

2021 PRECISION AGRICULTURE DEALERSHIP SURVEY

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Departments of Agricultural Economics and Agronomy

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ABOUT THE SURVEY, RESPONDENTS, AND RESPONDENT'S COMPANY/ORGANIZATION

In February-March 2021 CropLife magazine and the Departments of Agricultural Economics and Agronomy at Purdue University conducted the 21st survey of crop input dealers about precision agriculture technologies. As with previous surveys, recipients were asked questions about how they use precision agriculture within their business, what precision products and services they offer to their customers, their use of data generated on farms, adoption of precision farming by their farmer customers, and questions aimed at understanding practices such as constraints to adoption. This survey is the longest-running, continuous survey of precision farming practices in the world.

The questionnaire was all electronic, with a link emailed to a subset of CropLife's email list. Survey questions are at the end of this report. With any survey a recipient may not respond, respondents may not answer all questions, or may also answer some questions incompletely. We did not include a respondent's survey responses in this report if they:

- Only answered demographic questions (1, 2, 3, 4, 5, or 17) and nothing else.
- Did not answer 1, regardless of any other responses, which asks about their type of business. We report on business types separately, so 1 was essential for sorting.
- Responded to Question 1 as a farm equipment dealer or agricultural consultant.
- Did not answer 5, regardless of any other responses, which asks about crops grown in their area. We report field crops and specialty crops separately, so 5 was essential for sorting.

Otherwise we accepted all other responses, however complete or incomplete. In this report we present the 225 surveys from agricultural retail input suppliers working with field crops only. The remainder of the surveys (15) represent retail input suppliers of specialty crops, to be reported separately. Respondents identified as working with field crops indicated corn, soybeans, wheat, rice, cotton, milo, sugar beets, dry beans, or hay/forages were the primary crops for the products and services they provide. Those tagged specialty crops were providing products and services primarily to nursery, greenhouse, tree fruits and nuts, vegetables, berries, or grapes.

Past reports are assumed to be mainly field crops ag retail input suppliers, so contain the historical trends. 2017 was the first year we asked respondents if they were input suppliers, equipment dealers, consultants, or other. 2019 was the first year we asked about the crops in their areas so we could distinguish specialty dealers from field crops dealers. Most field crop retailer survey responses were from Midwest states, similar to previous reports. Response by state is shown in Table 1 (categories may not add exactly due to rounding).

Table 1, Q17: Respondent location by state.

Midwest 88%				South 7%		West 5%	
Iowa	14%	Missouri	6%	Tennessee	3%	Colorado	2%
Illinois	13%	South Dakota	5%	Oklahoma	2%	Washington	2%
Indiana	12%	Nebraska	4%	Alabama	1%	Arizona	1%
Ohio	12%	Michigan	3%	Georgia	1%	Oregon	1%
Minnesota	7%	Kansas	2%	Kentucky	1%		
Wisconsin	7%	North Dakota	2%				

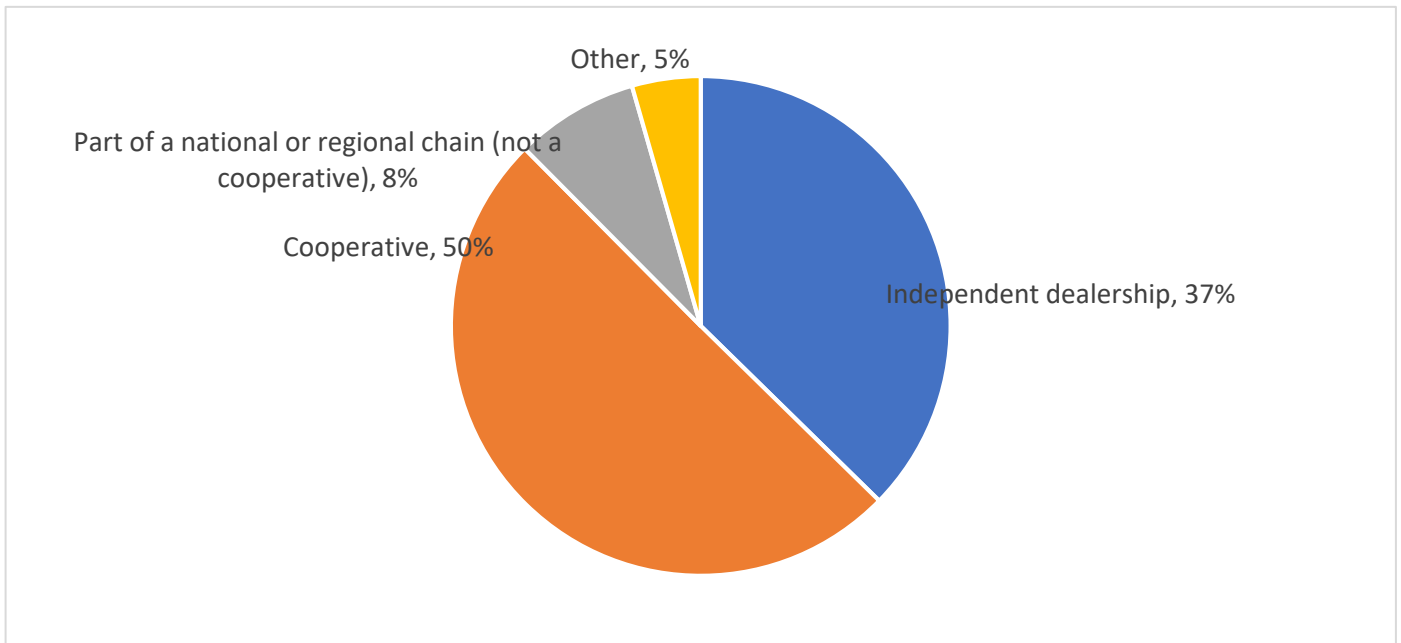


Figure 1, Q1: Organizational type represented by respondents.

Of the ag input retailers 50% indicated they represent a cooperative, 37% an independent dealership and 8% are part of a national or regional dealership (not a cooperative), Figure 1.

The organizations the respondents represent are primarily multiple-retail locations, Figure 2. Four percent of the respondents worked for a company that did not own or manage a retail outlet. Twenty-three percent of respondents reported having only one retail outlet. The number of respondents that owned or managed five stores or less was 45%. The number of respondents that worked for a company that owned or managed six or more stores was 56%. Ag retail consolidation is apparent looking back to previous surveys. For example, a decade ago in 2011 the number of respondents that had six or more stores was 38%.

The survey asked about the position the respondent held within their organization. Forty-five percent reported being the owner or location manager, and one quarter were in sales or sales management. Other common job responsibilities for respondents were department manager (9%), technical consultant/agronomist (9%), and precision manager (8%). Overall the respondents of the survey are those that lead and manage the organization, or work directly with customers (Figure 3).

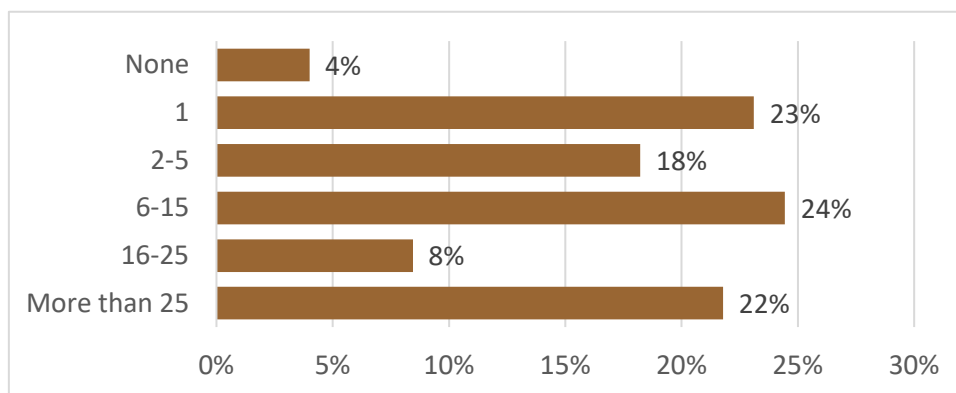


Figure 2, Q4: Number of retail outlets owned or managed by company.

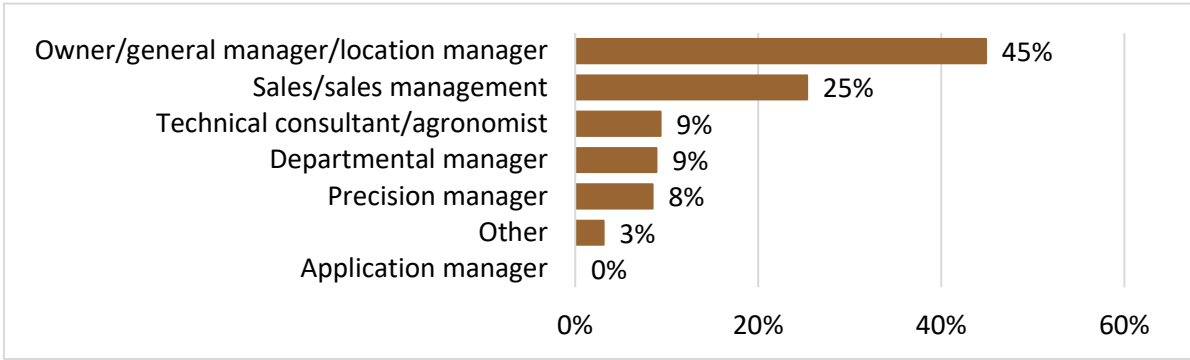


Figure 3, Q3: Responsibility of survey respondent.

DEALER USE OF PRECISION TECHNOLOGIES

Dealers get utility from the precision technologies they use for their own business purposes, such as guidance and section/nozzle controllers on their applicators. We detail that here, followed by the precision products and services they offer to customers in the next section.

Note that the survey went from every year to every other year from 2009 to 2019, and is now back to yearly. All technologies were down in 2017 compared to 2015, but all rebounded for 2019—a weak farm economy and other financial pressures on retailers then could explain the dip (Figure 4). Note the overall downward trend for manual control (lightbar) guidance, peaking at three fourths of dealers a decade ago but with current usage rates down now to only about one third of dealers. The decline is because it is being replaced with autoguidance technology. Note that the guidance numbers prior to 2004 do not distinguish manual and autoguidance, as the survey question then just asked about guidance in general because autoguidance was not widely available commercially then.

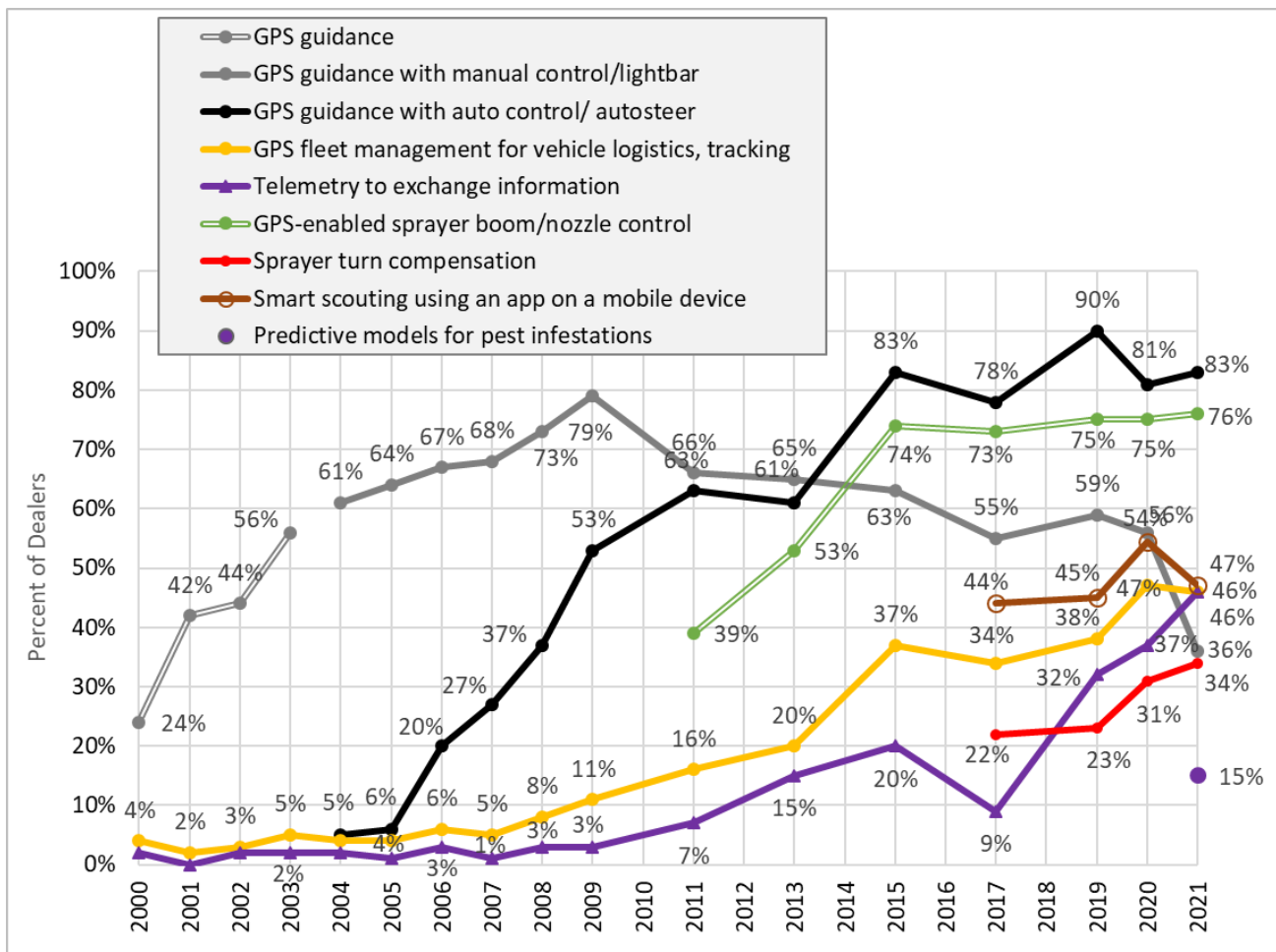


Figure 4, Q7: Retailer use of precision technology for their business.

