Tracking Two Decades of Precision Agriculture through the CropLife Purdue Survey

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A paper from the Proceedings of the
14th International Conference on Precision Agriculture
June 24 – June 27, 2018
Montreal, Quebec, Canada

Abstract. *The CropLife/Purdue University precision dealer survey is the longest-running continuous survey of precision farming adoption. The 2017 survey is the 18th, conducted every year from 1997 to 2009, and then every other year following. For individuals working in agriculture there is great value in knowing who is doing what and why, to get a better understanding of the utilities and applications, and to guide investments. A major revision in survey questions was made in 2017, to reflect the growth in data driven agriculture. But the long-term trend questions were left intact, to continue to log changes in the industry. Major sections of the survey include precision technologies used by the retailers within their business/on their equipment, the adoption rates of precision products and services offered by retailers to customers, the dealer's estimation of the acres in their area where farmers are using precision practices, and questions about profitability, technology investment, and constraints to adoption.*

The 2017 survey shows substantial increases in the adoption of practices that provide data for understanding and managing inter- and intra-field variability. Grid/zone soil sampling, which was being offered by 35 to 57% of dealers in a period stretching from 1999 to 2013, increased to 67% in 2015 and to 78% offering in 2017. Soil EC mapping increased from 19% in 2015 to 31% in 2017, and dealers offering UAV services from 19% to 30%. At the same time variable rate technology (VRT) seeding prescriptions, VRT lime application, and VRT fertilizer application services are up, yet VRT pesticide offerings are down. Seventy eight percent of dealers are using autoguidance for their custom application and 73% are using sprayer section controllers.

Dealers report that pooled farmer data is most used to guide fertilizer and liming decisions and for variable hybrid placement, and least used for determining crop seeding rates or crop sequences/rotations.

The most profitable precision offerings for dealers are generally related to fertilizers and soil amendments: grid or zone soil sampling, VRT liming, VRT fertilizer applications, and VRT fertilizer prescriptions. Dealers report some of their least profitable offerings to be satellite/aerial imagery, UAV/drone imagery, and chlorophyll/greenness sensors.

Keywords. *Precision farming, digital agriculture, agricultural input supplier*

About the Survey

In February 2017 CropLife magazine and the Departments of Agricultural Economics and Agronomy at Purdue University conducted the 18th survey of crop input dealers about precision agriculture technologies. As with previous surveys, dealerships were asked questions about how they use precision agriculture within their business, what precision products and services they offer to their customers, customer adoption of precision farming, and questions aimed at understanding practices such as constraints to adoption and profitability. In addition, to better understand farmers and retailers use of data, additional questions were added about these practices. This survey is the most complete, longest-running, and continuous survey of precision farming practices in the United States.

The questionnaire was deployed using two modes of contact: A paper copy was mailed to a subset of CropLife magazine's subscription list, and a link to the identical set of questions was sent via email from a subset of CropLife's email list. A total of 209 questionnaires were completed, a response rate of 8%. Responses were received from 29 states, with Illinois, Iowa, Indiana, Wisconsin, Ohio, Missouri, and Nebraska each representing more than 5% of respondents, listed in order of respondents.

Dealers were asked several questions about the organization they represent. Eighty-nine percent of respondents were agricultural retail input suppliers, 5% consultants, 4% farm equipment dealers, and 2% other. Of the ag retailers 47% indicated they represent a cooperative, 37% an independent dealership and 16% were part of a national or regional dealership (not a cooperative),

The organizations the respondents represent are primarily multiple-retail locations. Three percent of the respondents did not own or manage a retail outlet. Thirty-two percent of respondents reported having only one retail outlet, up 8% compared to 2015. The number of respondents that owned or managed five stores or less was 60%, up 13% over 2015. The number of respondents that owned or managed six or more stores is 45%, down 6% compared to 2015.

Another metric for understanding the surveyed organizations is the total annual retail sales of agronomy products (fertilizer, chemicals, seed) and services at the respondent's location in 2016. The $1 to 5 million group and the more than $20 million group had the most respondents with 28% each. The under $1 million and the $15 to 20 million categories each represented 7% of respondents, $5 to 10 million had 19%, and 10 to 15 million had 11%.

The survey asked about the position the respondent held within their organization. Forty-five percent reported being the owner or location manager, and 19% percent were a technical consultant or precision agriculture manager. Other common job responsibilities for respondents were sales and sales management (19%) and department manager (11%). Overall the respondents of the survey are those that lead and manage the organization, or work directly with customers. For a more complete accounting of the survey methods and results, see the full report at: http://agribusiness.purdue.edu/precision-ag-survey

Dealer Use of Precision Technologies

Dealers get utility from the precision technologies they use for their own business purposes, such as guidance on their applicators, as well as the precision products and services they offer to customers detailed in the next section. Eighty-one percent of dealers were offering some type of precision agronomic service for their customers.

The two technologies that stand out as the most widely utilized by dealers are GPS guidance systems with automatic control (autosteer) for fertilizer/chemical application, at 78% adoption, and auto sprayer boom section or nozzle control at 73% (Table 1). 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. About half of dealers are using remote sensing from aerial/satellite imagery to assist with their delivery of products and services, 44% are using an app on a mobile device to assist in field scouting and about one third are utilizing UAV (unmanned aerial vehicle) or drone technology to assist with their business. Twenty-two percent of dealers are using soil electrical conductivity mapping, but less than 10% of dealers are using other on-the-go sensors such as for soil pH or leaf greenness.

Table 1. Retailer use of precision technology for their business.

Precision Ag Technology	2017
Precision agronomic services for customers (such as soil sampling with GPS, GIS field mapping, etc.)	81%
GPS guidance systems with automatic control (autosteer) for fertilizer/chemical application	78%
Auto sprayer boom section or nozzle control	73%
GPS guidance systems with manual control (light bar) for fertilizer/chemical application	55%
Satellite/aerial imagery for internal dealership purposes	52%
Smart scouting using an app on a mobile device to record field situations and locations	44%
Field mapping with GIS to document work for billing/insurance/legal purposes	43%
UAV or drone for internal dealership purposes	34%
GPS to manage vehicle logistics, tracking locations of vehicles, and guiding vehicles to the next site	34%
Telematics to exchange information among applicators or to/from office locations	24%
Soil electrical conductivity (EC) mapping	22%
Sprayer turn compensation	22%
Y drops on fertilizer applicators	19%
Other soil sensors for mapping, mounted on a pickup, applicator or tractor (example: pH sensor)	9%
Chlorophyll/greenness sensors mounted on a pickup, applicator or tractor (CropSpec, GreenSeeker, OptRx, etc.)	9%
Do not use precision technology	5%

Retailer's use of precision ag technology over time is reported in Figure 1 with automated technologies and Figure 2 with sensing technologies. Note that the survey went from every year to every other year in 2011. For automated technologies, all were down compared to 2015. This has been the area of precision farming experiencing the most growth in recent years—a weak farm economy and other financial pressures on retailers could explain part of this. The downward trend for GPS guidance with manual control (lightbar) continues. Peaking at 79 percent in 2009, the current survey has usage rates down to 55 percent in 2017. 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.

Telemetry showed the greatest decline from the 2015 survey to the 2017 survey. The decrease in adoption of telematics may be related to poor signal strength, the amount of time needed to transfer the data, lack of connectivity with hardware and software packages, and/or the hardware or software is not easy to use. Data signal strength in some rural areas is poor and retailers are stretching further from their home bases which can lead to long data download times. Some programs have telemetry built in to their platform, others require data to be exported and migrated from platform to platform. The data migration can be problematic when dealing with converting data in to the proper files extensions For sensing technologies (Fig.2), all are up compared to 2015, especially UAVs and soil electrical conductivity (EC) mapping.

