PRECISION AGRICULTURE IN CANADA

2019 Precision Agriculture Dealership Services Surveys

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Introduction

Precision agriculture is a broad term used to describe a combination of modern agricultural technologies and farming management systems that are used to enhance data management in the agriculture industry. The concept of precision agriculture has existed since the 1980s but has been refined continuously as technology has advanced and agriculture has become increasingly digitalized. In the context of plant agriculture, the goal of precision agriculture is to increase economic benefits and minimize the environmental impacts of farming through the optimization of crop management. This can be achieved by recognizing the spatial heterogeneity of farming land and increasing inputs-use efficiency.

For over 20 years, CropLife magazine and the Departments of Agricultural Economics and Agronomy at Purdue University have undertaken the Precision Agriculture Dealership Survey. It is the longest-running continuous survey of precision farming adoption in the United States. In 2017, a similar survey in Ontario was conducted by University of Guelph and the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) through the membership of the Ontario Agri Business Association (OABA). This survey was repeated in 2019 in Ontario. Shortly after similar survey was also sent to members of the Canadian Association of Agri Retailers (CAAR) from across Canada.

The initiative of the OABA and CAAR surveys are to provide an accurate description on the adoption of precision services/technology, and how the technologies are used across Canada. The surveys also investigate the challenges and barriers faced by Canadian agribusinesses adopting precision agriculture technologies as well as the expected profitability of offering precision services. The surveys also provide an opportunity to compare the development of precision agriculture industry between Canada and the United States.

This report provides an overview of the level of adoption of precision agriculture technologies for crop production in Canada. The report begins with a description of the survey used to collect information on the use of these technologies by agriculture service providers in the province. The next section describes the characteristics of the agricultural retailers responding to the survey including dimensions such as geographic location, financial size, and business focus. The next section sheds light on custom application services offered by dealerships and the extent to which precision agriculture technologies have been used by the service providers. The technologies are categorized into four types: (1) geographic, (2) observational, (3) sales and analytical, and (4) variable rate. Definitions of the major terms related to the various technologies are listed in Appendix I. Soil sampling services offered, the systems to manage data by the retailers with their farm clients and 4R nutrient stewardship awareness are then discussed followed by an assessment by the retailers on the use of precision agriculture by the farmers themselves. The next section gives a breakdown of future investment in precision agriculture technologies and future adoption rates. The findings of the study are then summarized, and the implications are discussed.

Survey Design

In 2017, the Department of Food, Agricultural and Resource Economics (FARE) at the University of Guelph collaborated with the precision agriculture survey developers at Purdue to distribute a similar survey in Ontario through OABA members. In 2019 this survey was repeated Ontario and expanded to survey dealerships across Canada through CAAR members.

The OABA survey was sent out electronically initially on June 13th, 2019 to the emails of 144 registered members that were identified within the organization's trade directory as potential users of precision agriculture technologies. This was based on the members' coded designation(s) within its membership list. Four additional emails were also sent based on incorrect supposition and are therefore omitted from the total number of emails sent. Of the surveys sent out, 40 were returned with useable data, yielding a response rate of 27%. It is important to note that all answers were voluntary, and some respondents did not answer all the questions asked of them. Only respondents who answered more than 80% of the survey questions are included in the final report.

From the Ontario survey, a modified survey was developed and distributed in partnership with CAAR to agriculture retailers predominately in Western Canada, but also to some in Eastern provinces. For this survey there were two different methods of distribution. The survey was posted on the CAAR website, where the association internally directed its members to respond. Additionally, University of Guelph researchers contacted over 1200 members of CAAR by way of email, initially on August 2nd, and again on August 15th and 21st. Respondents had until September 17th to complete the survey either through the CAAR website or via the link emailed to them. The respondents contacted directly were members who were identified within the organization's trade directory as potential users of precision agriculture technologies. The survey instrument posted to the CAAR website differed in that respondents were required to enter contact information to avoid duplicate results if they had already completed it via the email distribution. Over the 6-week period that respondents could complete the survey, 122 were returned with useable data, yielding a response rate of 10 percent.

Dealerships were asked about their business attributes, their adoption of precision services, utilization of technologies, and the potential for future adoption of other technologies. Respondents were also asked about the economic considerations both when acquiring new technologies and when using them to provide services. The actual survey instruments for both the OABA survey and CAAR survey can be found in Appendices II and III.