The use of guidance technologies by dealers for their custom pesticide and fertilizer applications indicate a maturing market, with 83% of dealers using autoguidance in any capacity, and 86% of those who offer precision services using guidance of any type (including manual guidance/light bars, Figure 4). These numbers represent the percent of dealerships utilizing the technology in some form, which they may use on some or all of their equipment and on some or all of the acres they service. 86% of custom acres were applied using autoguidance (Question 15). GPS-guided boom section/nozzle controllers on sprayers, which reduce doubling-up and skips, are used at three-fourths of dealerships (Figure 3), and were used on 86% of custom acres. Another guidance-related technology, sprayer turn compensation, continues to grow, now at 34% of dealerships. About half of dealers are using telemetry to exchange information among applicators or to/from office locations, up dramatically in recent years, around half are using GPS fleet management to track the locations of vehicles and guide vehicles to work sites, and about half are using some type of a smart scouting app on a mobile device. Some year to year variation of survey results is normal, as survey respondents differ each year. A difference of a few points in one year may or may not signal a trend.

Seventy-six percent of total fertilizer sales were custom applied; 61% of total crop protection sales were custom applied (Questions 13 and 14, for those dealers who are doing custom application). The percent of fertilizer and pesticide sales that are custom applied was asked on every survey from 2000 to 2019, skipping 2020, and then again in 2021. The results are very consistent over two decades of time—the percent of fertilizers custom applied ranged from 57-65 (excepting 2021), and the percent of pesticides ranged from 52-62. In every survey the percentage of fertilizers custom applied always exceeded that of pesticides. In surveys from 2000 to 2013 the results were calculated separately for the Midwest vs. other areas—in these surveys the percentages custom applied were always higher in the Midwest, lower in other states, with just one exception in 2001 where the percent of fertilizers custom applied was slightly lower in the Midwest. In these 2000 to 2013 surveys the percent of pesticides custom applied was always at least 10% higher in the Midwest compared to other states, with just one exception in 2005 where the difference was 9%. See previous reports for more detail.

DEALER OFFERINGS OF SITE-SPECIFIC SERVICES

Another element of precision technology for dealers is in the services they offer to their farmer customers. Respondents were asked to report their current offerings of precision services and what they plan to offer three years from now, in 2024 (Figure 5). Current dealer offerings are ranked top to bottom. VRT fertilizer applications and grid or zone soil sampling lead the offerings at close to 90% of dealers offering. The next common offerings for dealers are yield monitor and other data analysis, VRT lime applications, and satellite/aerial imagery. On the other end of the scale only a few dealers responded that they were currently offering services in robotic weeding or robotic scouting, but if not currently offering 12% of dealers said they would be offering these in three years, by 2024, showing great confidence in their potential.

Over the next 3 years, the technologies respondents are planning the most growth (longest green bar in Figure 5) are in VRT pesticide application (26% of respondents will add), UAV/drone imagery (21%), chlorophyll/greenness sensors for N management (16%), profit/cost mapping (15%), VRT irrigation prescriptions (15%), and crop inputs applied with a UAV/drone (15%). In many past surveys, dealers have optimistically overestimated their precision offerings plans compared to the actual numbers the survey showed in years following.

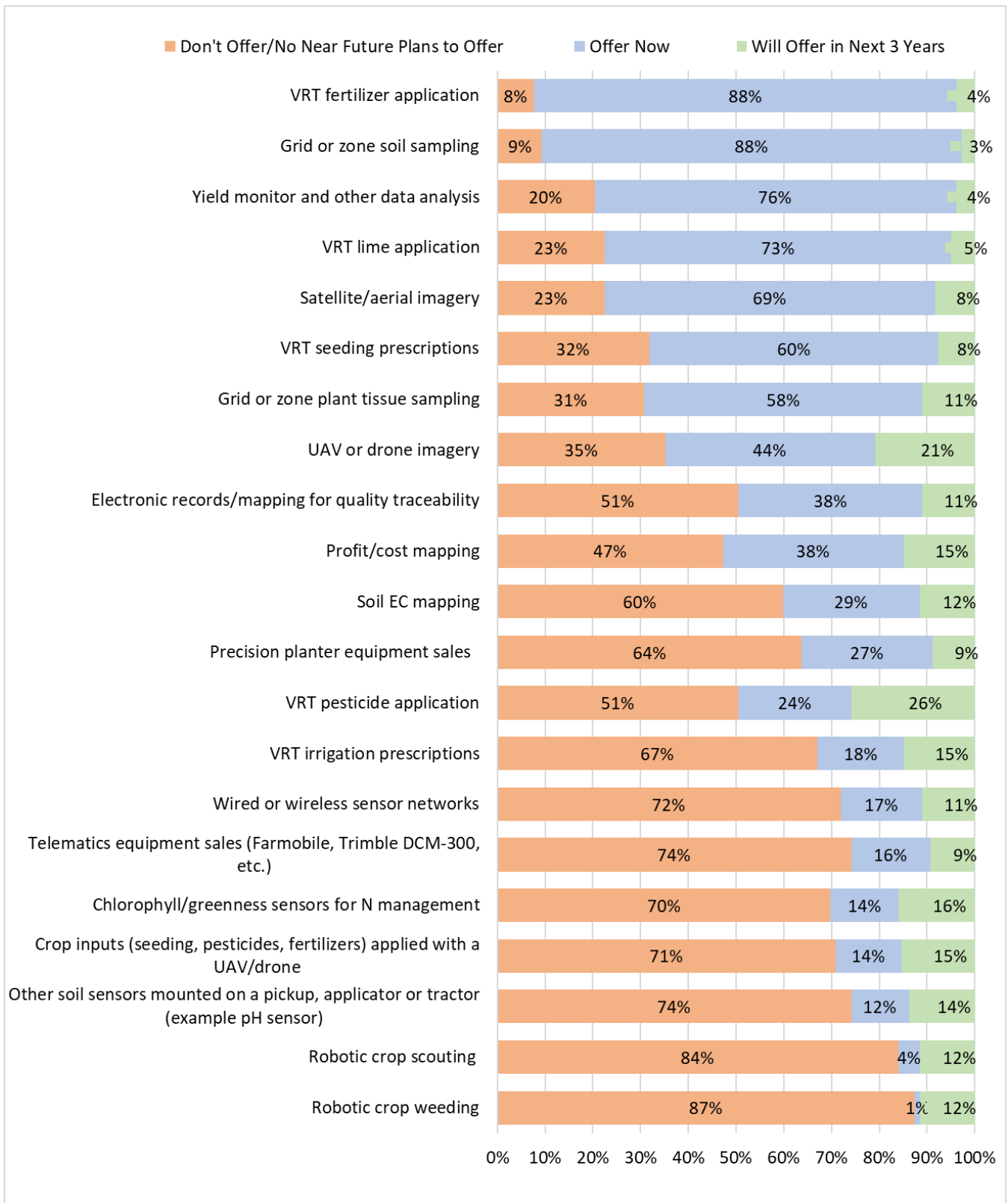


Figure 5, Q10: Dealer offerings of precision services, ranked by current offering. Due to rounding, rows may not total 100%.

Figure 6 shows the adoption of mostly information-gathering services over time, with projections as dotted lines. The 2024 projections are calculated as the sum of question 10 responses for each technology for “offer now” plus “will offer in next 3 years.” As with the technologies the dealers are using for their own purposes, these data represent the percent of dealers offering these services, not the percent of acres where these services were applied.

Precision Agriculture is a management strategy, but its practical implementation depends on a variety of mostly digital tools to capitalize on its benefits, from sensing, to analysis, prescriptions, and on to applications. These tools evolve and change over time, which drives the interest for the survey results. Some tools have proven their place with most retailers, such as grid or zone soil sampling—although that journey took over two decades (Figure 6). Most dealers offer satellite or aerial imagery, and more say they will be adding this in the future. Imagery can be a foundation for creating management zones or guiding site-specific inputs. In the last six years grid or zone soil sampling, UAV or drone imagery, and satellite/aerial imagery each grew over 20%. This is in contrast to the more modest growth in the use of chlorophyll/greenness sensors such as Greenseeker, CropSpec, or OptRx, the first of which entered the market in 2002 and which we started tracking dealer use a decade ago. The soil EC mapping from 2004 to 2009 shown in Figure 6 was asked in a question about what retailers were using for their business, but nearly all EC mapping is part of a dealer offering to a customer.

Variable rate technology (VRT) services, where a data driven approach is used to address inconsistency across fields, dipped slightly in 2021 but most types remain far above the levels of a decade prior (Figure 7), and there

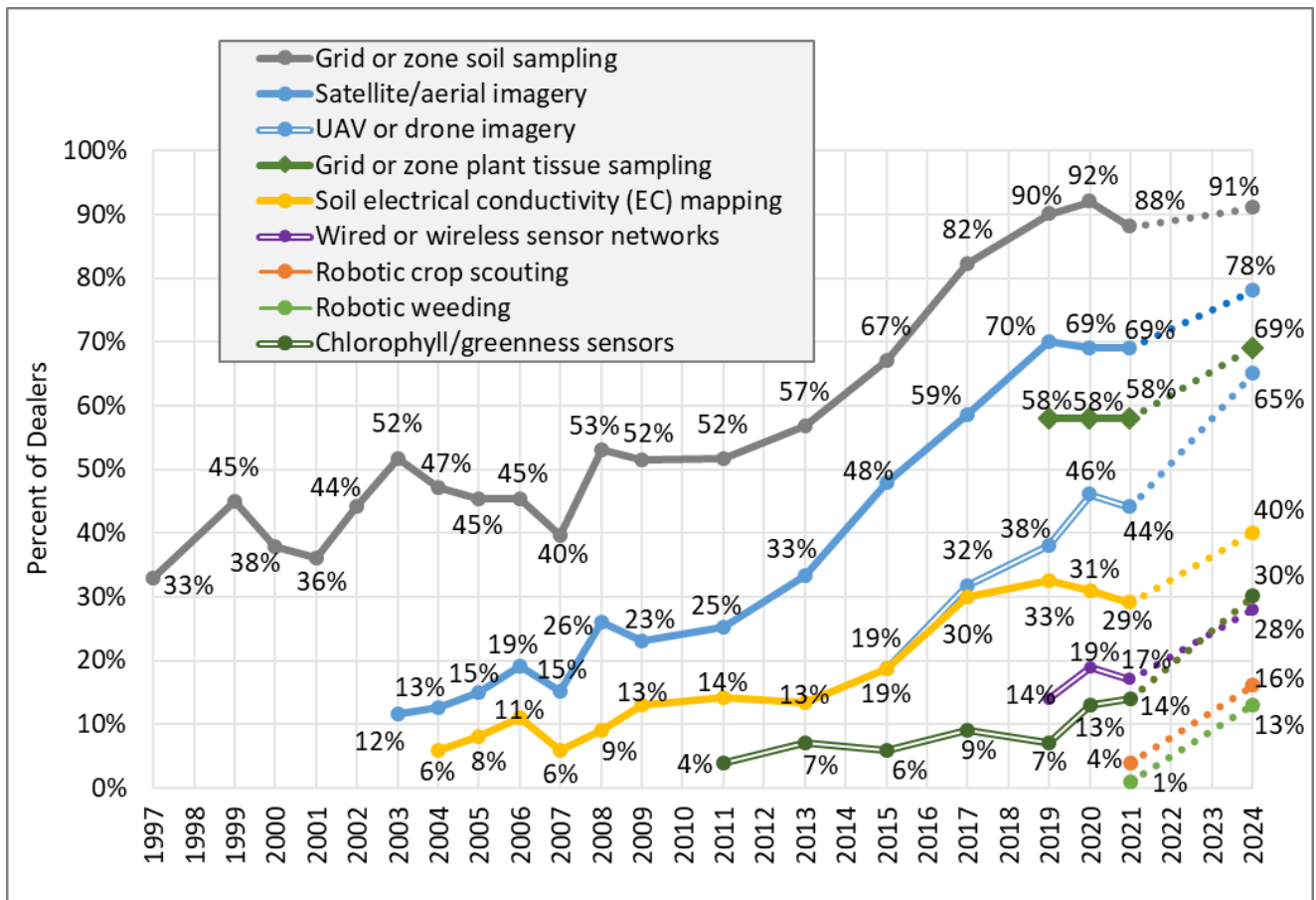


Figure 6, Q10: Dealer offerings of precision services over time, sensing and related technologies. 2024 are projections.

