6.3	403	6.1	436	+0.2
Meteorological towers	5.9	400	5.5	432	+0.4
Rotating Prop	5	404	4.4	436	+0.6
Chemicals	4.7	407	3.7	438	+1
Wind turbines	4.5	397	4	428	+0.5
Adverse weather	4.2	402	3.6	433	+0.6
Mechanical failure	4.1	408	3.9	435	+0.2
Birds	4.1	404	4.5	436	-0.4
Engine noise	3.9	407	3.2	433	+0.7
Limited space for maneuvering	3.7	401	3.4	429	+0.3
Unmanned aircraft systems (Drones)	3.6	400	n/a	n/a	n/a
Aircraft being shot at	2.9	402	n/a	n/a	n/a
Cockpit clutter	2.2	400	2	421	+0.2
Night application	1.7	386	n/a	n/a	n/a

Relative risk ranking in 2019 survey are very similar to the risk ranking in 2012 survey; however, the overall risk scores are generally higher in 2019.

Other risks identified by the operators are given in Table 27.

Table 27 – Other risks identified by operators

Other Risks		
Risk	Number of Responses	Ranking
Drift	1	10
Fatigue	2	10, 8
Farmers that book late and expect to be first	1	10
Aerostats (<i>fabric envelopes filled with helium while tethered by a single cable for weather radar</i>)	1	7
Distractions	2	7, 10
Other aircrafts	1	10
Guide Wires	1	10
Non-participating people	1	8
Lasers, spotlights	1	10
Lack of safety program	1	7

Table 28 – Operator and pilot risk rankings by comparison

Risk	Operator risk rank	Pilot risk rank*
Power lines	7.1	7.7
Communication Towers	6.3	6.8
Meteorological towers	5.9	6.0
Rotating Prop	5	4.7
Chemicals	4.7	4.4
Wind turbines	4.5	4.4
Adverse weather	4.2	5.0
Birds	4.1	4.4
Mechanical failure	4.1	4.6
Engine noise	3.9	3.9
Limited space for maneuvering	3.7	4.6
Unmanned aircraft systems (Drones)	3.6	3.9
Aircraft being shot at	2.9	3.2
Cockpit clutter	2.2	2.6
Night application	1.7	3.0

*250 responses

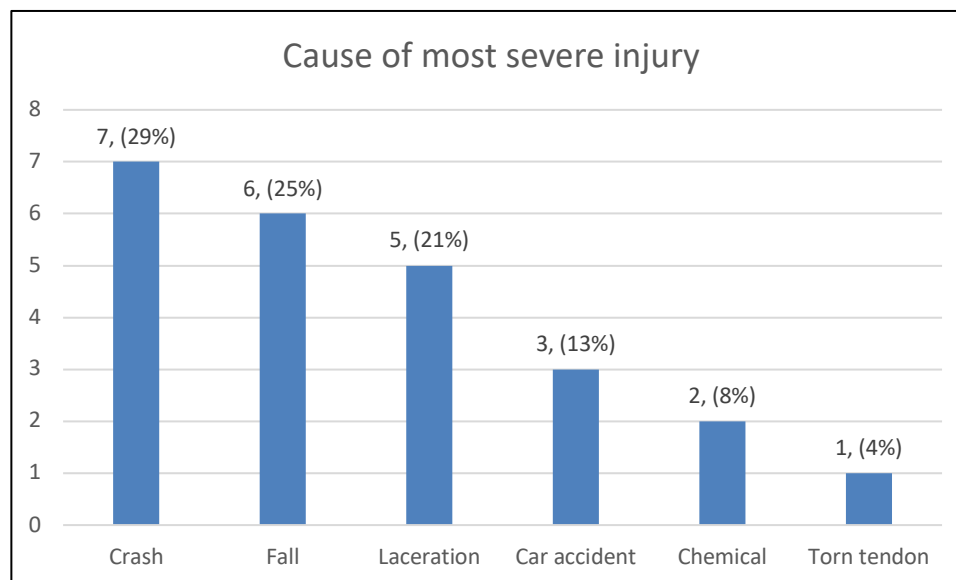
Overall, pilots perceive the same risks slightly higher than operators.

4.1.5. Injury

Respondents in the 2019 survey were asked about injury experience that required a hospital or doctor visit and 27 operations out of 425 (6%) who responded to the question said they experienced an injury at their operation during. In the 2012 survey, 26 respondents out of 444 responses, 5.86%, said that a person at their operation had suffered a work-related injury during 2010 that required treatment at a hospital or doctor's office.