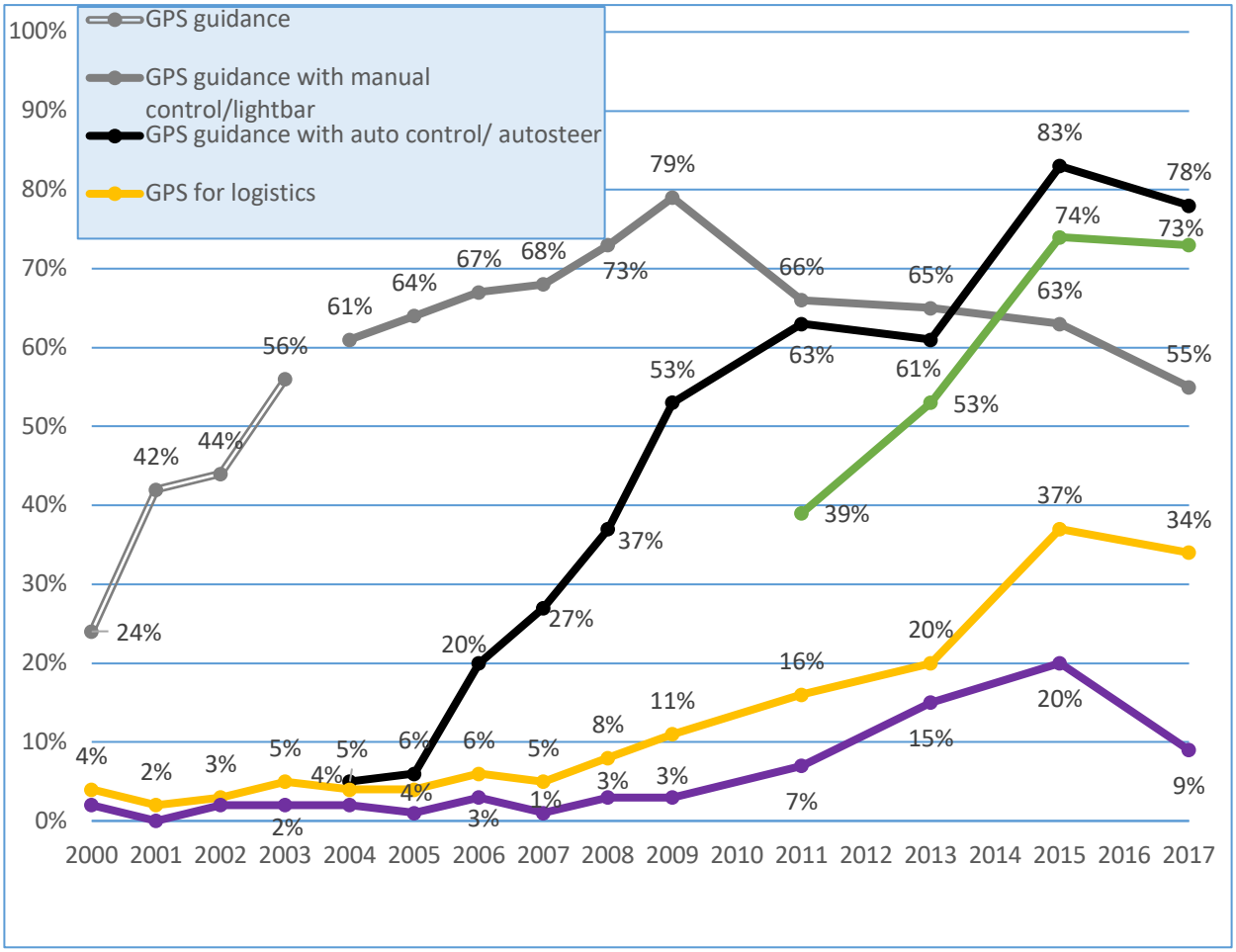

Figure 1. Use of precision technology over time by retailers, automated technologies.

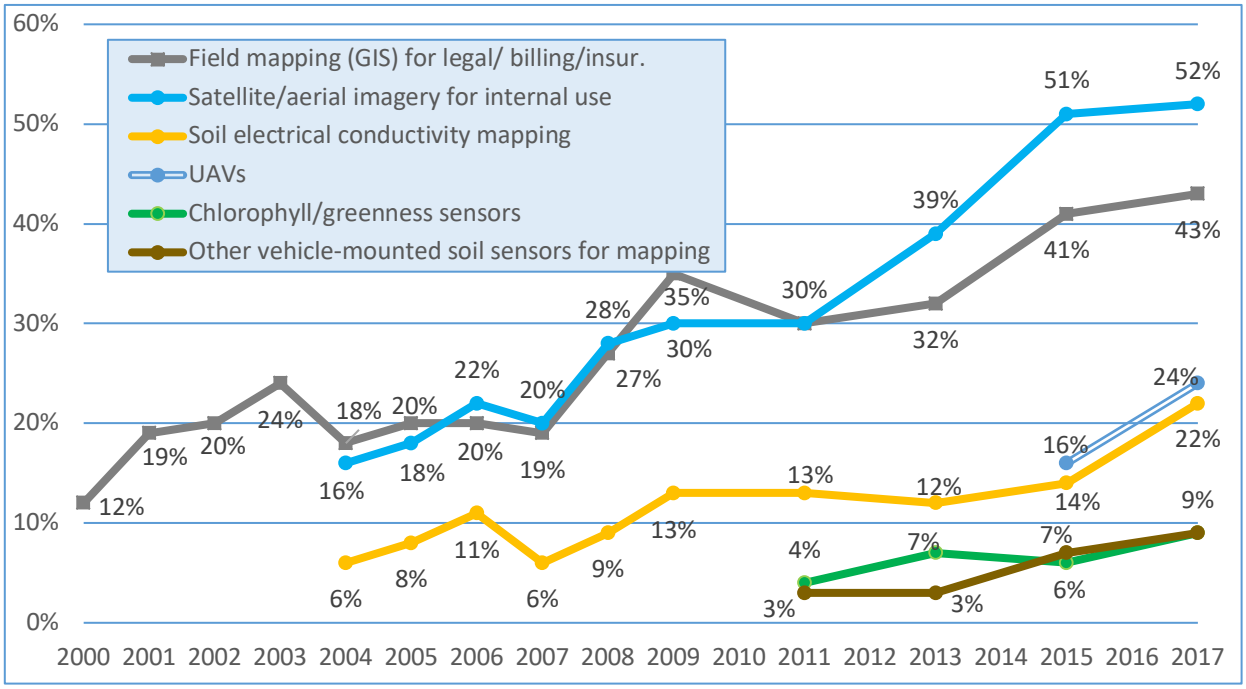

Figure 2. Use of precision technology over time by retailers, sensing technologies.

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 2020 (Figure 3). Site-specific services that dealers now offer most include field mapping, and technologies related to precision fertilizers and soil amendments-- grid or zone soil sampling, VRT fertilizer or lime prescriptions, and VRT fertilizer applications. Over the next 3 years, the areas that respondents are planning the most growth are in VRT pesticide application (24% of respondents will add), UAV/drone imagery (27%), chlorophyll/greenness sensors for N management (18%), and profit/cost mapping (22%). The areas of VRT seeding prescriptions (10%), yield monitor and other data analysis (10%), satellite/aerial imagery (12%), and soil EC mapping (10%) are the next most popular areas for growth. All other services are poised to grow 3 to 6% over the next three years. In many past surveys, dealers have optimistically overestimated their precision growth compared to the actual numbers the survey showed in years following.

Figure 4 shows the adoption of service and sensor precision ag services over time. All of these technologies showed growth from 2015 to 2017, and all but two areas had double digit growth. Field mapping with GIS increased 21% from 2015 to 2017 to lead all categories. Yield monitor and other data analysis had the lowest growth at 6% from 2015 to 2017.