Characteristics of the Respondents

Conducting two separate surveys among both OABA and CAAR members yielded responses from dealerships across Canada, which provides an accurate depiction of adoption rates national and allows for a comparison of the regional differences in precision agriculture technology use. In order to properly assess and verify that the respondents are representative of the agri-businesses in Canada, they were asked a series of questions to determine their demographics.

Respondents of the CAAR survey were asked which province(s) their business is located in. 87% of respondents of the CAAR survey indicated that their business operates in only a single province, with 83% of single province operations located in one of the prairie provinces, (Figure 1).

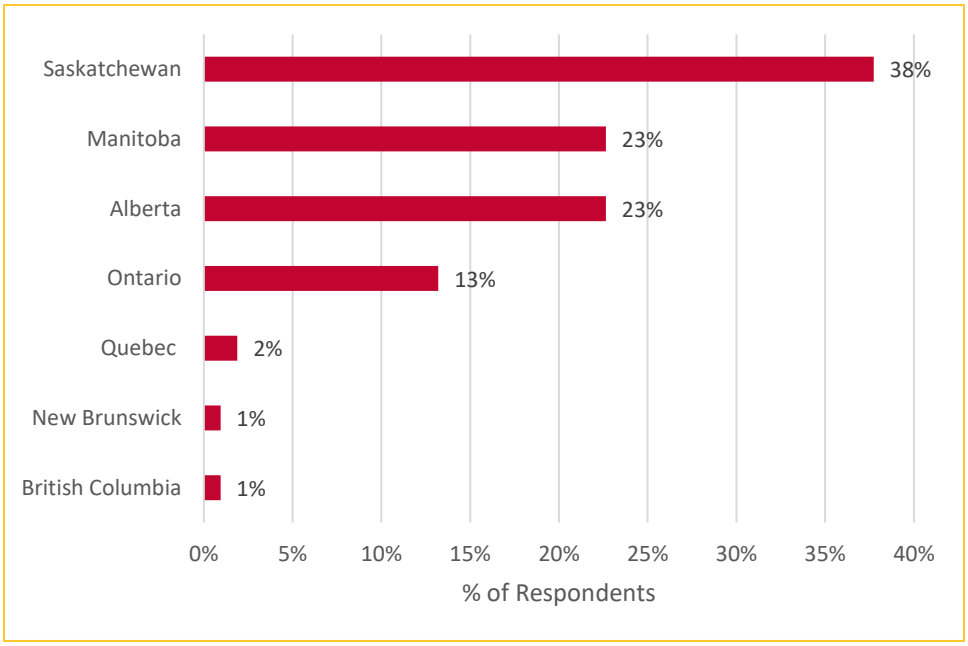


Figure 1. Location of CAAR respondents' businesses in a single province

Of those businesses located in multiple provinces nearly 40% had locations in all of the provinces (Figure 2). The others with businesses in multiple provinces were primarily located in Quebec, Ontario and the Western provinces.