In the 2019 survey 87% of those operations who had an injury, experienced just one. Two operations had two injuries and one operation had 4 injuries. The primary cause of the most severe injury experienced at all operations is shown in Figure 61.

Figure 61 – Cause of the most severe injury



Seven (29%) of the injuries were the result of a crash and 25% were the result of a fall. In 2012, most of the injuries were the result of a fall. Body part injured is shown in Table 29.

Table 29 – Body part injured

Body part	Number	Body part	Number
Leg	7	Arm	4
Hand	5	Foot	2
Ear	2	Side	1
Head	3	Abdomen	1
Back/spine	4	Shoulder	1
Eye	1		

Table 30 – Estimate of work days missed

Number of days missed	Number of responses
Zero	7
One	3
Two	2
Four	1
Five	1
Seven	1
Ten	3
Fourteen	1
Fifteen	1
Forty-five	1
Sixty	2
One hundred fifty	1
Two hundred ten	1

When estimating the number of work days missed as a result of the injury, respondents reported a range from 0 to 210 days missed. See Table 30 above.

4.1.6. Operator Workload

To understand about workload of the operator, six questions were asked. The number of responses to the questions is shown below each table.

Survey question: As the operator, what is the usual number of days per year when flight operations are conducted?

Results are shown in Table 31 below along with results from 2012.

Table 31 – Average days per year flight operations are conducted

Days per year when flights conducted	2019*	2012**
Fewer than 50	7%	4%
50-100	24%	26%
101-200	43%	47%
More than 200	25%	23%

*420 responses, **446 responses

Survey question: As the operator, what is the usual number of hours worked per day during the application season(s)?

Table 32 – Average hours worked per day during application season

Hours per day	2019*	2012**
Fewer than 8 hours	7%	4%
8-12 hours	55%	67%
13-16 hours	35%	27%
More than 16 hours	3%	2%

*419 responses, ** 385 responses

Survey question: As the operator on average hour many hours do you sleep per night during the application season?

Table 33 – Hours of sleep per day during the application season

Hours of sleep	2019*	2012**
Fewer than 4	0%	<1%
4-6 hours	40%	32%
7-8 hours	59%	64%
More than 8 hours	1%	4%

*420 responses, ** 385 responses

Survey question: As the operator, what is the usual number of days worked per month during the application season?

Table 34 – Usual number of days worked per month during application season

Days worked/month	2019*	2012**
Fewer than 24 days	22%	33%
24 or more days	78%	67%

*419 responses, ** 444 responses

Survey question: As the operator, what is the usual number of consecutive days worked per month during the application season?

Table 35 – Usual number of consecutive days worked /month during application season

Consecutive days/month	2019*	2012**
Fewer than 7	18%	23%
7-10 days	19%	18%
11-14 days	14%	16%
More than 14 days	48%	43%

*419 responses, **444 responses

4.1.7. Health

To understand the overall health of operators a series of nine questions were asked. These questions were designed to be consistent with nationwide standardized health-related questions. The eight tables below present the results from 2012 and 2019.

Survey question: During the spraying season, how often do you feel tired at work even with adequate sleep?

Table 36 – Frequency of feeling tired

Frequency of feeling tired	2019*	2012**
Never	15%	8%
Sometimes	73%	80%
Frequently	10%	11%
Always	2%	1%

*418 responses, **445 responses

Survey question: Overall, how would you rate your health in the past 4 weeks?

Table 37 – Overall health rating

Overall health	2019*	2012**
Very poor	<1%	<1%
Poor	<1%	<1%
Fair	1%	3%
Good	22%	23%
Very good	42%	42%
Excellent	35%	32%

*418 responses, **444 responses

Survey question: During the past 4 weeks, how much did physical health problems limit your usual physical activities (e.g. walking or climbing stairs)?

Table 38 – Physical health limits physical activity

How much limitation	2019*	2012**
Could do no physical activity	<1%	<1%
Quite a lot	1%	<1%
Somewhat	6%	4%
Very little	20%	17%
Not at all	73%	79%

*418 responses, **444 responses

Survey question: During the past 4 weeks, how much difficulty did you have doing your daily work, both at home and away from home, because of your physical health?

Table 39 – Amount of difficulty doing work, or home activities

Amount of difficulty	2019*	2012**
Could not do daily work	0%	0%
Quite a lot	1%	<1%
Some	3%	3%
Very little	20%	10%
Not at all	76%	87%

*417 responses **444 responses

Survey question: How much bodily pain have you had in the past 4 weeks?

Table 40 – Amount of body pain

Amount of body pain	2019*	2012**
None	41%	36%
Very mild	41%	42%
Mild	15%	15%
Moderate	3%	7%
Severe	0%	<1%
Very severe	0%	0%

*418 responses, **444 responses

Survey question: During the past 4 weeks, how much energy did you have?