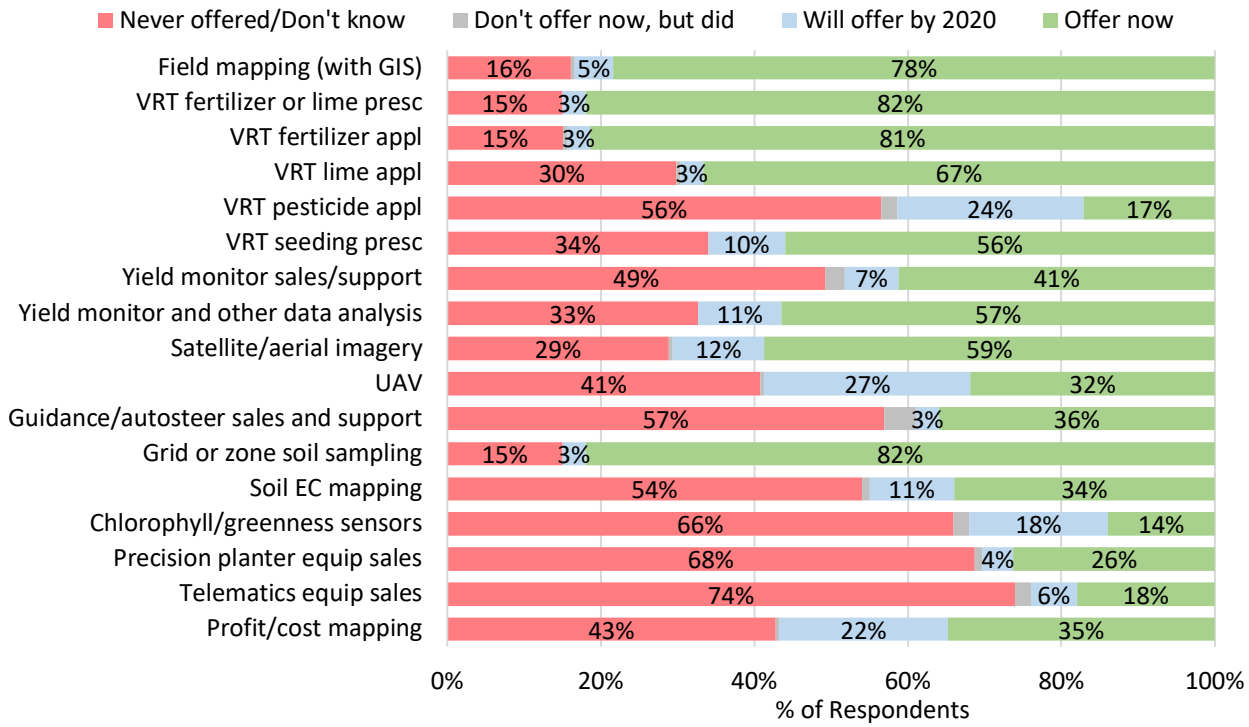

Figure 3. Dealer offerings of precision services.

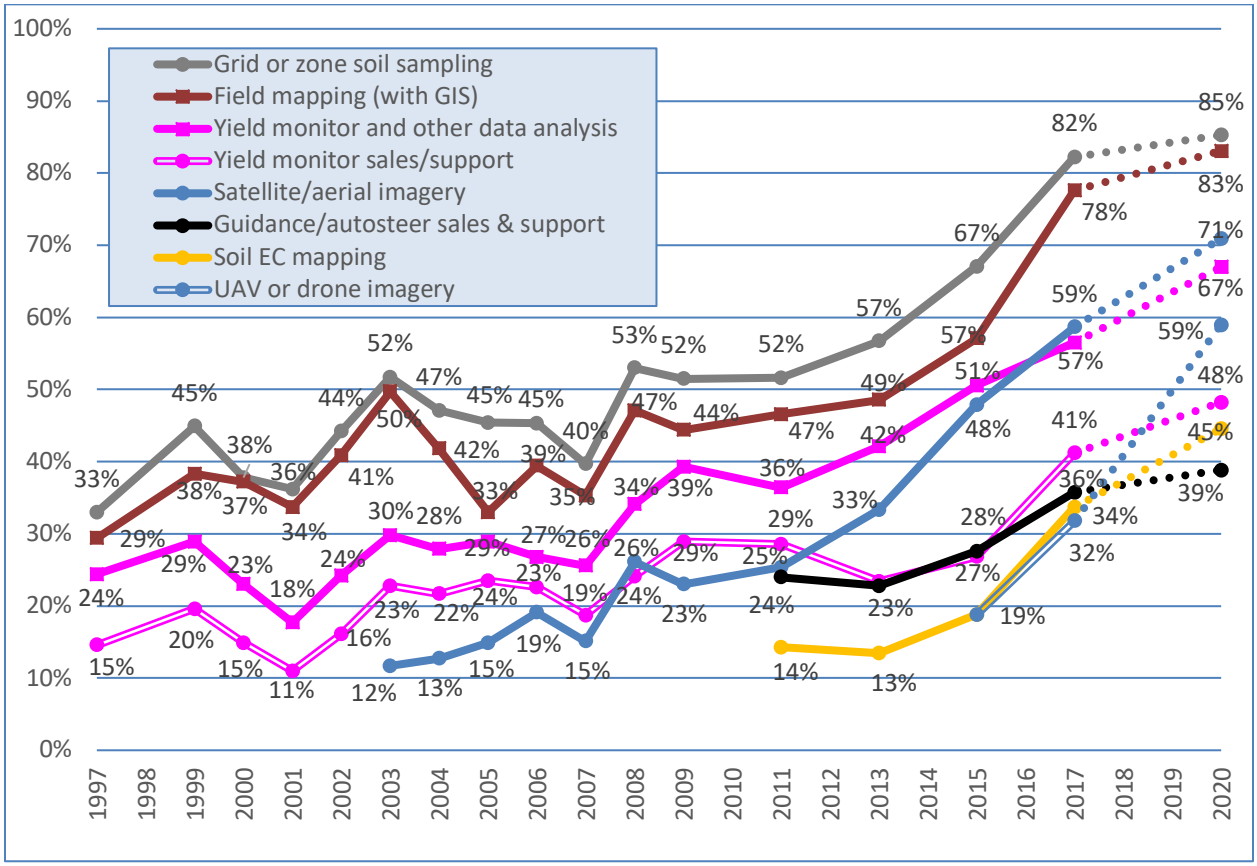

Figure 4. Dealer offerings of precision services over time, sensing technologies. 2020 are projections.

Figure 5 shows the adoption of variable rate technology services offered over time. All these site-specific services showed growth except VRT pesticide application which had a 10% decrease from 2015 to 2017. It can be a challenge to quantify the changing mix of various insect, disease, and weed populations across fields needed to craft a variable rate prescription. The growth leader in site-specific services was VRT fertilizer applications with a 12% increase. The 2017 survey question no longer separates VRT single fertilizer applications from multiple product applications. Also note that small changes in adoption may reflect the inherent variability and error present in any survey, as it is a different pool of respondents each time.

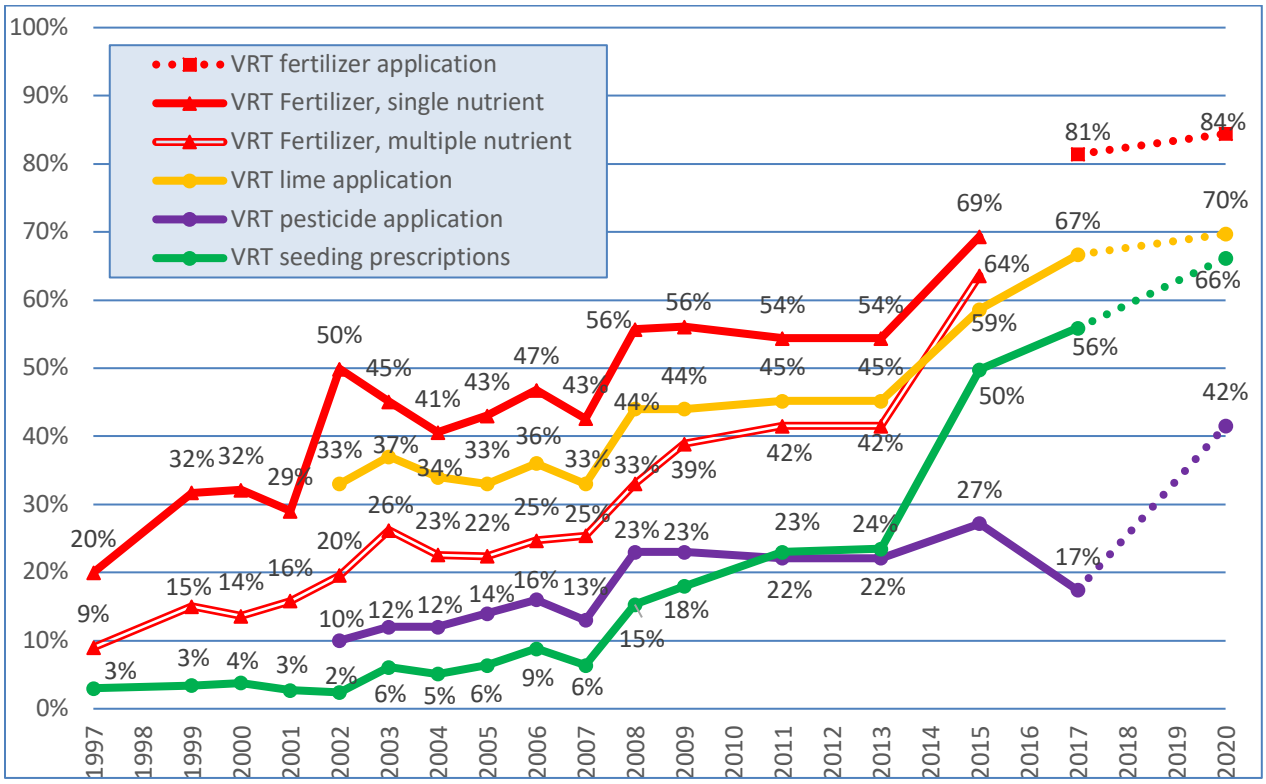

Figure 5. Dealer offerings of precision services over time, variable rate technologies. 2020 are projections.