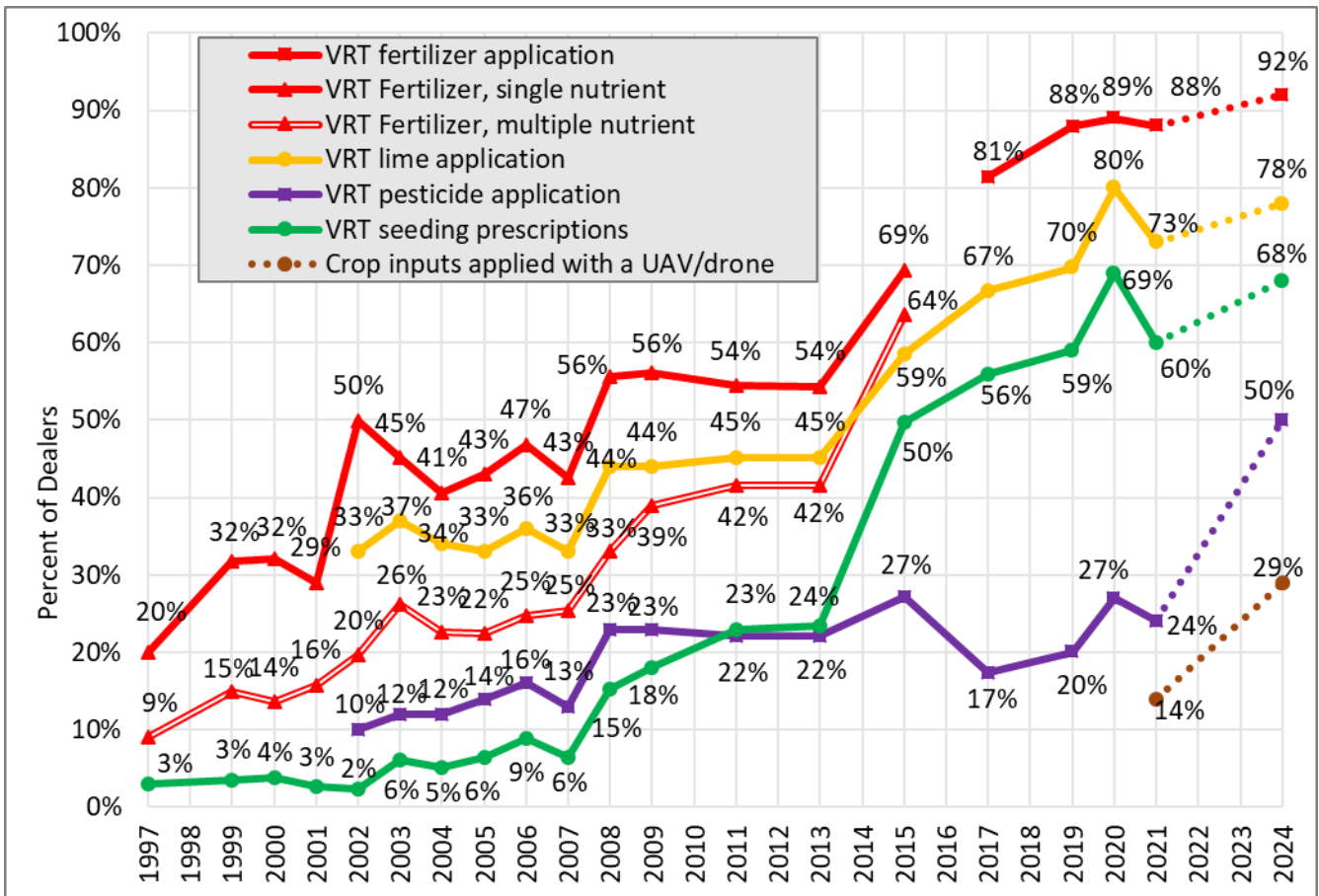


Figure 7, Q10: Dealer offerings of precision services over time, variable rate technologies. Starting at 2017 the survey stopped asking separately about single and multiple fertilizer applications. 2024 are projections.

is optimism into the future (dotted lines). From 2002-2013 about half of dealers were offering VRT fertilizer applications, but the mid 2010's were a pivot point, increasing to 69% in 2015 and now just short of 90% of dealers. VRT seeding recommendations have made a huge jump in the last several years, from 24% in 2013 to 50% in 2015, and 60% of dealers now offering these services. As with Figure 6, the 2024 projections are calculated as the sum of question 10 responses for each technology for "offer now" plus "will offer in next 3 years." Fourteen percent of dealers say they are currently offering crop inputs applied via a UAV/drone, the first time for this question, but 29% expect to be offering this by 2024 (Figure 7).

VRT pesticide application has been up and down for the last few years, and remains at about the same levels of a decade ago. 26% more dealers, to 50% by 2024, plan to add this as an offering in the next three years. This is more than anything else we ask about, continuing past optimism of a 25% three year out increase estimated in 2017, a 30% increase estimated in 2019, and a 20% increase estimated in 2020. As you can see, 2013 was an inflection point for all VRT offerings, following a decade of stagnation.

Starting in 2017 the survey no longer separately asks about VRT single fertilizer applications as compared to multiple product applications—thus the multiple red lines in Figure 7. As noted in previous graphics showing results over time, changes in the adoption numbers of a few percentage points may reflect the inherent variability and error present in any survey, as there is a different pool of respondents each time. A few percentage points difference in a single year may not signify a trend or a real difference from another technology.

ANALYSIS OF DATA

Precision agriculture can generate an overwhelming amount of data from yield monitors, soil sampling, machine operations across fields, as-applied amounts, and remote sensors, to name a few. Often producers need assistance in analyzing these data in the hopes they can be turned into meaningful insights.

Figure 8 reports how dealers help customers manage farm-level data in decision-making. Respondents could mark any or all that apply. The most common way dealers are helping customers was printing maps, such as yield, soil electrical conductivity, and soil maps. Beyond printing maps, 66% of dealers are archiving and managing yield, soil test, and other data for future use. Half or less of respondents work with farmers on their data individually.

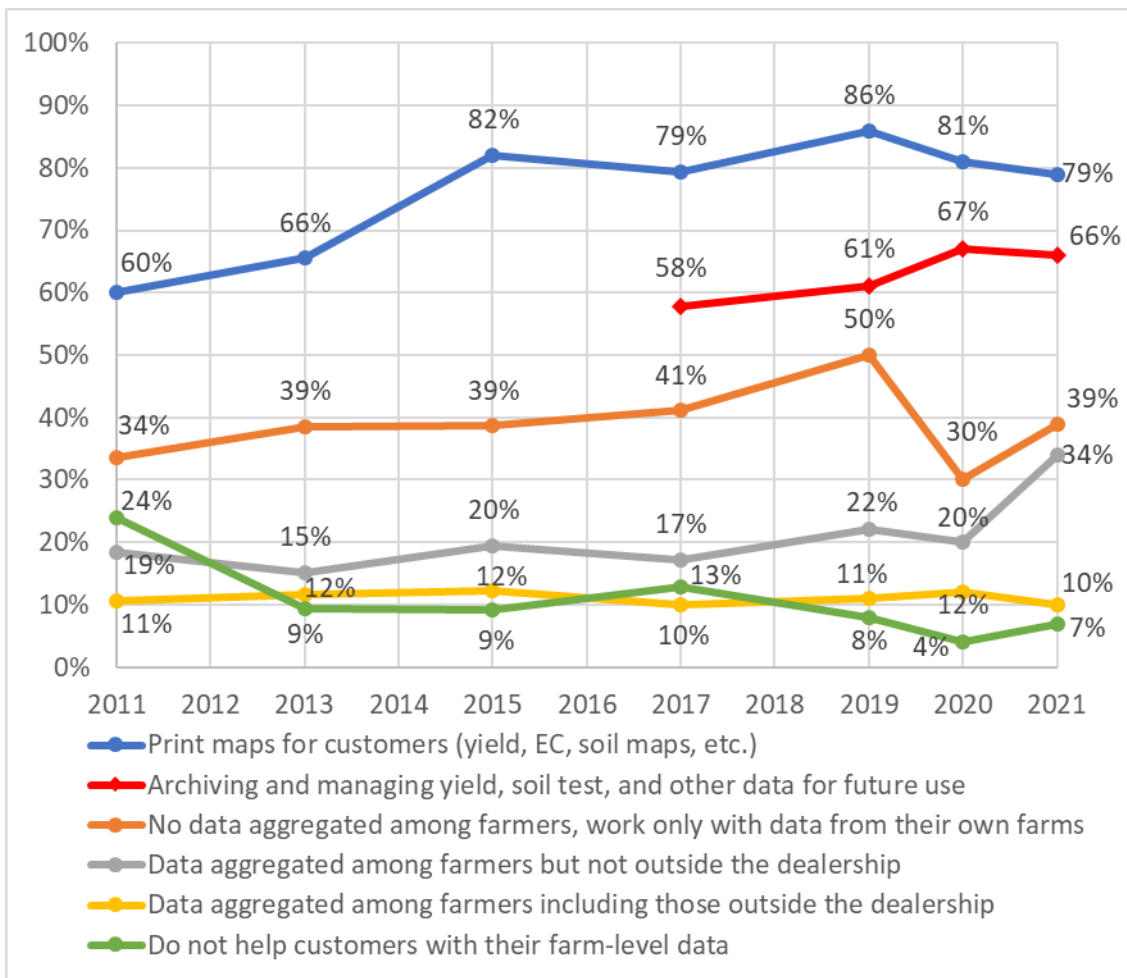


Figure 8, Q8: Managing farm-level data to assist customers in decision making over time.

In addition to the farmer’s individual data, one third the respondents reported working with farmers by using data aggregated among farmers within the dealership. Ten percent reported using data aggregated among farmers including those outside the dealership. Only seven percent of the respondents do not help farmers

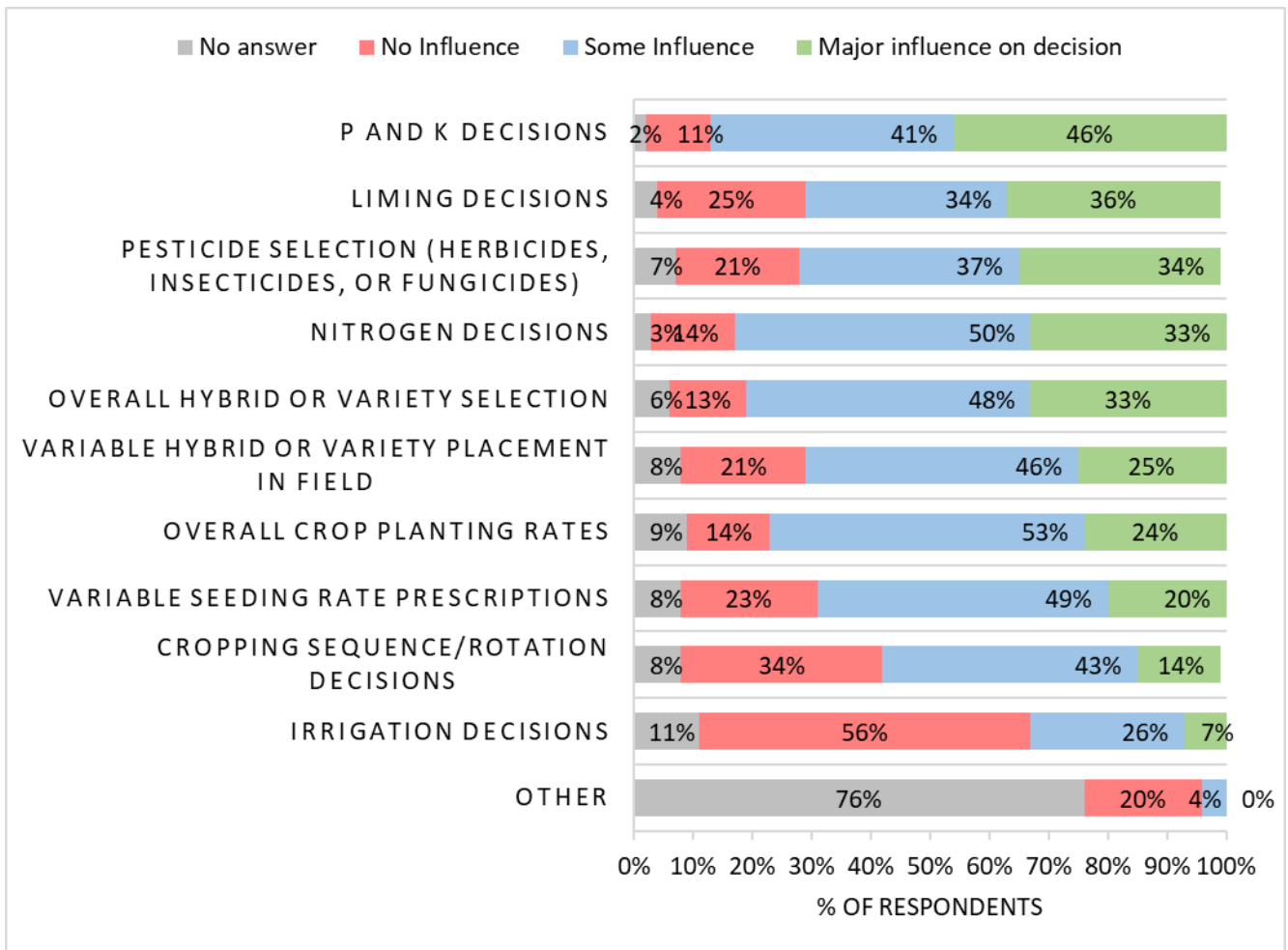


Figure 9, Q9: Crop management decisions influenced by pooled data from customer’s farms, ranked by major influence. Due to rounding, percentage numbers for a technology may not total 100.

with their farm-level data. Fifty-nine percent of retailers have a customer data privacy statement and/or data terms & conditions agreement, up from 58% in 2020, 47% in 2019, and 45% in 2017.