Table 41 – Level of energy in past 4 weeks

Level of energy	2019*	2012**
None	0%	0%
A little	1%	<1%
Some	21%	20%
Quite a lot	61%	65%
Very much	17%	15%

*418 responses, **444 responses

Survey question: During the past 4 weeks, how much did your physical or emotional problems limit your usual social activities with family or friends?

Table 42 – Social activity limitation due to physical/emotional problems

Limit of social activity	2019*	2012**
Not at all	62%	59%
Very little	30%	32%
Somewhat	6%	6%
Quite a lot	2%	3%
Could not do social activities	0%	0%

*417 responses, **443 responses

Survey question: During the past 4 weeks, how much have you been bothered by emotional problems (such as feeling anxious, depressed or irritable)?

Table 43 – Bothered by emotional problems in past 4 weeks

How much bothered	2019*	2012**
Not at all	66%	59%
Slightly	27%	32%
Moderately	6%	7%
Quite a lot	1%	2%
Extremely	<1%	0%

*415 responses, **443 responses

Survey question: During the past 4 weeks, how much did personal or emotional problems keep you from doing your usual work, school or other daily activities?

Table 44 – Personal/emotional problems kept you away from usual work or other activities

How much	2019*	2012**
Not at all	83%	81%
Very little	14%	16%
Somewhat	3%	3%
Quite a lot	<1%	0%
Could not do activities	0%	0%

*417 responses, **413 responses

Survey question: Do you work for pay outside the aerial application industry during the off season?

Results from 2012 and 2019 surveys are shown in Table 45 below.

Table 45 – Percent of operators who work outside the industry during off season

Work outside industry?	2019*	2012**
Yes	(160) 38%	(159) 40%
No	(256) 62%	(238) 60%

*416 responses **397 responses

Examples of types of work operators do outside the industry during the off season are given in Table 46 below.

Table 46 – Types of work during off season

Off-season work	
135 pilot	Drive school bus- sub
A and P	Fish and Game Flying, Instruction
Aerial Fire Fighting	Flight Instruction
aerial photography	Food processing Facility
AG School FBO	Gun shop owner/truck driver
Aircraft maintenance	Lawn Care
Aircraft Tech	Livestock producer
Airline	Mechanic
Airport line service	Mechanical
Airport manager	Military aviator
Business administration,	Operate a trucking company
Buy and Sell Aircraft	Operate machinery
Carpenter helper	Ranching
CDL Driving	Sales
Chemical, Fertilizer and seed sales	Trucking
Civil Engineering	Trucking
Clean tile drain systems	Weather Observer
Construction work	Wood working

Operators were asked their highest level of education and results are given in Table 47 below.

Table 47 – Education level

Education level	No of operators	Percent
College or technical college graduate	201	47.9%
High school graduate	65	15.5%
Master's degree	11	2.6%
Some college	140	33.3%
Some high school	3	0.7%

*420 responses

5. Summary/Conclusions

This is a cost-effective method to gather information about aerial applications in the US. Using Qualtrics as a web-based tool greatly simplified the programming necessary to conduct the survey. Preliminary notification that the survey was coming, support of the executive director of NAAA, the president of NAAA and the president of NAAREF, and multiple email reminders resulted in a very good response rate considering the length of the survey.

The response rate for this survey is very high compared to other surveys among similar target audiences. The total responses received was slightly higher than the 2012 survey and assuming 1,560 operators, we estimate a 35% response rate.

Results are from nearly all states and were from both NAAA members (82%) and non-members (18%). Responses appear to be spread geographically across the U.S. and represent the industry such that results from this survey can be generalized to the entire industry.

This survey is very similar to the survey conducted by NAAA in 2004 and 2012. The content and response rates were nearly identical, yet the methods differed. The 2004 survey was a mail survey whereas the 2012 and 2019 surveys were web-based. The 2012 and 2019 surveys included a few additional questions on health and risk perception, which made the survey slightly longer, yet direct comparisons can be made and trends identified.

Compared to 2012, more aircraft have boom shutoff capabilities to control drift, fewer pilots are doing mixing and loading themselves, more aircraft are equipped with GPS and fewer automatic flaggers are used.

Operations reported few injuries—just 5% of operations reported an injury resulting in hospital care or missed work time.

Trends to monitor going forward are the installation of ADS-B In and ADS-B Out, the practice of night applications, the growth of aerial imaging and precision application and UAS (drone) activity.