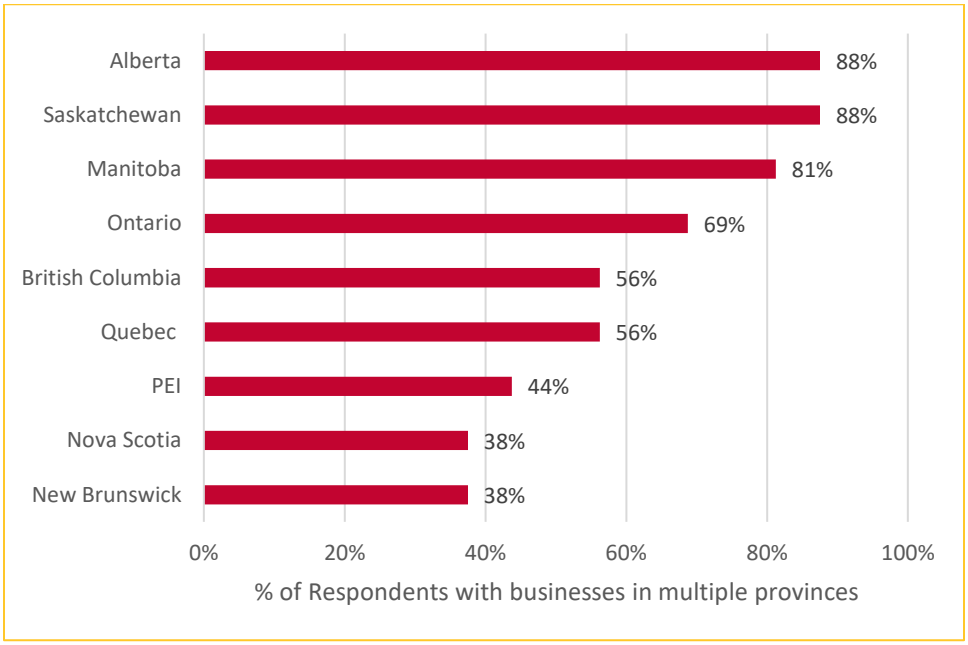


Figure 2. Location of CAAR respondents' businesses in multiple provinces

Respondents' dealerships of the OABA survey are all located in Ontario, therefore they were not asked what province their business was located in. The total provincial representation of businesses from both the CAAR and OABA survey is shown in figure 3, (all OABA responses are grouped into the Ontario category). Ontario was the province that the most responses indicated that their business has locations in at 65. Saskatchewan followed closely with 54 respondents indicating that their business has a location within the province.

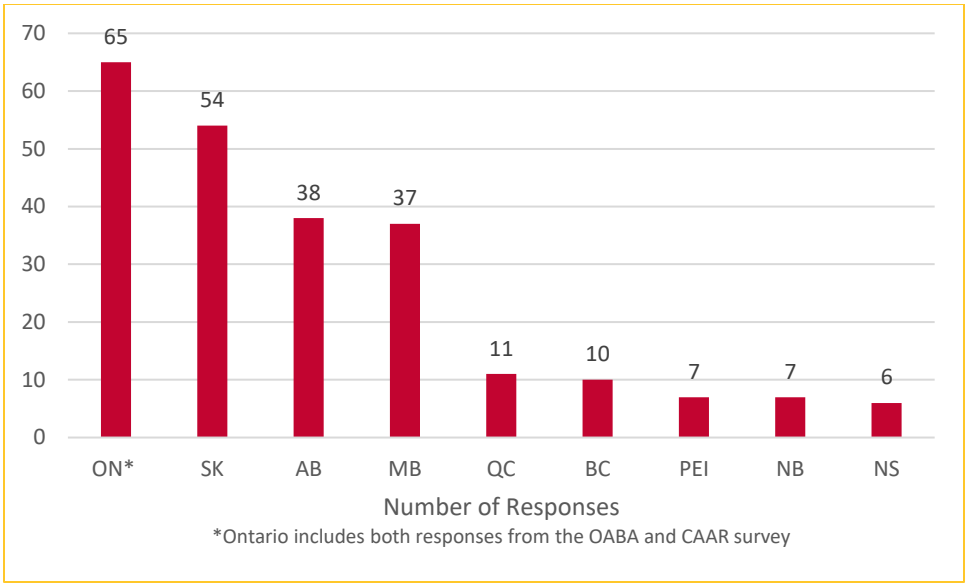


Figure 3. Respondents business location(s) by province

Respondents were also asked what type of input supply business they operate. 33% of respondents identified their business as a cooperative, 28% as an independent dealership and 23% as a dealership chain (Figure 4). The majority of those who selected other were respondents of the CAAR survey, with responses including business types such as government extensions and wholesales.