Soil Sampling Procedures

An important role of many agricultural dealers, especially of agronomic products and services, is helping producers manage soil nutrients. Most of the time this starts with soil sampling, a service offered by 82% of dealers. The exact location of the soil sample 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.

Respondents were asked about the soil sampling procedures they used—multiple responses were allowed for multiple procedures. Sixty-seven percent of dealers offer grid soil sampling, 54% offer traditional or whole field sampling, and 47% offer sampling using management zones (Figure 6). For dealers who offer management zones more are using soil mapping units or yield maps to delineate the zones, and fewer are using soil electrical conductivity (Figure 7). For dealers who grid sample, 2.5 acres (1 hectare) is the most common grid size (Figure 8). 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.

The overall trend of fewer respondents supplying soil sampling services, when comparing 2017 to 2015, may be due to the fact lower grain prices are causing farmers to economize on production inputs and services. Some farmers seem to be reducing sampling to cut costs. This may explain the shift in the grid sizes toward larger grids sampled shown in Figure 8.

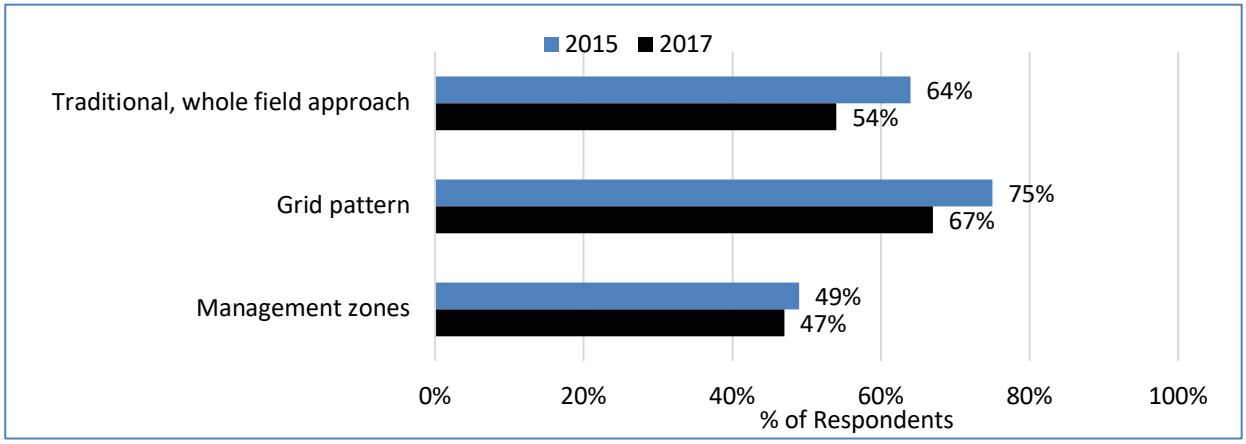

Figure 6. Types of soil sampling services offered by retailers.

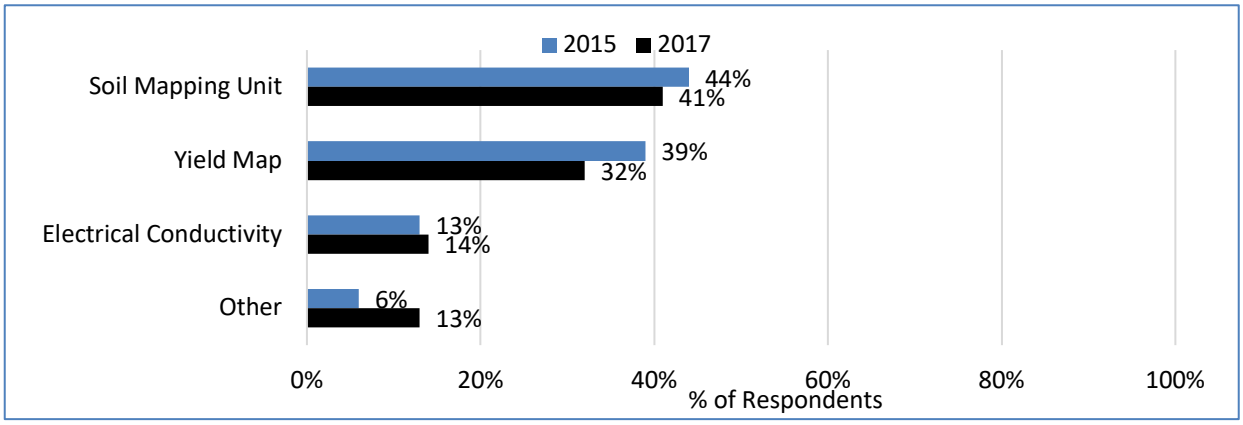

Figure 7. Factors used by retailers to determine management zones for precision soil sampling.

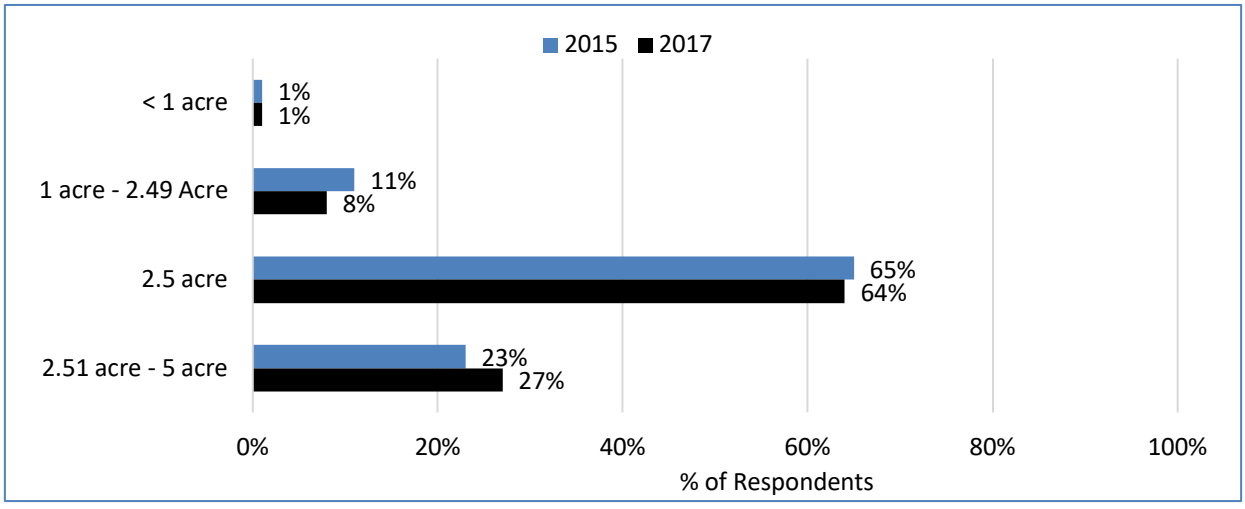

Figure 8. Grid sizes used by retailers for precision soil sampling.

Analysis of Data

Precision agriculture can provide an overwhelming amount of data from yield monitors, soil sampling, machine operations, and inputs applied to various portions of fields, to name a few. Often producers need assistance in analyzing these data for meaningful insights. Figure 9 reports how dealers help customers manage farm-level data in decision-making.