Figure 9 shows the types of decisions where pooled customer data is used for decision-making, reported by dealers as a major influence, some, or no influence. We define pooled data as that which is aggregated from multiple farms, either managed within the dealership or as part of an outside offering. Dealers report pooled data has the most influence for P & K (phosphorus and potassium fertilizer) decisions, distinctly more than any other. When considering a combination of some influence and major influence, the top decisions using pooled data are P & K, nitrogen, overall hybrid and variety choice, and overall planting rates.

There has been a remarkable uptick in crop management decisions from pooled data in recent years (Figure 10). Eighty-seven percent of dealers said phosphorus and potassium decisions were at least somewhat influenced by pooled data, doubling compared to four years ago, and 86% saying nitrogen decisions were being influenced, up from 39% in 2017. Eighty-one percent of dealers indicated pooled data had at least some influence for overall hybrid/variety placement, and 69% said pooled data was informing variable planting rate prescriptions, both more than double compared to three years ago. Using site-specific information from fields, such as remote sensing imagery, soil test results, soil or yield maps, to characterize and understand field variability and its impact on crop performance, and then to act upon that by variably managing fields—has been a greater challenge than many would have predicted two decades ago.

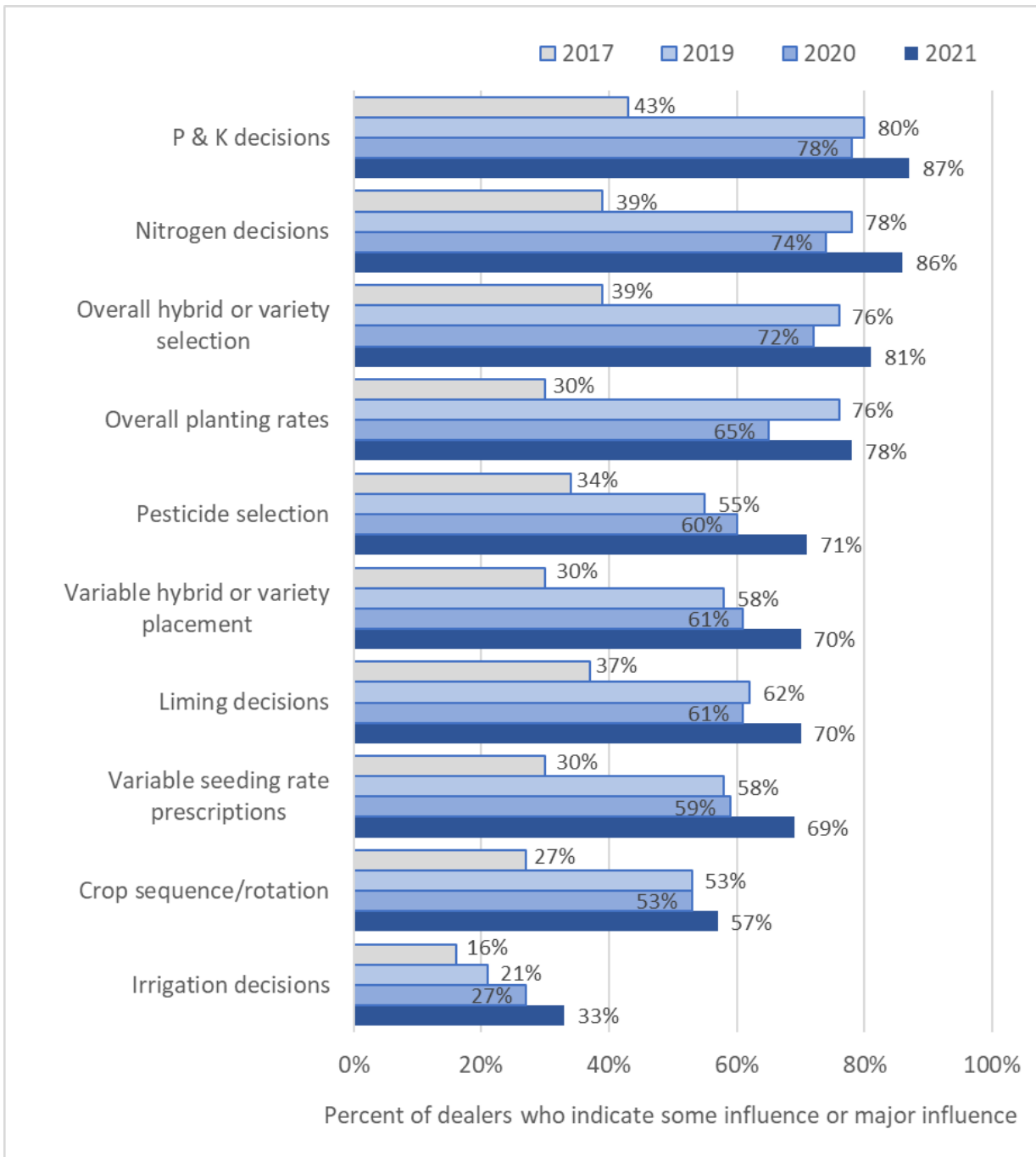


Figure 10, Q9: Crop management decisions influenced by pooled data from customer's farms over time.

SOIL SAMPLING PROCEDURES

Most agricultural dealers help producers manage soil nutrients, as previously discussed with dealer offerings, page 7. This often starts with grid or zone soil sampling, a service offered by nearly 90% of dealers. The exact location of the soil sample (or subsamples) is easily determined using GPS. The location information combined with a fertilizer recommendation from a lab informs the rates used for variable rate application technology.

As reported in previous sections 88% of dealers offer grid or zone soil sampling. Fifty-six percent of dealers offer grid soil sampling, much lower than previous years, 69% offer traditional or whole field sampling, and 52% offer sampling using management zones (Figure 11). Multiple responses were allowed for multiple procedures. For dealers who offer sampling in management zones, more are using soil mapping units or yield maps to delineate the zones, and fewer are using soil electrical conductivity (Figure 12, respondents could only choose one). For dealers who grid sample, 2.5 acres (1 hectare) is the most common grid size, although many commonly sample in larger grids (Figure 13). Grids larger than 2.5 acres are more common than smaller grids. The appropriate grid size is a compromise of the labor/time and equipment needed for sampling and soil testing costs vs. the specificity desired to inform variable rates.

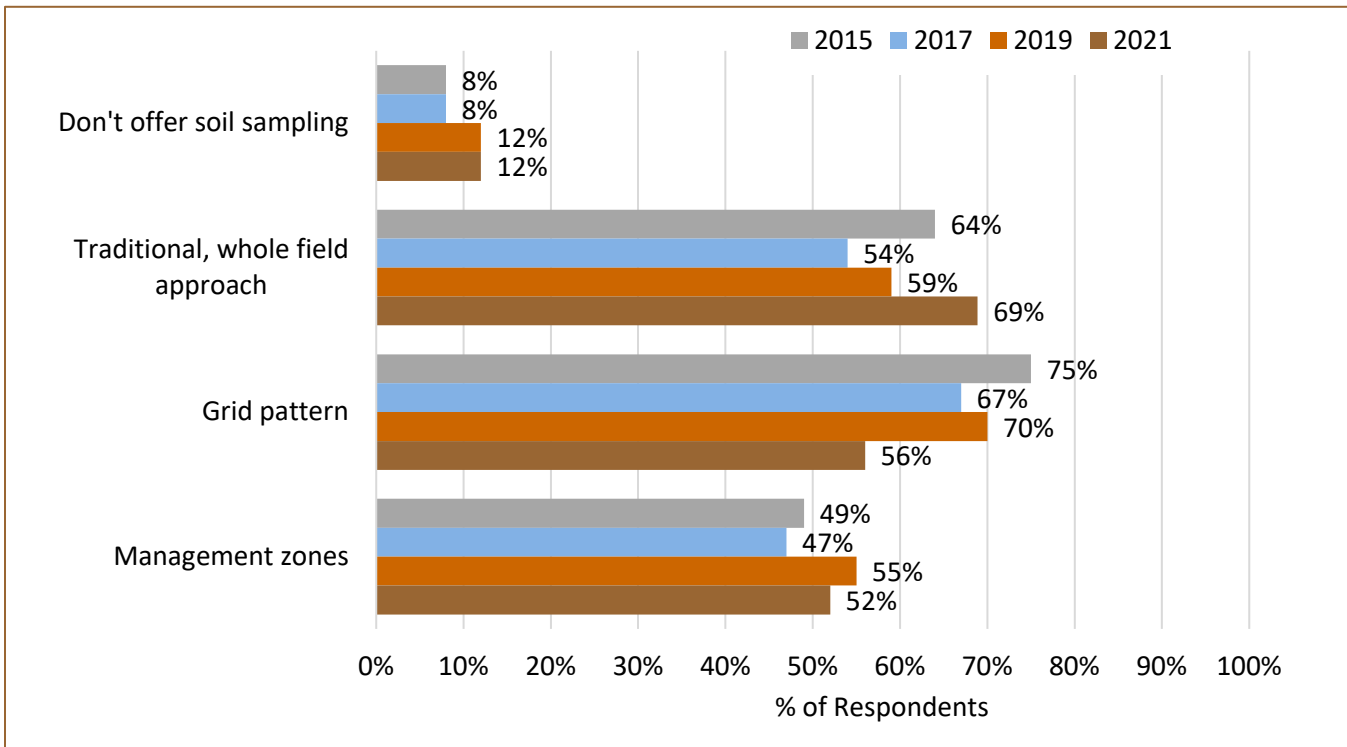


Figure 11, Q6: Types of soil sampling services offered by retailers. Multiple responses were allowed.

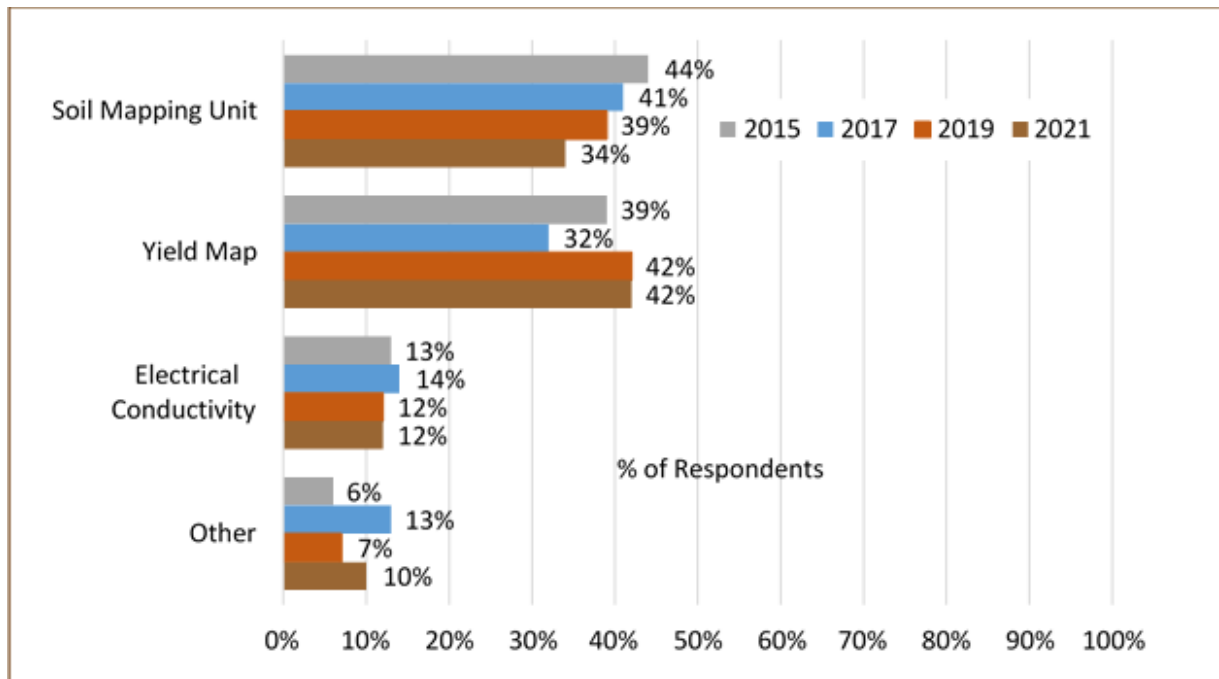


Figure 12, Q6: Factors used by retailers to determine management zones for precision soil sampling. Due to rounding, percentage numbers each year may not total 100.