6. Appendix A – Operator Survey

National Agricultural Aviation Association Survey of Operators

NAAA 2018 Survey

Note: Question numbering is not sequential but matches the database for ease of replication and matches the order they were presented to the respondent.

Q1 Thank you for participating in the 2018 Survey of Part 137 Operators and Pilots. It's been six years since the last survey, and now more than ever we need current and accurate data about what's happening in the industry. Completing this survey, which should take no more than 20 minutes, will help the industry communicate with farmers, constituents, policy makers and further inform decision makers. As in the 2011 survey, the NAAA will be summarizing the results and sharing with you and your colleagues. Please dedicate a few minutes to responding to the following questions.

Thank you,

Gary Jerger – 2018 NAAA President

Rod Thomas – 2018 NAAREF President

Andrew Moore – NAAA Executive Director

[Throughout the survey, use your mouse to navigate.]

Are you an owner/operator of a business that holds a Part 137 Certificate?

☐ Yes

☐ No



Q58 In what year were you born?

Q59 Are you?

☐ Male

☐ Female

Q60 Are you a member of the National Agricultural Aviation Association (NAAA)?

☐ Yes

☐ No

Q61 Are you a member of a state or regional agricultural aviation association?

☐ Yes

☐ No

End of Block: Demographic questions_ Operators

Start of Block: Operations Questions_ Operators

Q62 In which state is your aerial application business headquartered?

▼ Alabama ... My headquarters in not in the US

Q63 In which state(s) do you conduct aerial operations? Please include the state in which your application business is headquartered if you do application there.

- ☐ Alabama
- ☐ Alaska
- ☐ Arizona
- ☐ Arkansas
- ☐ California
- ☐ Colorado
- ☐ Connecticut
- ☐ Delaware
- ☐ District of Columbia
- ☐ Florida
- ☐ Georgia
- ☐ Hawaii
- ☐ Idaho

☐

Illinois

☐

Indiana

☐

Iowa

☐

Kansas

☐

Kentucky

☐

Louisiana

☐

Maine

☐

Maryland

☐

Massachusetts

☐

Michigan

☐

Minnesota

☐

Mississippi

☐

Missouri

☐

Montana

- ☐ Nebraska
- ☐ Nevada
- ☐ New Hampshire
- ☐ New Jersey
- ☐ New Mexico
- ☐ New York
- ☐ North Carolina
- ☐ North Dakota
- ☐ Ohio
- ☐ Oklahoma
- ☐ Oregon
- ☐ Pennsylvania
- ☐ Rhode Island
- ☐ South Carolina

☐ South Dakota

☐ Tennessee

☐ Texas

☐ Utah

☐ Vermont

☐ Virginia

☐ Washington

☐ West Virginia

☐ Wisconsin

☐ Wyoming

Q175 Where is your operation based?

- ☐ On a public (tax supported) airport
- ☐ On a private farm or on private property (not publicly funded)



Q64 How many years have you been in the aerial application industry?



Q65 How many years have you been a Part 137 Operator?



Q66 How many people do you employ in your application business?



Q67 How many of your employees are under the age of 18? (If none, enter '0'.)

Skip To: Q69 If How many of your employees are under the age of 18? (If none, enter '0'.) = 0



Q68 Of all the employees who are under 18, how many are your immediate or extended family?



Q69 If you were to hire a full-time pilot in 2018 with 1000 hours ag application time and two years of experience, what would you pay him or her annually? (Please make an estimate)

Q70 How often do you attend the PAASS Program?

- ☐ Annually
 - ☐ Every 2 years
 - ☐ Every 3 years
 - ☐ Less than every 4 years
 - ☐ Never
-

Q71 How often do the aircraft used at your operation get tested at Operation S.A.F.E. fly-in clinics?

- ☐ Annually
 - ☐ Every 2 years
 - ☐ As needed
 - ☐ Never
-

Q72 Are you a pilot?

☐ Yes

☐ No

Skip To: Q77 If Are you a pilot? = No



Q73 How many hours of total flight time do you have?



Q74 How many hours of ag time do you have?



Q75 How many years have you been an agricultural pilot?



Q76 How many agricultural hours did you fly in 2017?



Q77 NOTE: The next questions are about pilots, airplanes and helicopters used for application services at your operation. When the question refers to **normal operations**, it means the routine day-to-day number of aircraft used. It does **not** include unused back-up or spare aircraft. When a question asks for a **maximum (peak) operations**, it means you are using either you own back-up aircraft or outside aircraft on lease or other arrangement (usually during a 'run').

The next questions are about the airplanes and helicopters at your operation during **normal operations** and during **non-peak times**.

How many pilots fly during normal operations?



Q78 How many **airplanes** fly during normal operations?