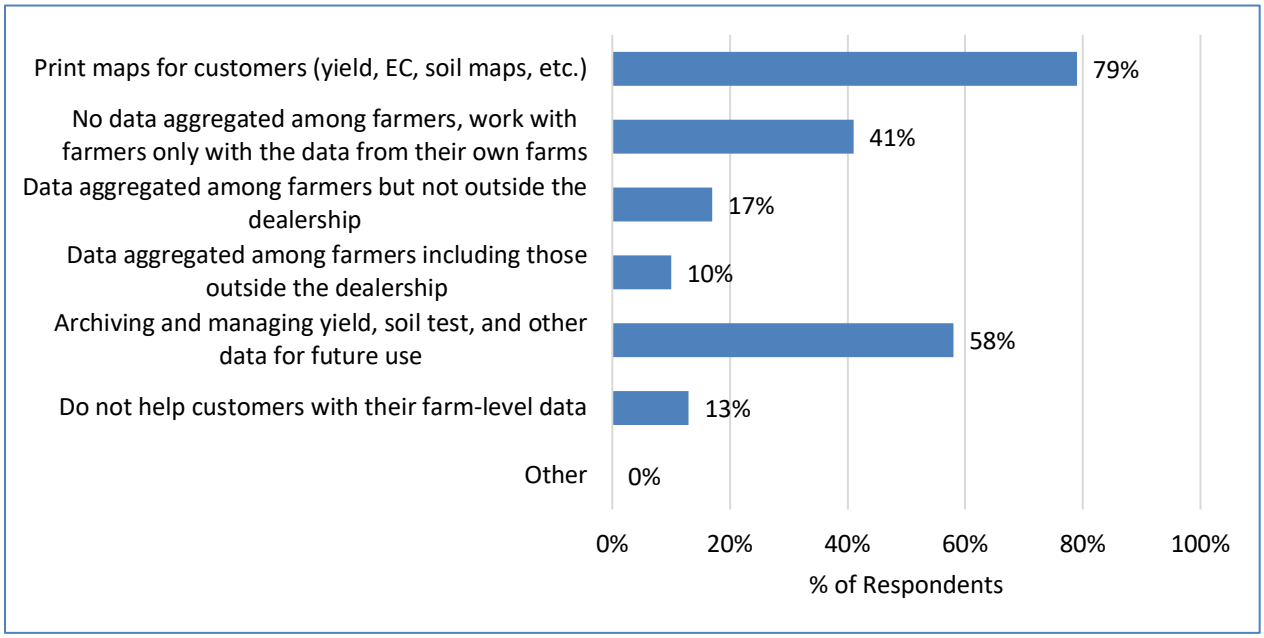

Figure 9. Ways dealers manage farm-level data to assist customers in decision-making.

The most common way dealers report helping customers was printing maps, such as yield, soil electrical conductivity, and soil maps. Beyond printing maps, 58% of dealers are archiving and managing yield, soil test, and other data for future use. Forty-one percent of respondents work with farmers individually.

In addition to the farmer's individual data, 17% of 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. Thirteen percent of the respondents do not help farmers with their farm-level data. Forty-five percent of dealers have a customer data privacy statement and/or data terms & conditions agreement.

Figure 10 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. Dealers report fertilizer and liming decisions are most influenced.

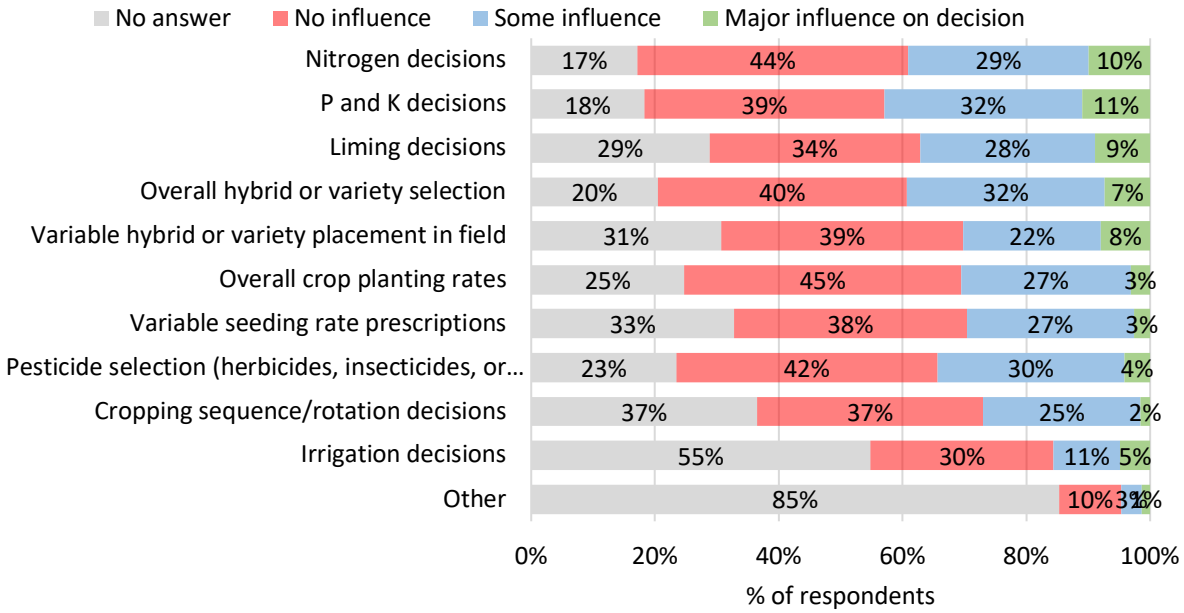

Figure 10. Management decisions influenced from pooled data.

Profitability of Precision Farming Offerings

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 11.

Overall, the categories with the greatest percent of respondents making a profit are VRT fertilizer or lime prescriptions (68%), VRT fertilizer applications (80%), VRT lime applications (69%), and grid or zone soil sampling (61%). The remaining services had less than 45% of respondents reporting a profit. UAV or drone imagery is a service area where dealers struggle the most to generate a profit where more than half of respondents are losing money or just breaking even.

Figure 12 shows the percent of respondents making a profit in certain precision ag services over time. VRT fertilizer applications and grid soil sampling have had steady profit growth since 2003. Satellite and aerial imagery has had a downward trend since 2003.

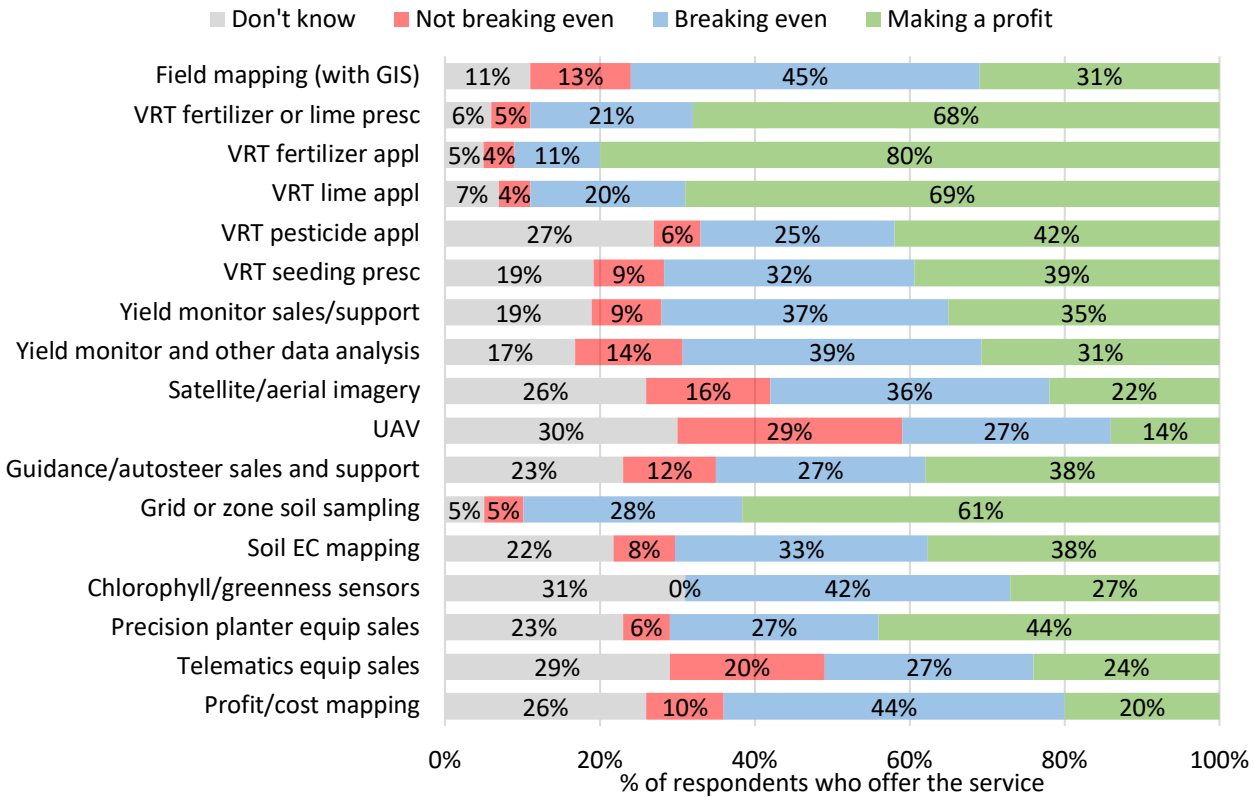

Figure 11. Profitability of precision service offerings for retailers.