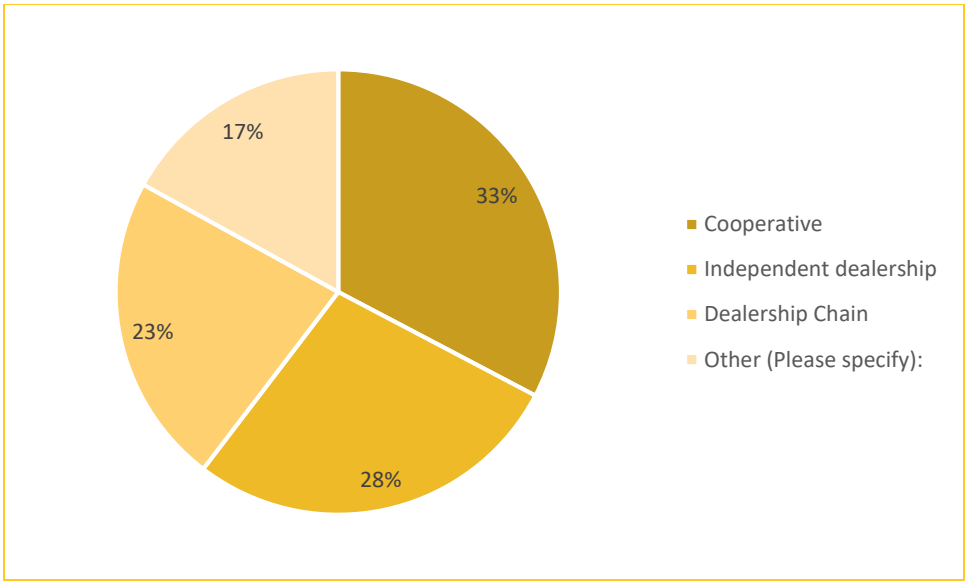


Figure 4. Type of input supply business

Respondents were also asked to indicate what their position within their company is (Figure 5). Nearly half (49%) indicated that they were either the owner, general manager, or location manger. An additional 20% reported to be employed as a technical consultant, or an agronomist. The remaining 30% of respondents reported to be employed as sales mangers (11%), department mangers (10%), precision mangers (3%), consultants (3%) and 4% reported to be employed in other positions. Application manager was an option provided on both the OABA and CAAR surveys, however no respondent identified as an application manager. The positions of the respondents are indicative of a respondent pool who have a comprehensive understanding of their company, and who would be qualified and knowledgeable with respect to the subject matter of the survey.

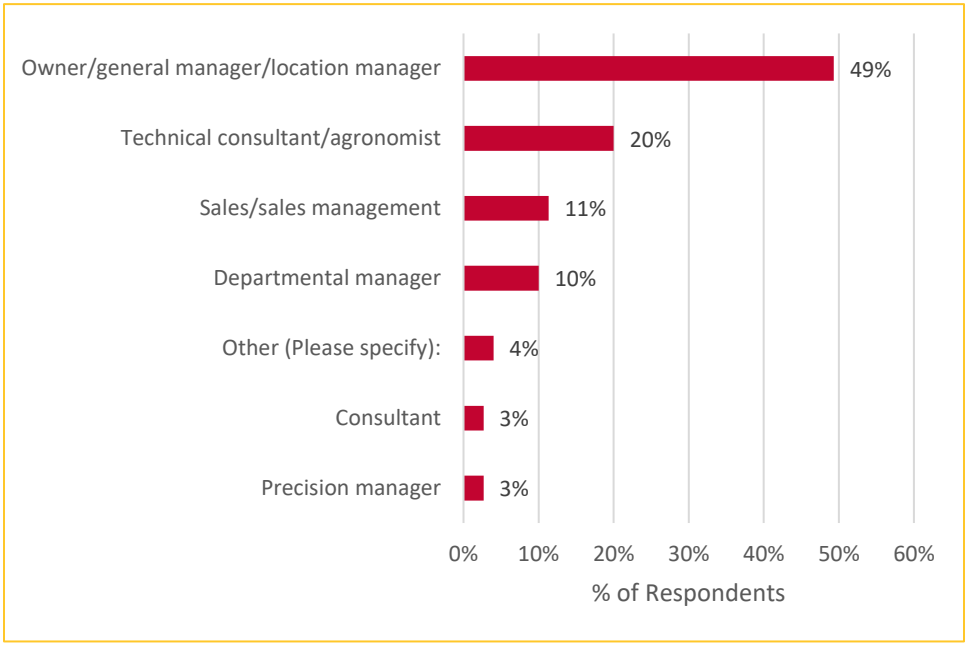


Figure 5. Respondent's position within their company

To gather information about the number of employees who are directly employed in jobs relating to precision agriculture, survey respondents were asked how many of employees are employed in different roles at their retail outlet (Figure 6). Across both surveys, there was an average of 5.9 agronomists, 2.0 applicators, 1.2 data mangers, 0.6 precision sales specialists, 0.1 technical support staff, and 0.1 precision equipment technicians per retail location. CAAR members reported to employ a greater number of agronomists than OABA members, with 6.8 agronomists per retail outlet, compared to 3.4 per outlet. There was also a large discrepancy between the amount of data mangers employed among OABA members compared to CAAR members, with OABA survey respondents employing an average of 3.6 data mangers per retail outlet compared to only 0.4 per retail outlet among CAAR respondents. This is most likely due to a small number of dealers in Ontario who employ many of these employees.