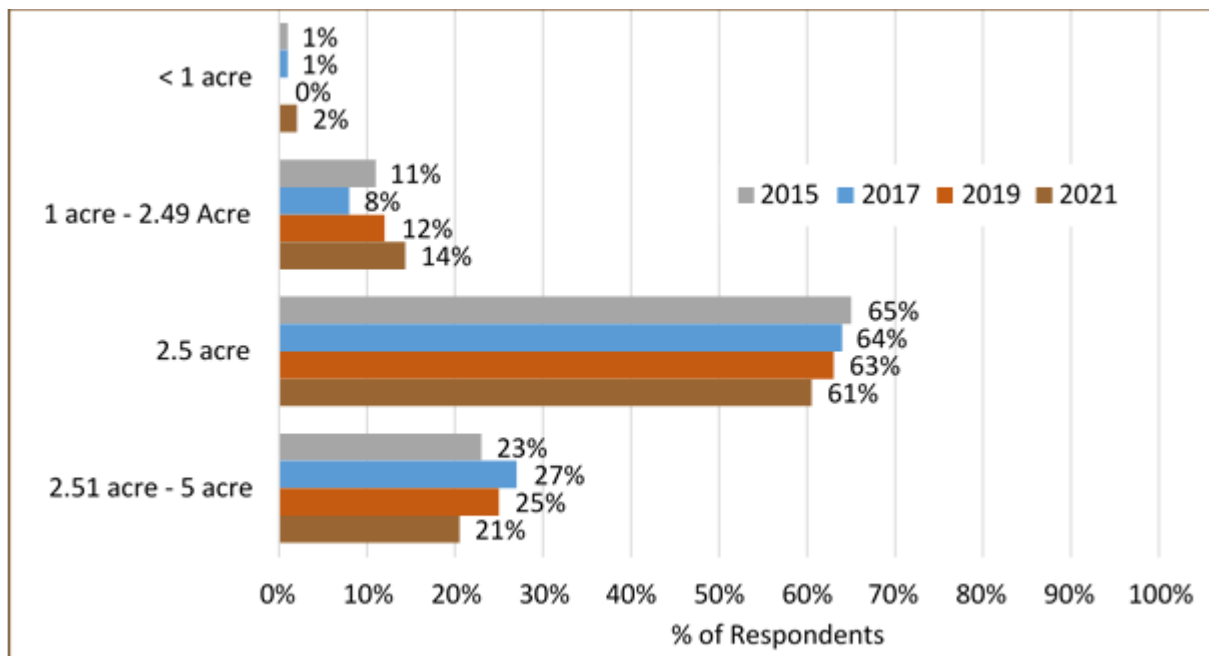


Figure 13, Q6: Grid sizes used by retailers for precision soil sampling. Due to rounding, percentage numbers by year may not total 100.

PROFITABILITY OF PRECISION SERVICE OFFERINGS—2020 RESULTS

To keep survey length manageable for participants, some questions are asked every other year including profitability. Dealerships were asked to report on the profitability of the precision technology services they offer: either making a profit, breaking even, not breaking even, or don't know, Figure 14.

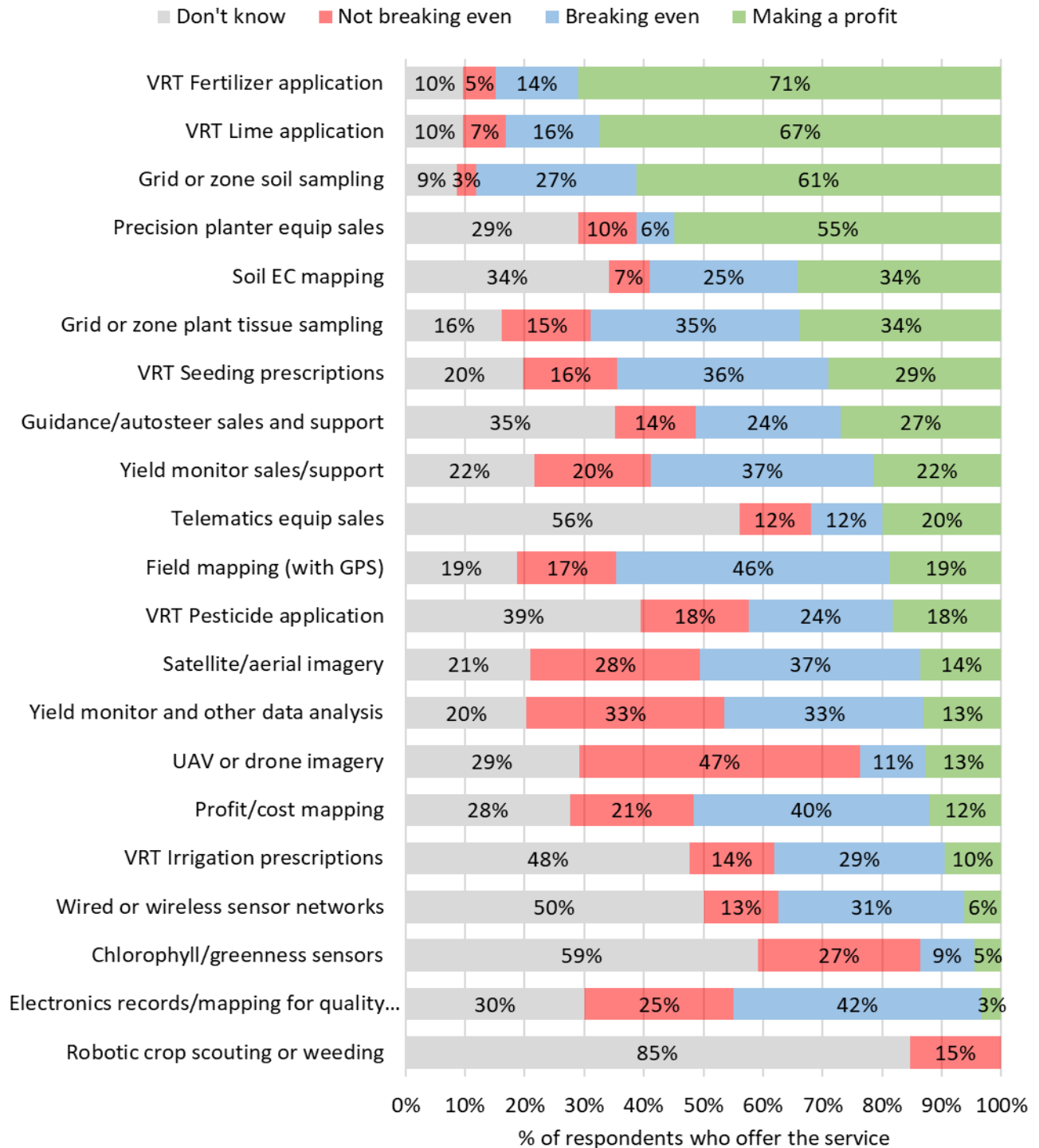


Figure 14: Profitability, from the 2020 survey.

The services with the greatest percent of respondents making a profit are VRT fertilizer applications (71%), VRT lime applications (67%), grid or zone soil sampling (61%), and precision planter equipment sales (55%). These four offerings stand apart from the others for profitability. On the other end of the spectrum UAV or drone imagery is a service area where dealers struggle the most with almost half of dealers reporting they are not breaking even. With many technologies a high percentage of dealers report that they don't know—some of these being newer products and services like robotic crop scouting or weeding, but also including some that have been around many years such as chlorophyll sensors. When including offerings that report just breaking even with profitability, over half of dealers report favorable bottom lines with grid or zone plant tissue sampling (69% breaking even or making a profit), variable seeding prescriptions (65%), field mapping (65%), precision planter equipment sales (61%), EC mapping (59%), yield monitor sales/support (59%), profit mapping (52%), guidance/autosteer sales and support (51%), and satellite/aerial imagery (51%).

Figure 15 shows the percent of respondents making a profit in certain precision ag services over time. More dealers report making a profit with VRT fertilizer applications and grid/zone soil sampling as compared to a decade past. Dealers reporting profits in satellite and aerial imagery and yield monitor and other data analysis have not had similar increases in that same time.

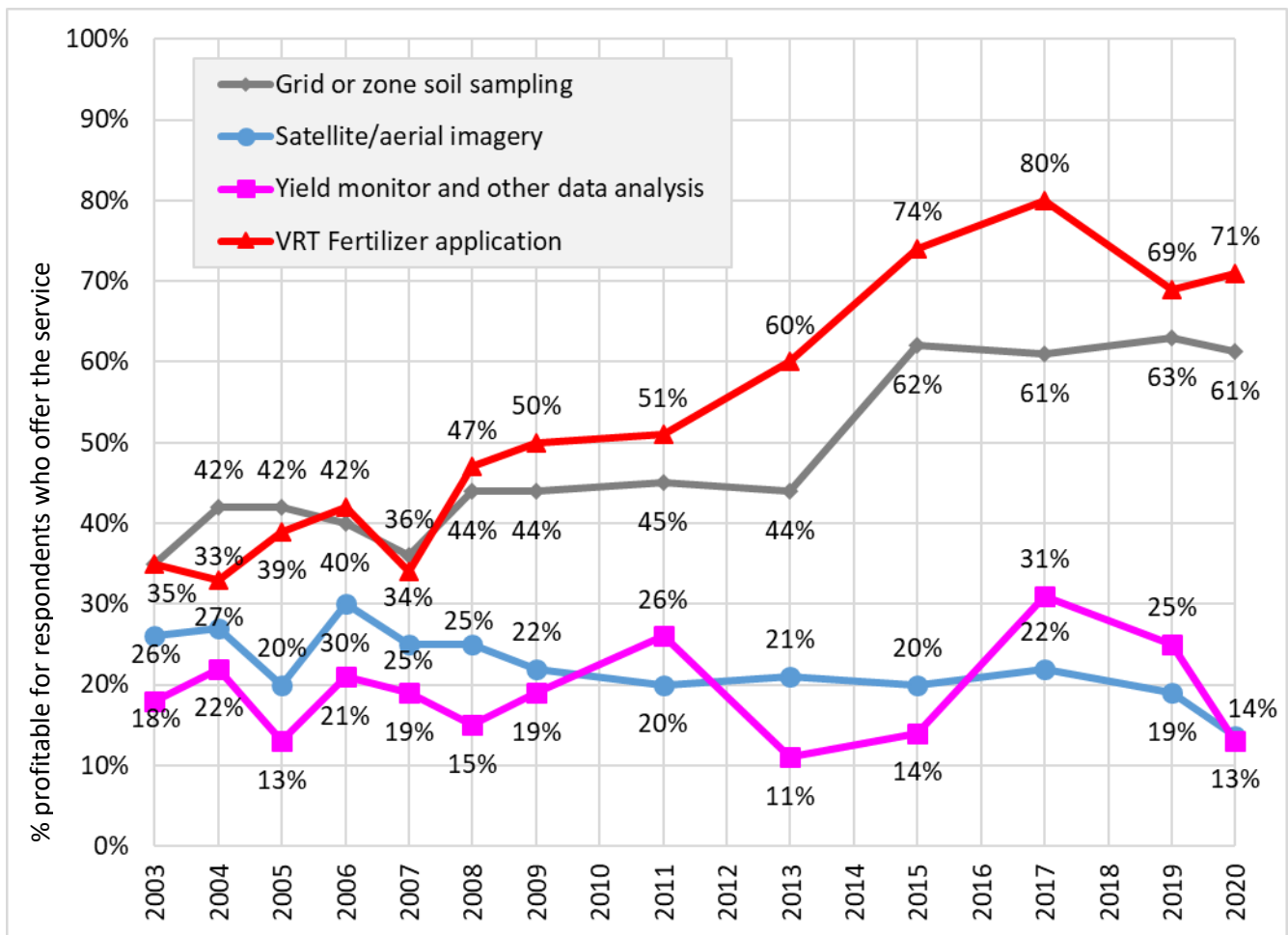


Figure 15: Profitability over time. Profitability was not asked on the 2021 survey.