Skip To: Q81 If How many airplanes fly during normal operations? = 0



Q79 During normal operations, how many airplanes are **turbine powered**?



Q80 During normal operations, how many airplanes have a **closed cockpit**?



Q81 During normal operations, how many **helicopters** does your business use? (If none, enter 0.)

Skip To: Q87 If During normal operations, how many helicopters does your business use? (If none, enter 0.) = 0



Q82 During normal operations, how many helicopters are **turbine powered**?



Q83 During normal operations, how many helicopters have a **closed cockpit**?



Q84 The next two questions are about the airplanes and helicopters at your operation during **maximum (peak) operations**.

How many airplanes operate during maximum (peak) operations?



Q85 How many helicopters operate during (peak) operations? **(Enter '0' if none.)**

Skip To: Q86 If How many helicopters operate during (peak) operations? (Enter '0' if none.) =



Q86 If you use both airplanes and helicopters at your operation in 2017, what percentage of the total acres were treated using helicopters? **(Do not type in %'.)**



Q87 The next few questions are about equipment in the planes or helicopters during normal operations.

How many aircraft used during normal operations have:

A GPS swath guidance system?



Q88

How many aircraft used during normal operations have:

An on-board wind/meteorological measurement system that displays wind speed and direction in the cockpit (e.g. Aircraft Integrated Meteorological Measurement System, AIMMS)?



Q89

How many aircraft used during normal operations have:

A single boom shut off valve?



Q90

How many aircraft used during normal operations have:

A method for reducing effective boom length such as valves or shut offs that can that can be adjusted on the ground or in flight?



Q91

How many aircraft used during normal operations have:

Electrostatic aerial spray technology system?



Q92

How many aircraft used during normal operations have:

A smoker to determine wind direction while performing aerial applications?



Q93 How many aircraft used during normal operations have:

The STC necessary to perform operations using night vision goggles?



Q94

How many aircraft used during normal operations have:

Inflatable seat restraints?



Q95

How many aircraft used during normal operations have:

ADS-B out?



Q96

How many aircraft used during normal operations have:

ADS-B in?

Q97 Do you intend to add ADS-B **in or out** during the next three years?

☐ Yes

☐ No

☐ Undecided

Q98 In 2017, did you make any **variable rate** applications either liquid or dry?

☐ Yes

☐ No



Q99 The next two questions are about **dry** and **liquid** applications.

How many aircraft have equipment for making constant rate applications (applies constant application rate regardless of speed) or making variable rate applications (varies the application rate across the field according to a prescription map of soil or crop conditions) for **dry applications**?

Q100 How many aircraft have equipment for making constant rate applications (applies constant application rate regardless of speed) or making variable rate applications (varies the application rate across the field according to a prescription map of soil or crop conditions) for liquid applications?

End of Block: Operations Questions_Operators

Start of Block: Standard practices at your operation

Q101 The next few questions are about standard practices at your operations.

At your operation, what percent of all spray jobs does the pilot also mix and load product? **(Do not type in '%'.)**



Q102 At your operation, if the mixer/loader and the pilot are different individuals, on average how many aircraft are simultaneously supported by that mixer/loader on a normal day?

Q103 At your operation, if the mixer/loader is not also a pilot, is this person certified or a licensed applicator?

☐ Yes

☐ No



Q104 At your operation, when pesticides are mixed and loaded for spray application, what percentage of the total mixing/loading jobs use the following practices? (Total must equal 100%)

[A closed transfer system is a mechanism that moves pesticide into a spray tank without applicator coming in contact with the pesticide.]

Open transfer (system that allows a mixer/loader to come in contact with pesticide) : _____

Closed transfer (system that does not allow a mixer/loader to come in contact with pesticide) : _____

Total : _____

Q105 Does your operation have decontamination equipment such as a shower available on the airfield?

☐ Yes

☐ No

☐ Don't know

Q106 At your operation, which of the following do you use to control spray drift? (Please check all that apply.)

- ☐ Drift control additives
- ☐ Wind detectors on ground
- ☐ Smoker to monitor wind speed and direction
- ☐ Smoker to monitor inversions
- ☐ Modify droplet size by changing pressure
- ☐ Modify droplet size by changing the nozzle orifice size
- ☐ Modify droplet size by changing nozzle type
- ☐ Modify droplet size by changing nozzle angle
- ☐ Modify droplet size by changing airspeed
- ☐ Change in flight patterns
- ☐ Right or left boom shut off
- ☐ Reduce effective boom length by a method such as valves or shut offs that can be adjusted on the ground or in flight

☐

Appropriate sized buffer zones on the downwind side of the field

☐

On-board wind/meteorological measurement system (e.g. AIMMS)

Q107 For swath guidance when applying pesticides by air, the operation uses: (check all that apply.)