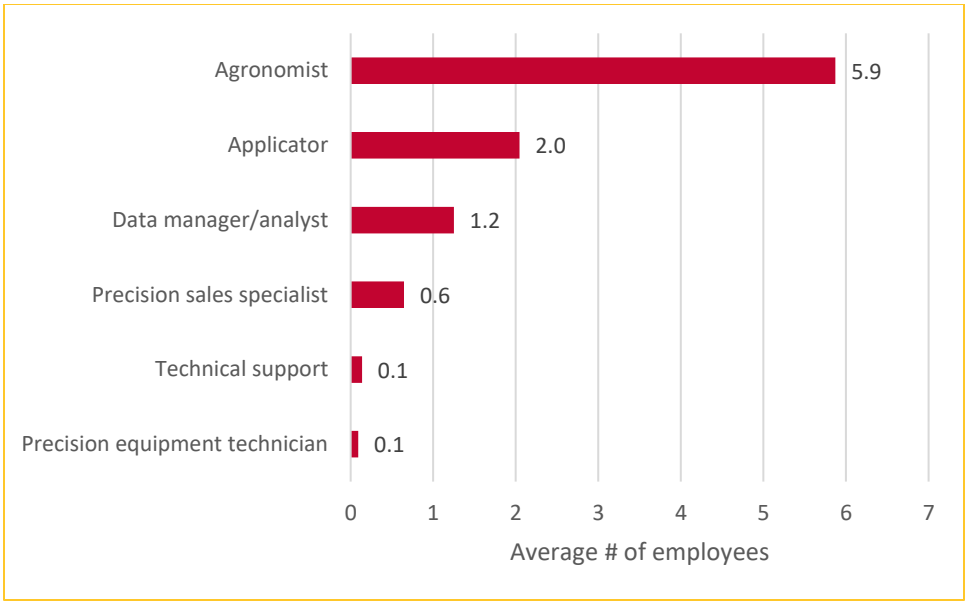


Figure 6. Number of employees directly employed in precision agriculture

Overall, the survey respondents from both the OABA and CAAR surveys represent a diverse sample size of crop input supply companies. Respondents represented numerous different types of input supply companies, of varying sizes and from provinces from across Canada. Respondent's held positions that would allow them to possess a strong understanding of their company and their use of precision agriculture technologies. The characteristics of respondents and their dealerships are reflective of the agriculture supply industry in Canada and helps to validate the results of the survey detailed throughout this report, beginning with custom application services in the following section.

Custom Application

A major component of business operations for many dealerships is the application of agricultural inputs on behalf of farmers. Table 1 details custom application services offered, the total amount of acres that were custom applied and the percentage of sales for pesticides, crop protection and lime products that were custom applied.

A sharp contrast between dealerships in Ontario and in Western Canada exists with regard to custom application services. Although, OABA survey respondents were not directly asked what custom application services they offered, nearly all respondents answered how many acres their retail outlets custom apply and what percentage of product sales are custom applied, suggesting custom application is very common across Ontario. This was not the case for Western Canada provinces, particularly Alberta and Saskatchewan, where only 52% and 46% of respondents indicated that their retail outlet offers custom application services of some kind.

Including respondents of the CAAR survey located in Ontario, there were 18 Ontario dealerships that indicated that they custom apply agricultural inputs on more than 50,000 acres in a typical year. In Alberta, Saskatchewan and Manitoba, farm sizes are bigger than those in Ontario, yet there were only 6 respondents in all three provinces combined, who stated their dealership custom applies agricultural inputs on more than 50,000 acres in a typical year.

Additionally, a greater percentage of fertilizer and crop protection products are custom applied in Ontario compared to western Canada dealership who offer custom application services. An average of 38% of fertilizer sales are custom applied in Ontario, compared to 14%, 13% and 20% in the provinces of Alberta, Saskatchewan and Manitoba, respectively. The difference is similar for crop protection products as well, with an average of 38% of sales in Ontario being custom applied, compared to 28%, 13% and 20% of sales in Alberta, Saskatchewan and Manitoba, respectively.