PRODUCER'S USE OF PRECISION TECHNOLOGIES

While the survey focuses primarily on the technologies used by dealers and precision services offered, we also asked dealers about their customers' practices. Respondents reported on the share of acres in their local market area that are utilizing various precision technologies, not the percentages of farmers.

Table 2 shows the estimated market area of an array of precision technologies in 2017, 2019, 2020, and 2021, ranked most to least for 2021. There was no survey in 2018. Yield monitors and GPS guidance with automatic control have the highest farmer adoption, with dealers reporting around three fourths of the acres in their market areas using these, up from last year. Yield monitors are standard equipment on nearly all new

Table 2, Q11: Farmer use of precision technologies, market area estimated by retailers.

	2017	2019	2020	2021
Guidance/Autosteer	60%	66%	66%	76%
Yield Monitor	-	69%	65%	75%
Sprayer Section Controllers	-	56%	62%	65%
Grid or Zone Soil Sampling	45%	52%	52%	60%
VRT Lime Application	40%	41%	44%	56%
Planter Row or Section Shutoffs	-	45%	46%	52%
VRT Fertilizer Application	38%	39%	44%	51%
Variable Down Pressure on Planter	14%	29%	31%	40%
Cloud Storage of Farm Data	14%	21%	29%	36%
Any Data Analysis Service	13%	26%	25%	33%
Satellite or Aerial Imagery	19%	26%	31%	27%
VRT Seeding	13%	19%	19%	23%
Electronic Records/Mapping for Quality Traceability	-	20%	21%	21%
Soil EC Mapping	9%	10%	14%	17%
Variable Hybrid Placement Within Fields	7%	11%	17%	15%
UAV or Drone Imagery	6%	9%	12%	10%
VRT Pesticide Application	3%	8%	7%	8%
Selective Harvest for Quality Improvement	-	4%	7%	7%
Chlorophyll/Greenness Sensors for N Management	3%	5%	5%	6%
VRT Irrigation	-	4%	5%	4%
Robotics/Automation for Scouting	-	-	-	1%
Robotics/Automation for Harvesting	-	0%	1%	--
Robotics/Automation on Harvester	-	-	-	1%
Autonomous Support Vehicle (grain cart) for Harvest	-	-	-	0%
Robotics/Automation for Weeding	-	0%	0%	0%

combines now, but having a yield monitor doesn't necessarily mean the farmer is creating a yield map. There are many benefits to autosteer including less operator fatigue, more time focused on operating equipment and less waste of applied inputs. By mistake, yield monitors and spray section controllers were not on the survey in 2017.

Coming in next for precision technology use on farms are sprayer boom section controllers, used now on two thirds of farmer acres, and precision soil sampling, at 60%. Planter row/section controllers, VRT fertilizer and VRT lime applications are used now on about half of farmer acres. On the opposite end, the much-discussed coming technologies of robotics automation have not yet materialized to any extent on U.S. farms. This was the third year the survey asked about VRT irrigation, where dealers indicated just 4% of their market area was using this. This number comes with some consideration, as most responders were from the Midwest where in most areas irrigation is the exception. This was also third year to ask about selective harvest, where dealers report it occurs on 7% of the acres in their trade areas.

In Figures 16 and 17, you can see the changes over time in the percent of the market area of various precision ag technologies used by farmers. The two time-scale graphics do not include all technologies due to lack of room and visual clarity—see Table 2 or previous reports. As with the dealer information, starting in 2017 the survey did not ask separately about single and multi-nutrient VRT fertilizer applications on farms (Figure 17). Some variation in survey results from year to year is to be expected, as survey respondents are not the same each year. All precision ag practices show growth on farms in recent years, with the exception of VRT pesticide applications which fell back in 2017 but rebounded some in 2019, 2020, and 2021. The biggest gainer in adoption on farms in recent years has been planter variable down pressure.

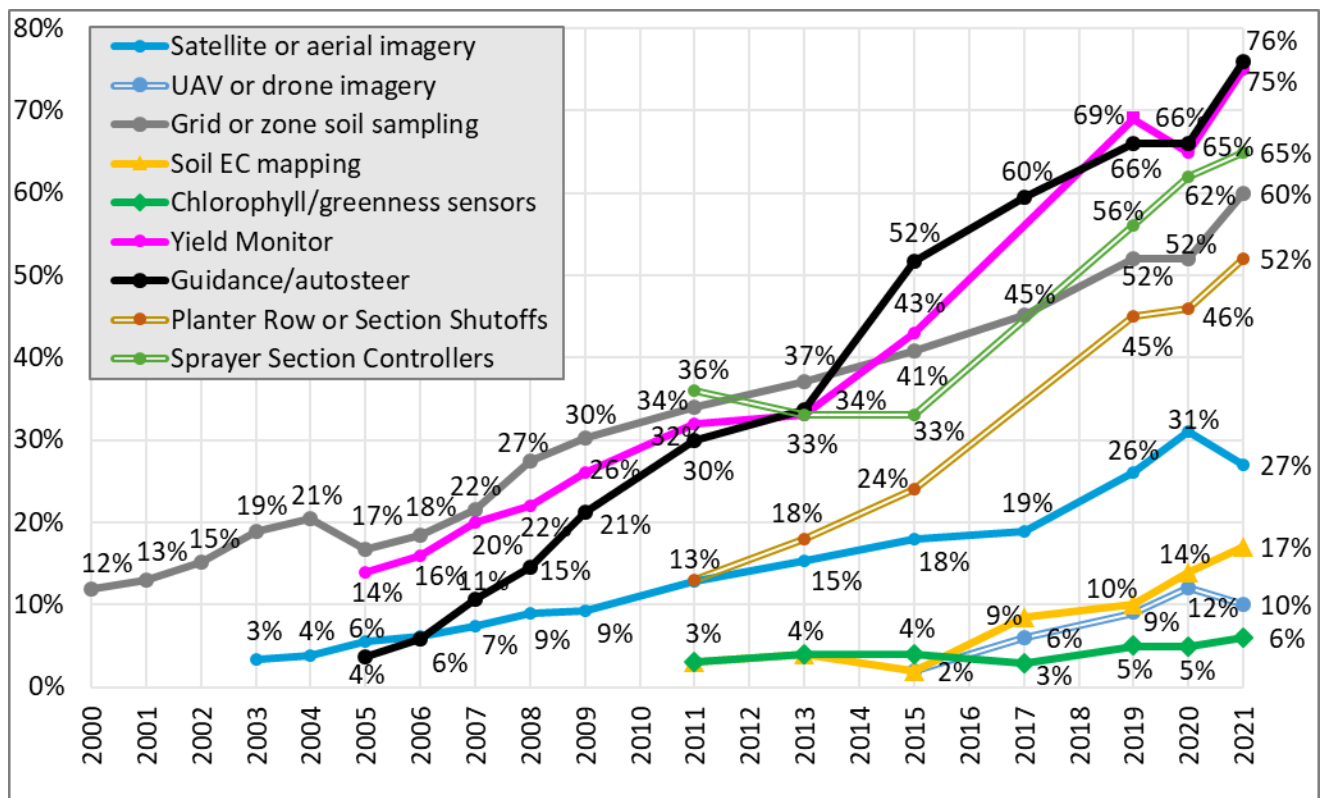


Figure 16, Q11: Producer use of precision technologies, retailers estimate of their market area. Yield monitor, sprayer section controllers, and planter row/section shutoffs were inadvertently omitted in the 2017 survey.

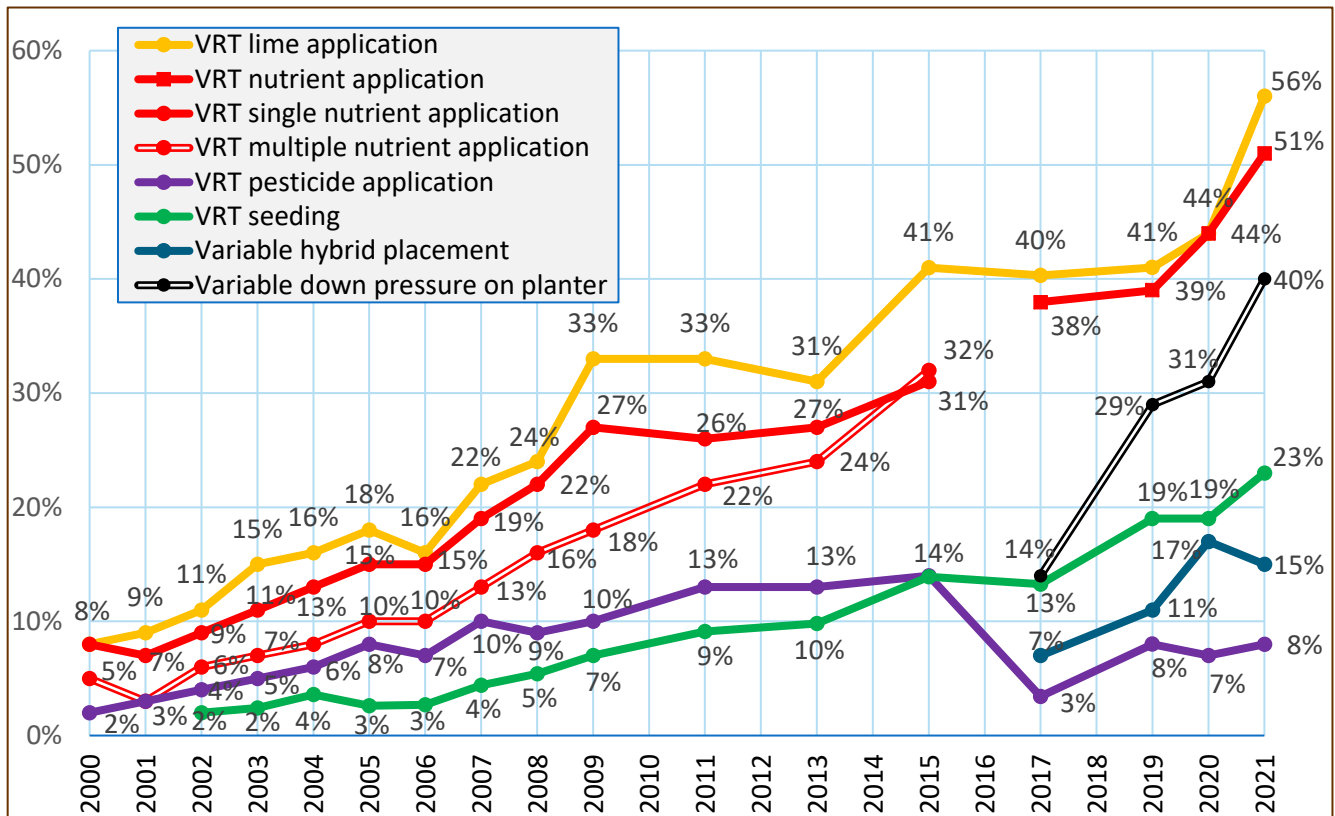


Figure 17, Q11: Farmer use of variable rate technologies (VRT), market area estimated by retailers. Starting at 2017 the survey stopped asking separately about single and multiple fertilizer applications.

BARRIERS TO GROWTH AND EXPANSION

In an attempt to understand differences in the use of precision technologies, not just report on their use, the survey asked respondents to report on producer and dealer barriers. What is preventing more farmers from adopting or expanding their use of precision farming? What is preventing you from offering more precision services? These barriers were evaluated across technologies. We did not ask this question in 2020, as part of our efforts to reduce the overall survey length.

Producer Barriers

Figure 18 shows the perceived barriers as reported by dealers over time for issues that would influence customer decisions on technology. All except one went down in 2021, after all were up in 2019. Note also the time scale is irregular before 2009 as the question was not asked on consecutive surveys. Reported is the percentage who agree or strongly agree the stated barrier is preventing more farmers from adopting or expanding their use of precision agriculture. Farm income pressure tops all other factors going back almost two decades when this question was first asked, but as you can see it swings up and down more than any other factor. In 2013 farm income was at historic highs (thus the low point in farm incomes being a barrier), but incomes quickly reversed to be well below the average of the last two decades for 2015 and 2017. The

second highest customer barrier for 2021 was customer concerns about data privacy, up compared to previous years. Third highest was also related to farm incomes, the cost of precision services being greater than the benefits, but this was the second highest perceived barrier for all previous years. The third highest factor for most of the last decade was customer lack of confidence in site-specific agronomic recommendations. Topography limiting use, soil types limiting profitability, and interpreting and making decisions taking too much time are barriers that dealers rate consistently lower from year to year as factors why farmers may not be using precision agriculture.