☐

GPS

☐

Automatic flaggers

☐

Human flaggers

☐

Other, please specify _____

Q108 If your aircraft are equipped with smoker(s) to determine wind direction while performing aerial applications, how often are these used? (Check all that apply.)

- ☐ Do not have aircraft equipped with a smoker
 - ☐ Before an application near a sensitive area
 - ☐ Every swath
 - ☐ Every 2-4 swath runs
 - ☐ Every 5-7 swath runs
 - ☐ Every load
 - ☐ Other, please specify _____
-

Q109 At your operation, do you conduct remote sensing or aerial imaging?

- ☐ Yes
 - ☐ No
-

Q110 Do you use UAS (drones) in your operation?

☐ Yes

☐ No

Skip To: Q112 If Do you use UAS (drones) in your operation? = No

Q111 How do you use UAS at your operation?

- ☐ Applications
- ☐ Remote sensing or imaging
- ☐ Other, please specify _____

Q112 At my operation, to identify and track sensitive areas, I use: (Check all that apply.)

- ☐ Sensitive crop registry (i.e. FieldWatch)
- ☐ Data I collect myself
- ☐ Data stored and given to pilots digitally
- ☐ Data stored and given to pilots on hand-drawn maps
- ☐ Other, please explain _____

Q113 Do you make applications during the hours of darkness?

☐ Yes

☐ No

Skip To: Q117 If Do you make applications during the hours of darkness? = No



Q114 Please estimate the total number of acres you treated during hours of darkness in 2017.

Q115 During applications conducted after dark, we use:

☐

Night lights

☐

Night vision goggles

Q116 Please rank the reasons for doing applications during hours of darkness. **(Drag and drop the reasons. 1 = primary reason.)**

_____ To protect pollinators

_____ Because of cooler temperatures

_____ Because there's less wind

_____ Because field workers are not present

_____ Other, please specify

Q117 Do you sell some or all of the chemicals used for aerial applications?

☐ Yes

☐ No

Q118 Are some or all of the chemicals paid for by the farmer/rancher and shipped directly to your operation?

☐ Yes

☐ No



Q119 At your operation in 2017, how many satellite loading sites did you use?

Q120 For the next few questions, please report on the loading area you usually use at the operation.

Does the loading area you usually use have a re-capture system (loading pad) to control spills?

☐ Yes

☐ No

Q121 Is the loading area you usually use covered?

☐ Yes

☐ No

Skip To: Q124 If Is the loading area you usually use covered? = Yes

Q122 Do you have a method of capturing rainfall at your operation?

☐ Yes

☐ No

Q123 Do you have a way to clean the pad?

☐ Yes

☐ No

Q124 Are there fire extinguishers at the loading area (other than in the aircraft)?

☐ Yes

☐ No

Q177 During normal ag operations, how often do you contact Air Traffic Control (e.g. operating near controlled air space)

☐ Never, I have no reason to contact ATC as part of my normal ag operations.

☐ Less than five times per year

☐ Six or more times per year

End of Block: Standard practices at your operation

Start of Block: Standard practices at your operation Part 2.

Q125 Please select the crops you treated in 2017.

- ☐ Aquatic weed and algae control
- ☐ Alfalfa
- ☐ Corn
- ☐ Cotton
- ☐ Cover crop work
- ☐ Forests
- ☐ Leafy Vegetables
- ☐ Mosquito Control (aquatic)
- ☐ Mosquito Control (non-aquatic)
- ☐ Other Public Health Pest Control
- ☐ Orchards (Fruit/Nut)
- ☐ Organic crops
- ☐ Pastures and range land

☐

Rice

☐

Right-of-Way

☐

Roots and Tubers (includes potatoes, beets, onions and bulbs)

☐

Small fruits (Grapes/Berries)

☐

Small grains (Wheat/Barley)

☐

Sorghum

☐

Soybeans

☐

Other, please specify _____

Carry Forward Selected Choices - Entered Text from "Please select the crops you treated in 2017. "



Q126 You selected the following crops in the previous question. Please complete the table below with your best estimate. For each crop or use, indicate the **number of acres** that your company treated during 2017 **with your entire fleet**.