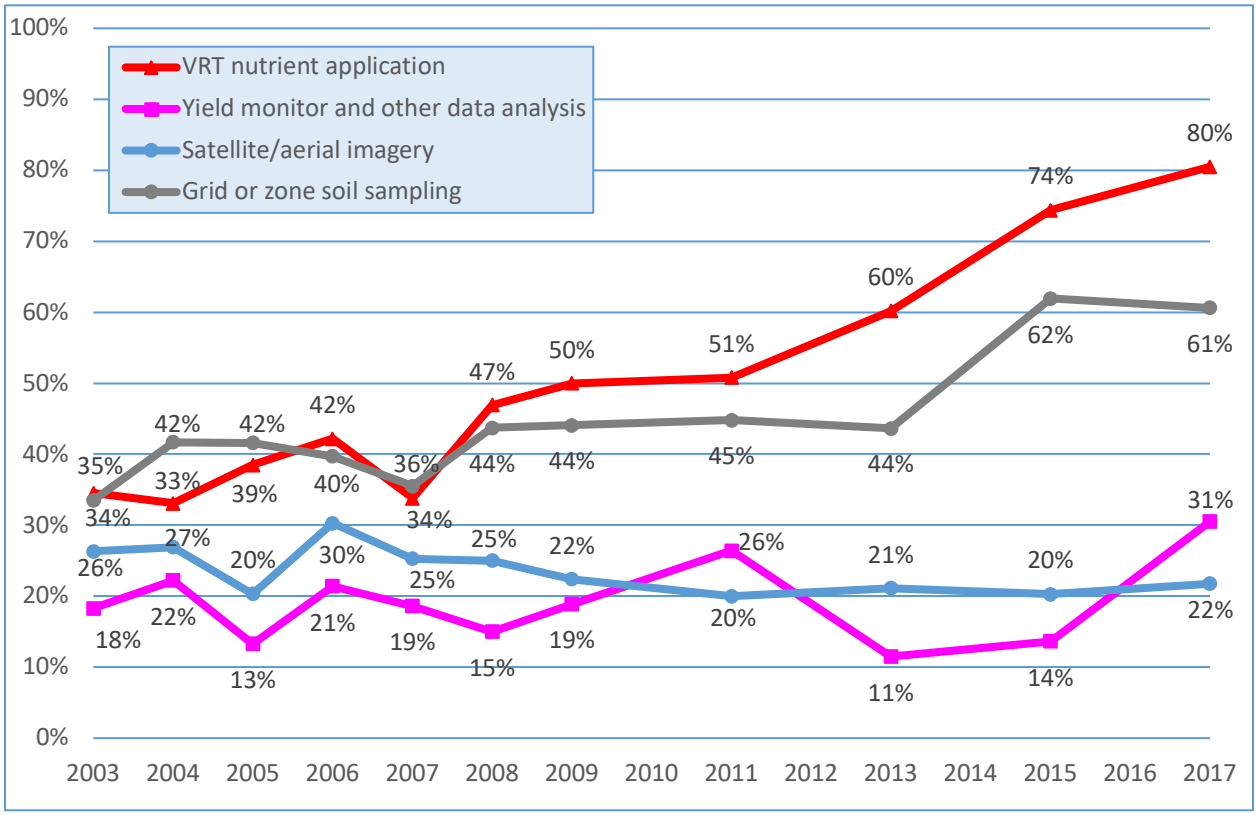

Figure 12. Profitability of precision service offerings over time.

Producer's Use of Precision Technologies

While the survey focuses primarily on the technologies used and precision services offered by dealers, dealers' insights into their customers' practices offers a different look into the adoption of these practices. As a part of the survey, respondents reported on the share of acres in their local market area (not percent of farmers) that are utilizing various precision technologies, both now and in the future.

Table 2 shows the estimated market area of the various precision technologies available. GPS guidance with automatic control continues to have the highest farmer adoption. There are many benefits to autosteer including less operator fatigue, more time focused on the operating equipment and less waste of applied inputs. Field mapping, soil sampling and VRT lime and fertilizer applications make up the next highest grouping with between one third and one-half of acres in the dealer's areas using these technologies. The next grouping is planter adaptations to improve precision, satellite and aerial imagery, VRT seeding and cloud storage technologies with 13% to 22% of the market area. The final group is the newer technologies looking at data analysis technologies, on-the-go sensors, VRT pesticides, changing hybrids on-the -go and UAVs with 3% to 9% of the market area. Some of these technologies are very new and unproven in their capabilities.

Table 2. Producer use of precision technologies, retailers estimate of their market area.

Precision Ag Technologies	Estimated Market Area	
	2017	Est 2020
Guidance/Autosteer	60%	72%
Field Mapping (with GIS)	45%	61%
Grid or Zone Soil Sampling	45%	62%
VRT Lime Application	40%	51%
VRT Fertilizer Application	38%	54%
Planter Adaptations to Improve Precision	22%	37%
Satellite or Aerial Imagery	19%	33%
Cloud Storage of Farm Data	14%	32%
Variable Down Pressure on Planter	14%	28%
VRT Seeding	13%	30%
Any Data Analysis Service (Encirca, FieldView, FBN, FarmServer, etc.)	13%	30%
Soil EC Mapping	9%	17%
Variable Hybrid Placement Within Fields	7%	19%
UAV or Drone Imagery	6%	22%
Y Drops on Fertilizer Applicator	6%	16%
Telematics	5%	12%
VRT Pesticide Application	3%	13%
Chlorophyll/Greenness Sensors for N Management	3%	10%

In Figures 13 and 14, you can see the changes over time in the percent of the market area of various precision ag technologies used by farmers. As with the dealer information, the 2017 survey doesn't separate single and multi-nutrient VRT fertilizer applications. All precision ag practices show steady growth, with the exception of VRT pesticide applications which fell back to 2001 levels from the 2015 survey to the 2017 survey. The estimated growth in the next three years would return VRT pesticide applications back to 2013 levels.

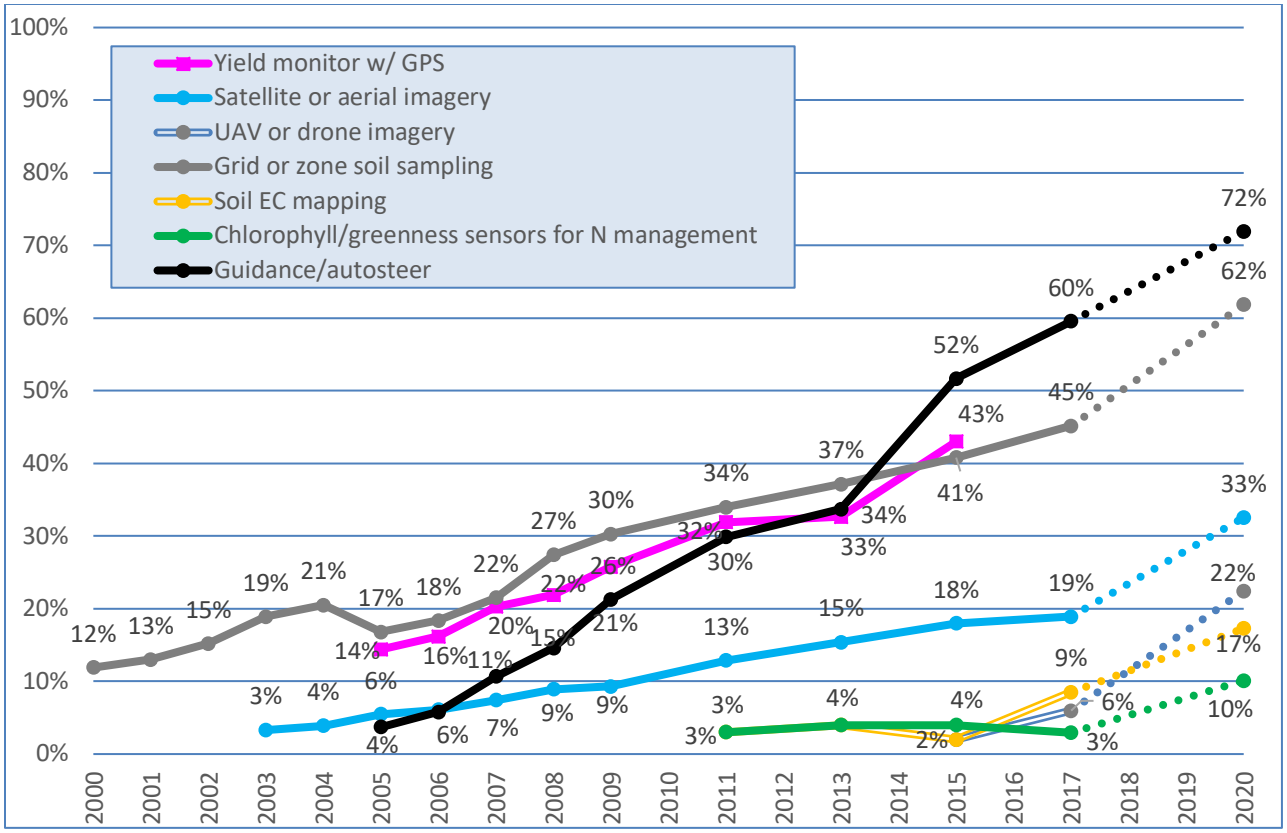

Figure 13. Farmer use of precision technologies, percent of acres as estimated by retailers. 2020 numbers are projections.