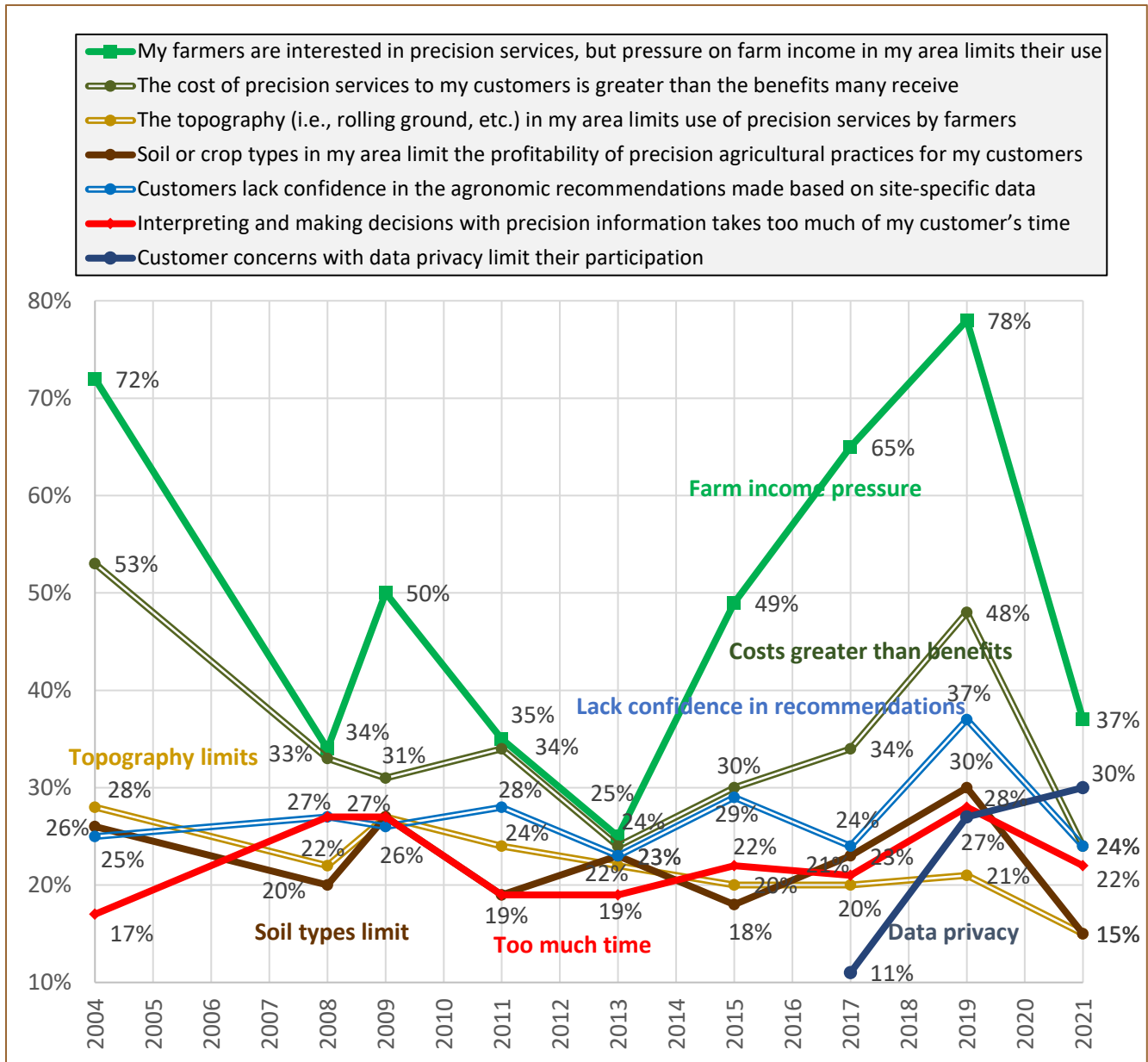


Figure 18, Q16: Customer issues that create barriers to expansion and growth in precision agriculture.

Dealer Barriers

Figures 19 and 20 show factors related to dealers and technology—what barriers are keeping them from expanding their use of precision agriculture, and what is preventing them as dealers from offering more precision ag services? Similar to the farmer barriers, reported is the percentage who agree or strongly agree the stated barrier is preventing them from adopting or expanding their use of precision agriculture. All dealer barriers were down in 2021 compared to 2019, just as all went up in 2019 compared to 2017. The three biggest barriers for success that dealers identified at present are “it is difficult to find employees who can deliver precision agricultural services” at 49%, “the equipment needed to provide precision services changes quickly, increasing my costs” at 46%, and “the fees we can charge for precision services are not high enough to make precision services profitable,” at 42%. Excluding in 2011 when “the cost of the equipment required to provide precision services limits our precision offerings” was higher than the difficulty of finding employees, these three highest factors for 2021 were always the highest three going back more than a decade.

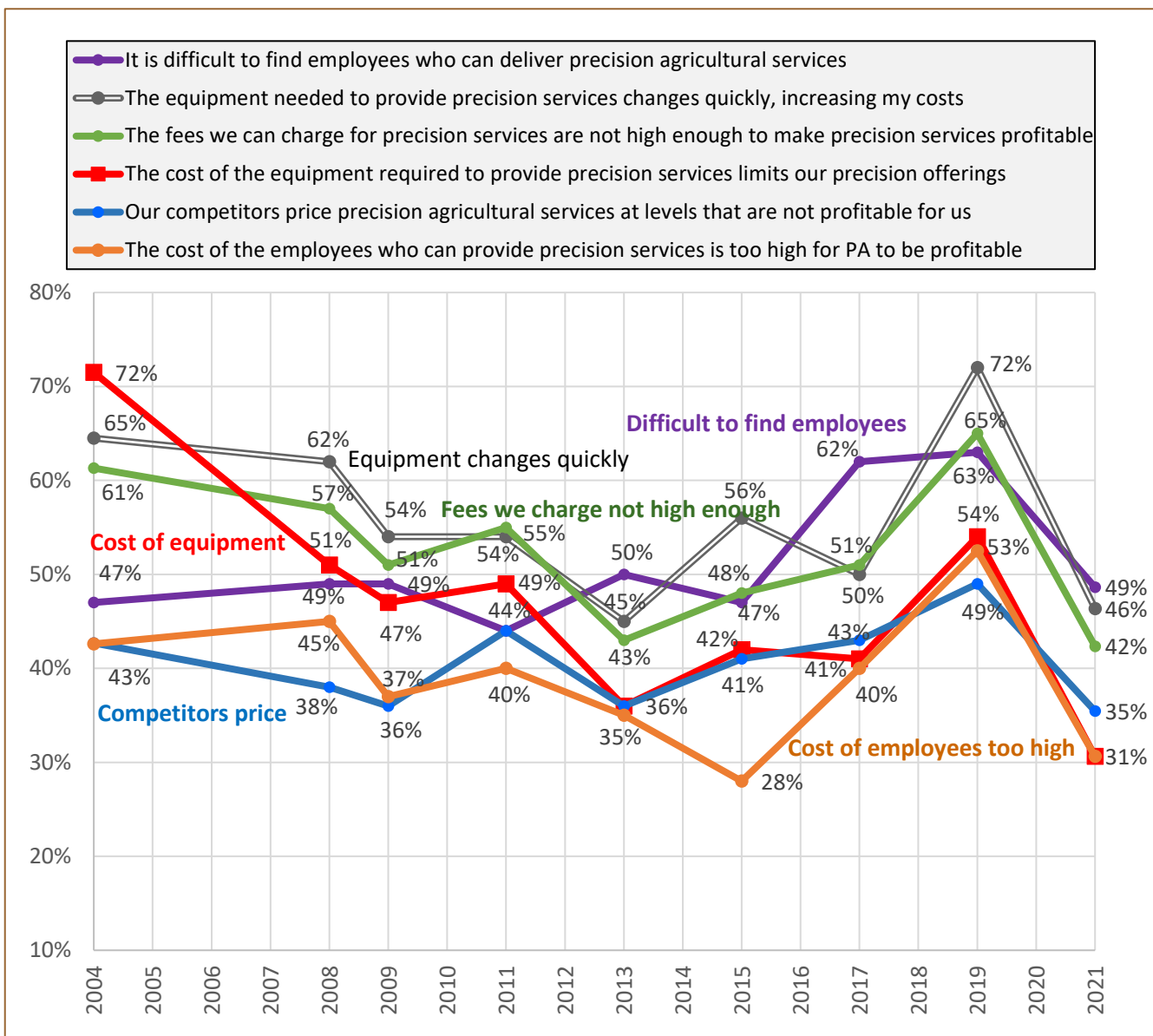


Figure 19, Q16: Dealer and technology issues that create a barrier to expansion and growth in precision agriculture.

On the opposite end of the scale as a barrier was lack of manufacturer support, which dealers have consistently rated low, indicating most dealers feel they get good company support. Also consistently low as a barrier is “the equipment required to deliver precision services is too complex for many of my employees,” the second lowest for almost two decades with the exception of one year.

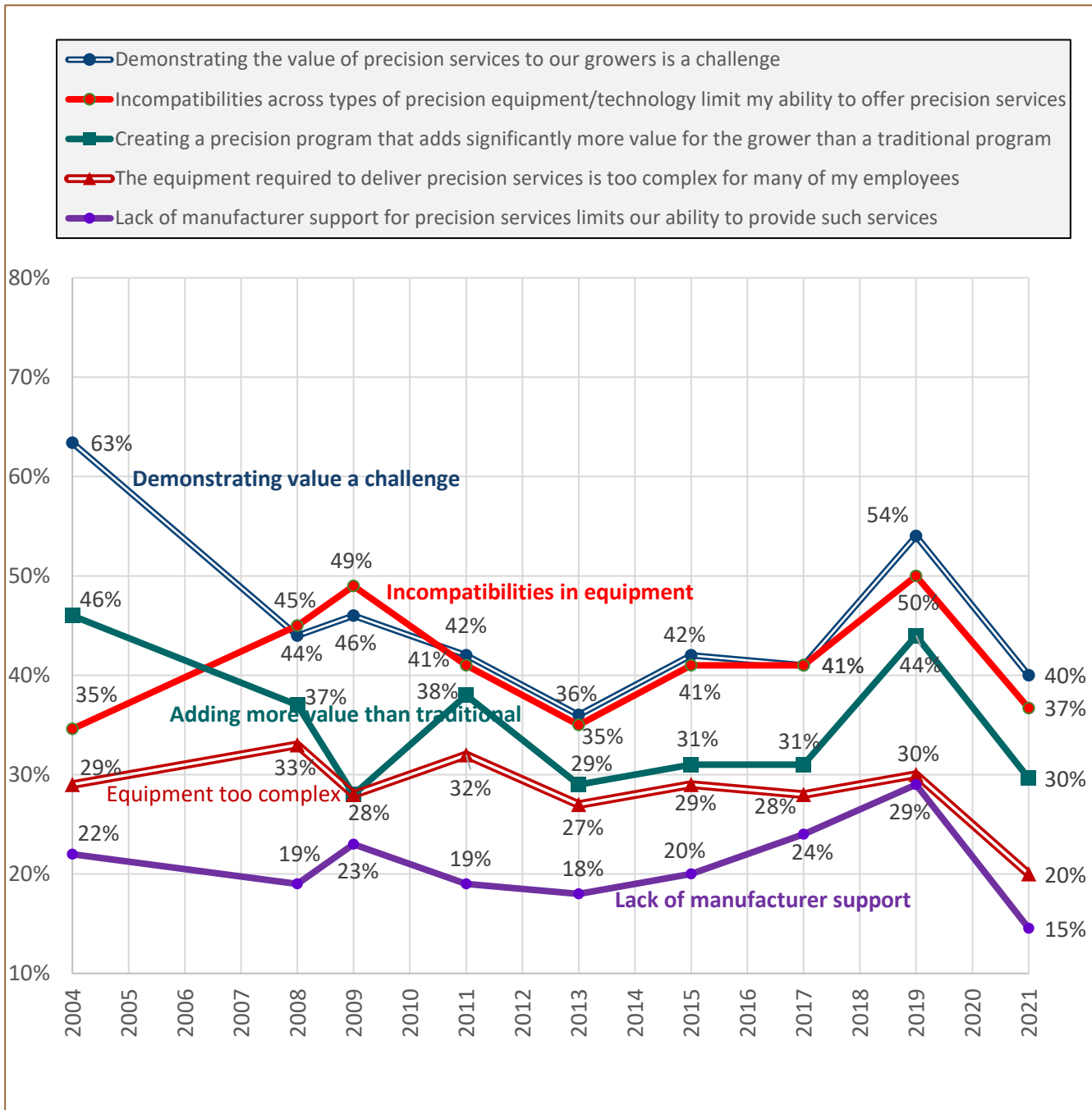


Figure 20, Q16: Dealer and technology issues that create a barrier to expansion and growth in precision agriculture.