	Total acres treated
Aquatic weed and algae control	
Alfalfa	
Corn	
Cotton	
Cover crop work	
Forests	
Leafy Vegetables	
Mosquito Control (aquatic)	

Mosquito Control (non-aquatic)	
Other Public Health Pest Control	
Orchards (Fruit/Nut)	
Organic crops	
Pastures and range land	
Rice	
Right-of-Way	
Roots and Tubers (includes potatoes, beets, onions and bulbs)	
Small fruits (Grapes/Berries)	

Small grains (Wheat/Barley)	
Sorghum	
Soybeans	
Other, please specify	

Carry Forward Selected Choices - Entered Text from "Please select the crops you treated in 2017. "



Q127 You selected the following crops in the previous question. For each crop, Please enter the **usual** and **maximum number** of acres treated in a **single day** in a single aircraft.

	Acres treated in single day	
	Usual number of acres	Maximum number of acres

Aquatic weed and algae control		
Alfalfa		
Corn		
Cotton		
Cover crop work		
Forests		
Leafy Vegetables		
Mosquito Control (aquatic)		
Mosquito Control (non-aquatic)		

Other Public Health Pest Control		
Orchards (Fruit/Nut)		
Organic crops		
Pastures and range land		
Rice		
Right-of-Way		
Roots and Tubers (includes potatoes, beets, onions and bulbs)		
Small fruits (Grapes/Berries)		
Small grains (Wheat/Barley)		

Sorghum		
Soybeans		
Other, please specify		



Q128 The next questions are about sprayers (liquid applications) and spreaders (dry applications).

Percent of all acres treated in 2017 using a sprayer : _____

Percent of all acres treated in 2017 using a spreader : _____

Total : _____

Skip To: Q130 If The next questions are about sprayers (liquid applications) and spreaders (dry applications). = Percent of all acres treated in 2017 using a spreader



Q129 If you used a sprayer in 2017,

what percent of these acres treated were pesticide only? : _____

what percent of these acres treated were fertilizer alone? : _____

what percent of these acres treated were a mixture of both pesticide and fertilizer? : _____

Total : _____



Q130 If you used a spreader in 2017, (Leave blank if you only use a sprayer)

what percent of these acres treated were fertilizers? : _____

what percent of these acres treated were cover crop(s)? : _____

what percent of these acres treated were harvestable crop seeding such as rice? : _____

what percent of these acres treated were pesticide applications? : _____

Total : _____



Q131 At your operation, estimate the average size of the field (in acres) you treated in 2017.

Q132 During the active spray seasons your employees/contractors may be exposed to many hazards. Score each item below where 1 is considered 'not a risk' and 10 is 'extremely risky'.

Example:

Crossing the street without looking 7

Mowing lawn with bare feet 7

Running with scissors 2

	Risk Ranking
	Enter number below

Chemicals	
Rotating prop	
Engine noise	
Cockpit clutter	
Birds	
Power lines	
Communications towers	
Wind turbines	
Meteorological towers	

Mechanical failure	
Adverse weather conditions	
Limited space for maneuvering	
Unmanned Aircraft Systems (Drones)	
Aircraft being shot at	
Night application	
Other, please specify	

End of Block: Standard practices at your operation Part 2.

Start of Block: Standard practices at your operation Part 3

Q133 In 2017, did you encounter **unmarked communication tower(s)** when making aerial applications?

☐ Yes

☐ No

Q134 In 2017, did you encounter any **wind turbine(s) and/or unmarked meteorological tower(s)** when making aerial applications?

☐ Yes

☐ No

Q135 In 2017, did you encounter **Unmanned Aircraft Systems (UAS or drones)** when making aerial applications?

☐ Yes

☐ No

Q136 At your operation, have you established a policy about working in the vicinity of wind turbines?

☐ Yes

☐ No

Skip To: Q138 If At your operation, have you established a policy about working in the vicinity of wind turbines? = No

Q137 My policy about working in the vicinity of wind turbines is to:

☐ Refuse to do the application

☐ Charge an additional amount (premium or surcharge)

☐ Apply only by helicopter

☐ Other, please specify _____

Q138 In your operation, do your loaders load chemicals while the engine(s) are running ('hot' fueling or 'hot' loading)?

☐ Yes

☐ No

Skip To: Q140 If In your operation, do your loaders load chemicals while the engine(s) are running ('hot' fueling... = No

Q139 Do you consider the practice of 'hot' loading to be a requirement for conducting your operations?

☐ Yes

☐ No

Q140 In 2017, did anyone at your work operation report a work-related injury that required treatment at a hospital or doctor's office in 2017?

☐ Yes

☐ No

Skip To: End of Block If In 2017, did anyone at your work operation report a work-related injury that required treatment a... = No



Q141 How many work-related injuries were there at the operation?