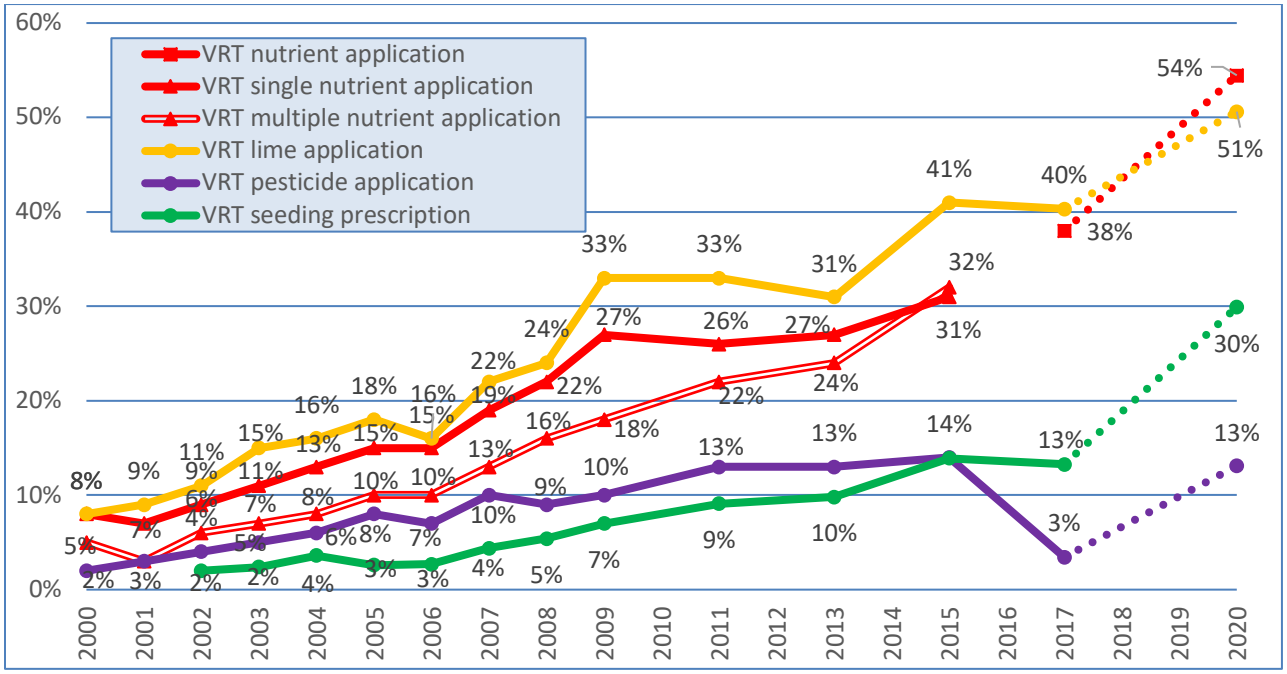

Figure 14: Farmer use of variable rate precision technologies, percent of acres as estimated by retailers. 2020 numbers are projections.

Future Investment Plans

Dealers were asked about their investment plans in 2017 for precision technologies, selecting a range in dollars. Thirteen percent of retailers were not planning on investing in precision technologies in 2017. Comparing over time, those retailers looking to invest in precision technologies are doing so at the smaller monetary levels. Those retailers investing $10,000 or less is up 7% from the 2015 survey. Retailers investing $100,000 or more is down 9% from the 2015 survey. Retailers investing $10,001 to $99,999 are at the same levels as 2015.

An important consideration, not included in this survey, is the investment in the human capital and supporting assets. For instance, dealers may be investing in UAV technologies, but tangential investments in additional employees, office space, computers, storage facilities, or employee vehicles required were not considered in the survey.

Barriers to Growth and Expansion

In an attempt to understand what prevents growth and expanded use of precision technologies the survey asked respondents to report on producer and dealer barriers. These barriers were evaluated for precision agriculture as a whole; specific technologies were not evaluated.

Producer Barriers

Figure 15 shows the perceived barriers by respondents over time. Farm income pressure is the most volatile from year to year followed by cost of services greater than the benefit from the services. Topography limiting use, soil types limit profitability, interpreting and making decisions and customer confidence seem to stay fairly flat from year to year. The only two evaluated barriers in which more respondents agreed than disagreed in 2017 is farm income pressure (65% agree vs. 11% disagree) and the cost of precision ag services is greater than the benefits (34% agree vs. 30% disagree).

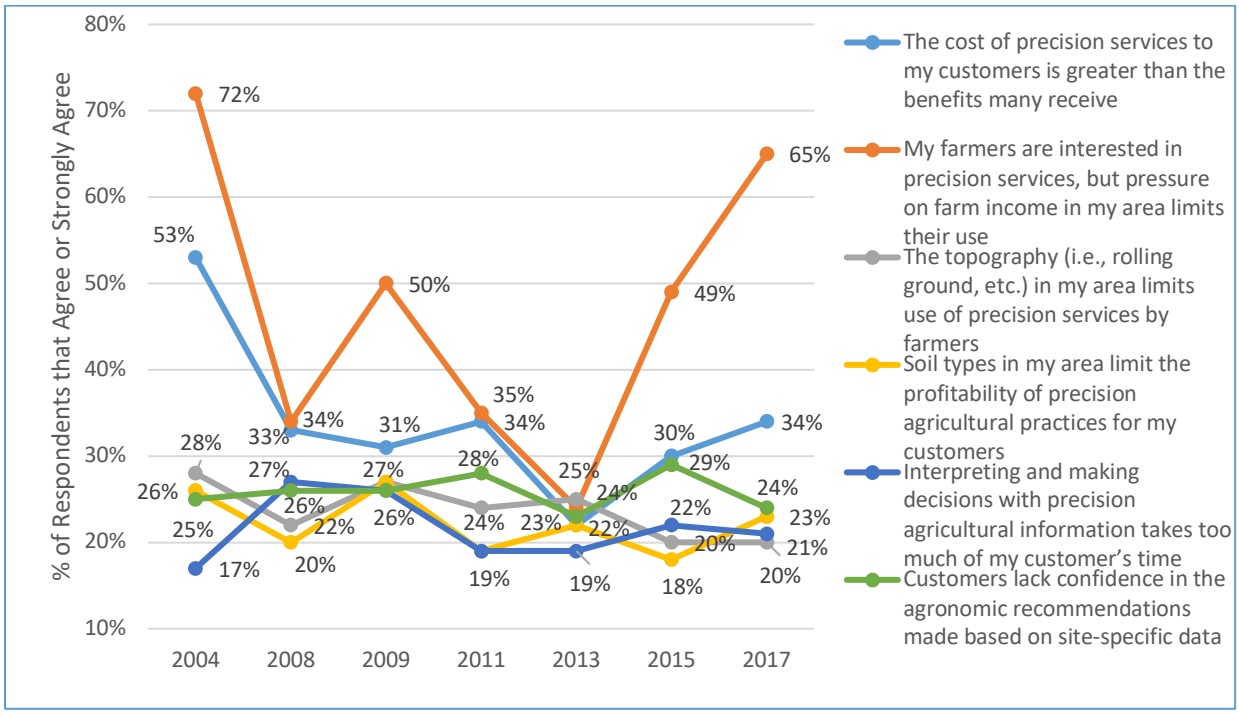

Figure 15. Customer issues that create barriers to expansion and growth in precision agriculture..

Dealer Barriers

When asked about the barriers dealers face, a range of responses were reported, Figures 16 and 17. In 2017, the highest barrier of the options offered to dealers in the survey was the difficulty in finding employees who can deliver on precision products and services, followed by the fees they can charge are not high enough to enable a profit.