SUMMARY

The Precision Agriculture Dealership survey has been tracking the changes in digital technology use in crop retail input establishments and on farms since the mid-1990's. Since that time there have been watershed changes to the technologies as well as new types introduced. Twenty-five years ago agri-dealers offering precision services were most likely grid or zone soil sampling along with offering customers variable rate fertilizer applications. And with the advent of the combine yield monitor at about that same time, there was much activity in trying to link soil nutrient tests with crop yield responses, and then working to determine the optimum combination of nutrients and soil amendments for any particular part of a field. Soil maps and aerial or satellite imagery were often a part of modeling crop responses, too.

Today, soil sampling along with VRT fertilizer applications are customer offerings at most dealerships, along with helping customers analyze their yield monitor and other data, offering aerial or satellite imagery, making variable seeding recommendations, and precision plant tissue sampling. In the next few years the greatest areas of growth will be in the numbers of dealers offering variable pesticide applications and in UAV imagery. UAV's to apply crop inputs are being used by fourteen percent of dealers in their offerings, but that many more say they will be adding this in the future. Robotic scouting and robotic weeding services are being offered by a few dealers, but many times more than are offering now are planning to offer in the future. Most dealers are using autoguidance and spray section/nozzle controllers for their custom pesticide applications, as has been the situation for several years. Growing rapidly in use, but still at less than half of dealerships are fleet management to help manage sprayers and fertilizer rigs going from farm to farm, and in telemetry to expedite the exchange of information so what is applied is correct.

Most dealers offer precision soil sampling, but more offer whole field or grid sampling services as compared to management zones. If a dealer is zone sampling, more are using soil maps or yield maps to delineate zones as compared to soil electrical conductivity. If a dealer is grid sampling, most are offering samples in 2.5 acre grids, about a quarter offer in larger grids, and less than that in grids smaller than 2.5 acres.

Pooled on-farm data, especially for nutrient management, hybrid/variety selection and planting rates, is guiding decisions at rates twice that of just four years ago. Eighty-seven percent of dealers said phosphorus and potassium decisions were at least somewhat influenced by pooled data, similar to last year but doubling compared to three years ago, and 86% saying nitrogen decisions were being influenced, up from 39% in 2017. 81% of dealers indicated pooled data had at least some influence for overall hybrid/variety placement, and 69% said pooled data was informing variable planting rate prescriptions.

This year we did not ask about the profitability of specific precision products and services. But we did ask dealers to rate the primary barriers preventing more farmers from adopting or expanding their use of precision agriculture, and factors preventing them from offering more precision ag services. Responses to all 18 possible barriers of adopting precision agriculture all went down in 2021 compared to 2019, indicating continued optimism for precision ag, but with just one exception, concerns with data privacy. The three biggest barriers for success that dealers identified at present are *it is difficult to find employees who can deliver precision agricultural services; the equipment needed to provide precision services changes quickly, increasing my costs; and the fees we can charge for precision services are not high enough to make precision services profitable*. Excluding the farm income response which rises and falls with commodity prices, and in 2011 when dealers rated the cost of equipment barrier higher than the difficulty of finding employees, these three highest factors for 2021 were always the highest three going back a decade.

Dealers report that most of the acres in their trade areas are farmed using autoguidance, most acres are sprayed with boom section controllers, and that most harvesting is done with a yield monitor. Planter row/section controllers, VRT fertilizer and VRT lime applications are used now on about half of farmer acres. Still not on most acres but growing rapidly is planter variable down pressure. On the opposite end, the much-discussed coming technologies of robotics automation have not yet materialized to any extent on U.S. farms.

SURVEY INSTRUMENT



21st Precision Agriculture Services Dealership Survey



IRB APPROVAL 1702018754

Dear agricultural retailer,

The CropLife/Purdue survey is the longest-running, most widely used survey that chronicles the development and adoption of precision agriculture! We depend on your continued input. Please complete by March 1, 2021. Thank you for your participation!

Bruce Erickson & Jess Lowenberg-DeBoer *Purdue University* | Paul Schrimpf *CropLife/Meister Media*

1. Which best describes your business? *[mark only one]*

- Agricultural retail input supplier
- Farm equipment dealer
- Agricultural consultant
- Other: *[please specify]* _____

2. If you answered agricultural retail input supplier above.

- Are you a: *[please mark only one]*
- Independent dealership
 - Cooperative
 - Part of a national or regional chain (not a cooperative)
 - Other: *[please specify]* _____

3. Your primary responsibility: *[please mark only one]*

- Owner/general manager/location manager
- Departmental manager
- Precision manager
- Application manager
- Technical consultant/agronomist
- Sales/sales management
- Other: *[please specify]* _____

4. How many total retail outlets does your company own or manage? *[please mark only one]*

- None
- 1
- 2-5
- 6-15
- 16-25
- More than 25

5. Rank the following crop types according to the value of products and services you provide to each *[1=highest, 2 next highest, etc. Leave blank if less than 2% of your business.]*

- field crops (corn, soy, wheat, rice, cotton, milo, sugar beets, dry beans, etc.)
- hay and forages
- nursery or greenhouse
- vegetables (incl. potatoes, melons, lettuce, tomatoes)
- tree fruits & nuts
- berries (strawberries, blueberries, raspberries, etc.)
- grapes
- Other: *[please specify]* _____

6. Do you offer soil sampling — traditional, following a grid pattern and/or by management zone? *[mark all that apply]*

- Don't offer soil sampling
- Traditional, whole field approach
- Grid pattern
- Management zones

If grid, what grid size most common? *[mark only one]*

- < 1 acre
- 1 acre - 2.49 acre
- 2.5 acre
- >2.5 acre

If zone, determined by what factor? *[mark only one]*

- Soil mapping unit
- Electrical conductivity
- Yield map
- Other *[please specify]*: _____

7. In which of the following ways does your dealership use precision technology? *[mark all that apply]*

- GPS guidance systems with manual control (light bar)
- GPS guidance systems with automatic control (autosteer)
- Auto sprayer boom section or nozzle control
- Sprayer turn compensation
- Telematics to exchange information among applicators or to/from office locations
- GPS fleet management for vehicle logistics, tracking locations of vehicles, and guiding vehicles to the next site
- Smart scouting using an app on a mobile device to record field situations and locations
- Predictive models for pest infestations
- Do not use precision technology

8. How do you help manage the farm-level data (i.e., yield maps, soil tests, EC, imagery) of your farmer- customers to assist in their decision-making? *[mark all that apply]*

- Print maps for customers (yield, EC, soil maps, etc.)
- No data aggregated among farmers, work with farmers only with the data from their own farms
- Data aggregated among farmers but not outside dealership
- Data aggregated among farmers including those outside dealership
- Archiving and managing yield, soil test, and other data
- Other *[please specify]* _____
- Do not help customers with their farm-level data

9a. What crop management decisions are being influenced by pooled data from your customer's farms?

	No influence	Some influence	Major influence
<i>[please mark only one column per row]</i>			
Nitrogen decisions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
P and K decisions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Liming decisions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Overall hybrid or variety selection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Variable hybrid or variety placement in field	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Overall crop planting rates	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Variable seeding rate prescriptions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pesticide selection (herbicides, insecticides, or fungicides)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cropping sequence/rotation decisions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Irrigation decisions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other <i>[please specify]</i> : _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

9b. Does your company have a customer data privacy statement and/or data terms & conditions agreement?

- Yes
- No

10. Which services/products do you offer now? If not now, will you in three years? If you don't offer now and have no plans for the near future, leave blank.

	Offer now	Will offer by 2024
VRT fertilizer application	<input type="checkbox"/>	<input type="checkbox"/>
VRT lime application	<input type="checkbox"/>	<input type="checkbox"/>
VRT pesticide application	<input type="checkbox"/>	<input type="checkbox"/>
VRT seeding prescriptions	<input type="checkbox"/>	<input type="checkbox"/>
VRT irrigation prescriptions	<input type="checkbox"/>	<input type="checkbox"/>
Yield monitor and other data analysis	<input type="checkbox"/>	<input type="checkbox"/>
Satellite/aerial imagery	<input type="checkbox"/>	<input type="checkbox"/>
UAV or drone imagery	<input type="checkbox"/>	<input type="checkbox"/>
Grid or zone soil sampling	<input type="checkbox"/>	<input type="checkbox"/>
Grid or zone plant tissue sampling	<input type="checkbox"/>	<input type="checkbox"/>
Soil electrical conductivity (EC) mapping	<input type="checkbox"/>	<input type="checkbox"/>
Other soil sensors mounted on a pickup, applicator or tractor (example: pH sensor)	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll/greenness sensors (CropSpec, GreenSeeker, OptRx, etc.)	<input type="checkbox"/>	<input type="checkbox"/>
Precision planter equipment sales	<input type="checkbox"/>	<input type="checkbox"/>
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.)	<input type="checkbox"/>	<input type="checkbox"/>
Profit/cost mapping	<input type="checkbox"/>	<input type="checkbox"/>
Electronic records/mapping for traceability	<input type="checkbox"/>	<input type="checkbox"/>
Wired or wireless sensor networks, IoT	<input type="checkbox"/>	<input type="checkbox"/>
Robotic crop scouting	<input type="checkbox"/>	<input type="checkbox"/>
Robotic crop weeding	<input type="checkbox"/>	<input type="checkbox"/>
Crop inputs (seeding, pesticides, fertilizers) applied with a UAV/drone	<input type="checkbox"/>	<input type="checkbox"/>

11. Approximately what percentage of the total acreage in your market area (all growers, not just your current customers) is currently using the following practices?

VRT fertilizer application	_____%
VRT lime application	_____%
VRT pesticide application	_____%
VRT seeding	_____%
Variable hybrid/variety placement within fields	_____%
Variable rate irrigation	_____%
Satellite or aerial imagery	_____%
UAV or drone imagery	_____%
Guidance/autosteer	_____%
Sprayer section controllers	_____%
Planter row or section shutoffs	_____%
Variable down pressure on planter	_____%
Grid or zone soil sampling	_____%
Soil EC mapping	_____%
Chlorophyll/greenness sensors for N management	_____%
Yield monitor	_____%
Cloud storage of farm data	_____%
Any data analysis service (Granular, Fieldview, FBN, etc.)	_____%
Wired or wireless sensor networks, IoT	_____%
Robotics/automation for weeding	_____%
Robotics/automation for scouting	_____%
Robotics/automation on harvester	_____%
Autonomous support vehicle (grain cart) for harvest	_____%
Electronic records/mapping for traceability	_____%
Selective harvest for quality improvement	_____%

12. In a typical year how many total acres do you custom apply at your specific location (fertilizer, chemicals, seeding – total acres including multiple applications)? _____ acres [If none, go to Question 16]

13. In 2020, approximately what percentage of your total fertilizer sales were custom applied? _____%

14. In 2020, approximately what percentage of your total crop protection sales were custom applied? _____%

15. In 2020, approximately what percentage of your total custom application (total acres, all products) used:

Manual GPS guidance (light bar) _____% Auto sprayer boom section or nozzle control _____%

Automated GPS guidance (autosteer) _____% Variable rate prescription map _____%

16. What are the primary barriers preventing more farmers from adopting or expanding their use of precision agricultural services and/or preventing you from offering more precision services?

Please rate the following statements on a scale from 1 (strongly disagree) to 5 (strongly agree).

	Disagree	Agree
Customer Issues		
The cost of precision services to my customers is greater than the benefits many receive	1 2 3 4 5	
My farmers are interested in precision services, but pressure on farm income in my area limits their use	1 2 3 4 5	
The topography (i.e., rolling ground, etc.) in my area limits use of precision services by farmers	1 2 3 4 5	
Soil or crop types in my area limit the profitability of precision agricultural practices for my customers	1 2 3 4 5	
Interpreting and making decisions with precision information takes too much of my customer's time	1 2 3 4 5	
Customers lack confidence in the agronomic recommendations made based on site-specific data	1 2 3 4 5	
Customer concerns with data privacy limit their participation	1 2 3 4 5	
Dealer Issues		
The cost of the equipment required to provide precision services limits our precision offerings	1 2 3 4 5	
The cost of the employees who can provide precision services is too high for precision ag to be	1 2 3 4 5	
It is difficult to find employees who can deliver precision agricultural services	1 2 3 4 5	
The fees we can charge for precision services are not high enough to make precision services profitable	1 2 3 4 5	
Lack of manufacturer support for precision services limits our ability to provide such services	1 2 3 4 5	
Creating a precision program that adds significantly more value for the grower than a traditional agronomic program is difficult for us	1 2 3 4 5	
Demonstrating the value of precision services to our growers is a challenge	1 2 3 4 5	
Our competitors price precision agricultural services at levels that are not profitable for us	1 2 3 4 5	
The equipment needed to provide precision services changes quickly, increasing my costs	1 2 3 4 5	
The equipment required to deliver precision services is too complex for many of my employees to use	1 2 3 4 5	
Incompatibilities across types of precision equipment and technology (different data formats, inability to share information) limit my ability to offer precision services	1 2 3 4 5	

17. For your retail location, what state are you located in? _____ What is your ZIP code? _____

THANKS AGAIN FOR YOUR INPUT!