Q142 Thinking of the person most severely injured at your operation in the past two years: What was the initial cause of the injury? (Select one only)

- ☐ Crash
- ☐ Collision with other aircraft or fixed object while on the ground
- ☐ Struck by object
- ☐ Fire
- ☐ Fall
- ☐ Run over
- ☐ Chemical
- ☐ Electrocuting
- ☐ Laceration
- ☐ Other, please specify _____

Q143 Thinking of the most severe injury in the past two years: What part or parts of the person's body was injured?

- ☐ Head
- ☐ Back/spine
- ☐ Side

☐

Hand

☐

Eye

☐

Chest

☐

Neck

☐

Ear

☐

Arm

☐

Foot

☐

Leg

☐

Abdomen

☐

Lung

☐

Other, please specify _____



Q144 Thinking of the most severe injury in the past two years: Please estimate the number of workdays this person missed because of the injury.

End of Block: Standard practices at your operation Part 3

Start of Block: Workload questions

Q145 The next few questions are about work load as the operator.
As the operator, what is the usual number of days per year when flight operations are conducted?

- ☐ Fewer than 50 days
- ☐ 50-100 days
- ☐ 101-200 days
- ☐ More than 200 days

Q146 As the operator, what is the usual number of hours worked per day during the application season(s)?

- ☐ Fewer than 8 hours
- ☐ 8-12 hours
- ☐ 13-16 hours
- ☐ More than 16 hours

Q147 As the operator on average how many hours do you sleep per night during the application season?

- ☐ Fewer than 4 hours
- ☐ 4-6 hours
- ☐ 7-8 hours
- ☐ More than 8 hours

Q148 As the operator, what is the usual number of days worked per month during the application season?

- ☐ Fewer than 24
- ☐ 24 or more

Q149 As the operator, what is the usual number of consecutive days worked per month during the application season?

- ☐ Fewer than 7
- ☐ 7-10
- ☐ 11-14
- ☐ More than 14

Q150 During the spraying season, how often do you feel tired at work even with adequate sleep?

- ☐ Never
- ☐ Sometimes
- ☐ Frequently
- ☐ Always

End of Block: Workload questions

Start of Block: Health Questions

Q151 Overall, how would you rate your health in the past 4 weeks?

- ☐ Excellent
 - ☐ Very good
 - ☐ Good
 - ☐ Fair
 - ☐ Poor
 - ☐ Very poor
-

Q152 During the past 4 weeks, how much did physical health problems limit your usual physical activities (e.g. walking or climbing stairs)?

- ☐ Not at all
 - ☐ Very little
 - ☐ Somewhat
 - ☐ Quite a lot
 - ☐ Could not do physical activities
-

Q153 During the past 4 weeks, how much difficulty did you have doing your daily work, both at home and away from home, because of your physical health?

- ☐ Not at all
 - ☐ Very little
 - ☐ Somewhat
 - ☐ Quite a lot
 - ☐ Could not do daily work
-

Q154 How much bodily pain have you had in the past 4 weeks?

- ☐ None
 - ☐ Very mild
 - ☐ Mild
 - ☐ Moderate
 - ☐ Severe
-

Q155 During the past 4 weeks, how much energy did you have?

- ☐ Very much
 - ☐ Quite a lot
 - ☐ Some
 - ☐ A little
 - ☐ None
-

Q156 During the past 4 weeks, how much did your physical or emotional problems limit your usual social activities with family or friends?

- ☐ Not at all
 - ☐ Very little
 - ☐ Somewhat
 - ☐ Quite a lot
 - ☐ Could not do social activities
-

Q157 During the past 4 weeks, how much have you been bothered by emotional problems (such as feeling anxious, depressed or irritable)?

- ☐ Not at all
 - ☐ Slightly
 - ☐ Moderately
 - ☐ Quite a lot
 - ☐ Extremely
-

Q158 During the past 4 weeks, how much did personal or emotional problems keep you from doing your usual work, school or other daily activities?

- ☐ Not at all
- ☐ Very little
- ☐ Somewhat
- ☐ Quite a lot
- ☐ Could not do daily activities

End of Block: Health Questions

Start of Block: Final questions

Q159 Do you work for pay outside the aerial application industry during the off season?

- ☐ Yes
- ☐ No

Skip To: Q161 If Do you work for pay outside the aerial application industry during the off season? = No

Q160 What work do you do?

Q161 What is your highest level of education?

- ☐ Some high school
 - ☐ High school graduate
 - ☐ Some college
 - ☐ College or technical college graduate
 - ☐ Master's degree
 - ☐ Doctorate
 - ☐ Choose not to answer
-

Q162 Thank you for participating in this important survey.

- ☐ Finish

Skip To: End of Survey If Thank you for participating in this important survey. = Finish

End of Block: Final questions