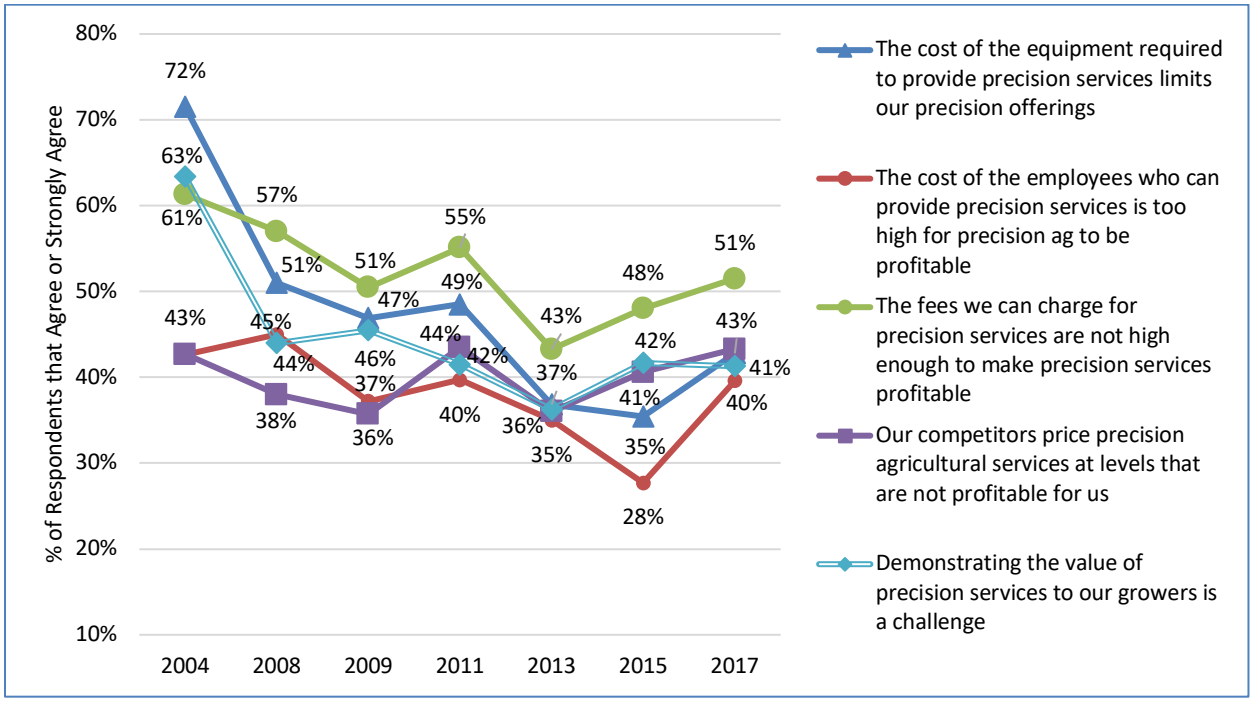

Figure 16. Dealer and technology issues that create a barrier to expansion and growth in precision agriculture.

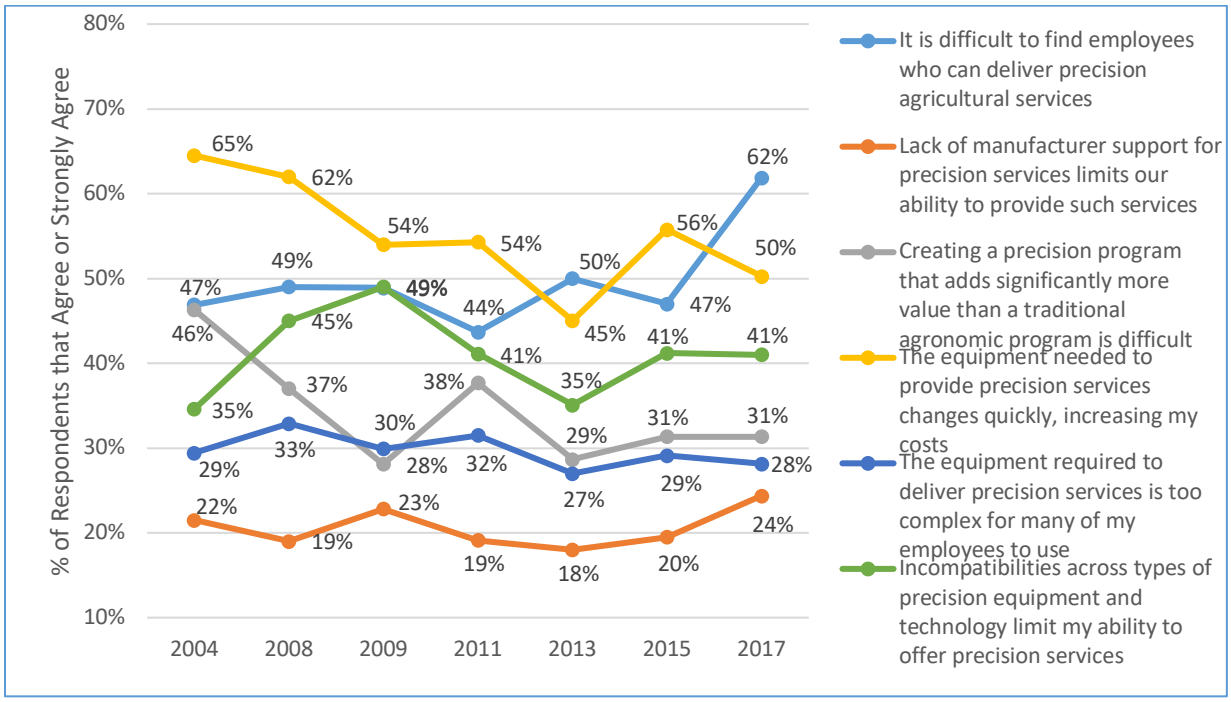

Figure 17. Dealer and technology issues that create a barrier to expansion and growth in precision agriculture.

Summary

Precision agriculture utilizes information technology through a set of related tools, aiming to manage crops more accurately and meticulously. Using embedded and remote sensors that measure soil and crop parameters spatially and temporally, software that analyzes variability to detect correlations and trends for informing inputs, through to more exact and tailored applications of seeds, fertilizers, pesticides, and other inputs--with the overall goal to increase the efficiency of the production process through better-utilized inputs and/or enhanced productivity. This survey spans most of the period since US agricultural retailers and farmers began using GPS to guide soil sampling and apply fertilizers and soil amendments variably across fields, and farmers used GPS-linked yield monitors to create maps that helped illuminate differences across fields and among years.

Since the mid-1990's there have been watershed changes to the technologies as well as new types introduced. The most significant of these in changing how crops are produced has been GPS guidance—first manual, and now supplanted by autoguidance systems that are becoming ubiquitous among farms and dealerships in the U.S. Sprayer boom section and planter row controllers are offshoots of guidance that are achieving widespread use.

Autoguidance and autocontrols on inputs are now mostly standard equipment across dealerships, partially because they are relatively simple to use and the benefits are relatively obvious. Guidance and section controllers do not depend on site-specific information to extract value, only location and previous applications. They help reduce input costs by reducing skips, overlaps and duplicate applications. In contrast, the information-intensive side of precision farming continues to struggle in demonstrating value. 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.

The 2017 survey shows an increased use in data collection technology such as greenness sensors, UAV's and EC mapping, while the use of logistics and telemetry services have declined. Respondents continue to struggle with generating a profit with the higher end precision ag tools and services. More dealer respondents are offering precision ag services with the exception of VRT pesticide applications. Farmers in the market areas of the dealers continue to adopt more precision ag practices. Some of these increases may be from improved hardware and software compatibly, greater ability to move, store, and analyze data, and familiarity with some of these new technologies.

The 2017 survey shows farmer income and the value perceived by the growers continues to be a barrier for growth. Respondents struggle with hardware and software incompatibilities, hiring the people to manage precision ag services, competitive pricing and difficulty in showing the customer value. As seen in the past, as farm incomes go down, there is a reduction in precision ag services purchased or utilization of cheaper services. As dealerships began to struggle with profit margins, smaller investments were made in precision technologies. One of the emerging dealership issues is the need for employees with the skills and experience to utilize precision agriculture tools and grow the precision service business. This is a job opportunity for those willing to acquire those skills and for the educational institutions who rise to the challenge of providing precision agriculture education.