Table 1. Custom Application Services by Retailers

Characteristic	Alberta	Sask.	Manitoba	Ontario	Ontario*	Multi**	Total
Services offered							
Fertilizer	8	8	11	6	x	4	39
Crop protection	3	9	12	6	x	4	36
Lime	0	1	0	6	x	2	11
None	10	21	7	5	x	8	52
Acres applied							
< 25,000	5	3	5	1	16	1	31
25,000-50,000	1	6	3	3	7	3	23
>50,000	2	0	4	2	16	1	25
% of sales Custom applied (Avg)							
Fertilizer	13.7%	12.9%	20.5%	36.8%	38.4%	30.0%	
< 25%	6	5	7	2	8	3	31
25% - 50%	1	1	2	2	15	0	21
50% - 75%	0	0	1	2	11	1	15
>75%	0	0	1	0	2	0	3
Crop protection	27.5%	12.6%	20.2%	48.5%	38.3%	20.0%	
< 25%	0	6	10	1	10	2	29
25% - 50%	2	1	1	2	11	1	18
50% - 75%	0	0	0	2	9	0	11
>75%	0	0	1	1	2	0	4
Lime	N/A	N/A	N/A	46.2	x	100	

*Ontario is separated into Ontario responses from the CAAR survey and all responses from the OABA survey. *indicates OABA respondents. **Multi includes CAAR responses who indicated that their dealership operates in more than one province

Custom application of crop inputs by the dealership on behalf of the farmer occurs for approximately 15% of crop input products sold in the Prairies and 40% of crop input sales in Ontario. However, for a variety of reason not discussed in-depth in this report, precision technology is often not requested by the farmer, even when the service is available. In order to assess the level of precision agriculture technology used for custom application services respondents who offer custom application services were asked what percentage of their total custom applied area used specific precision agriculture technologies (Figure 7).

Automatically controlled guidance systems (autosteer) and automatic sprayer boom section or nozzle control were the most widely used precision technologies used for custom application services, with respondents stating that 87% and 76% of the total area custom applied uses the technology. Precision technologies used to make crop input prescriptions were not stated as commonly used on the total area custom applied. Prescriptions from satellite imagery, UAV imagery, soil electrical conductivity mapping, and chlorophyll sensors were reported to be used for only 16%, 14%, 7% and 6%, respectively, of the total area custom applied by dealerships.

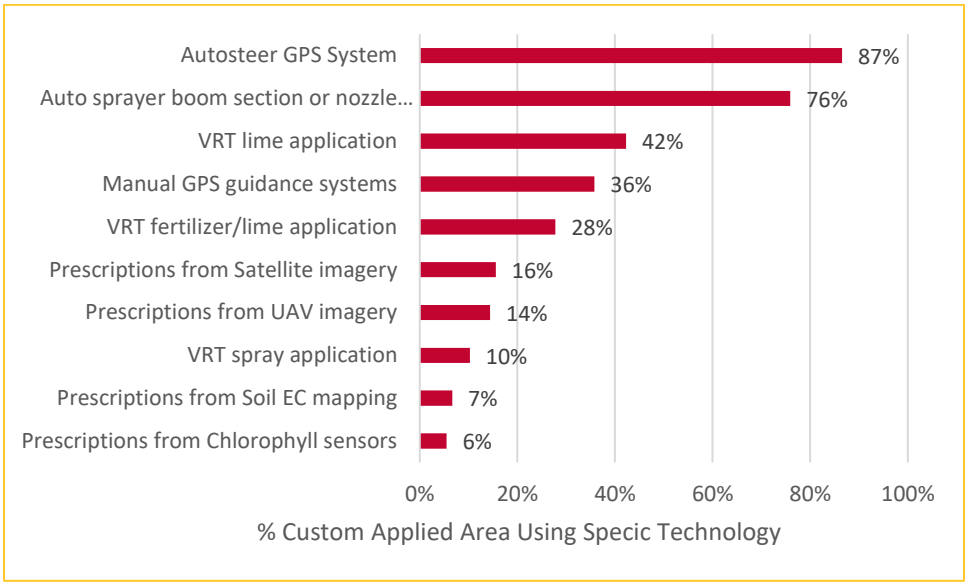


Figure 7. Use of Precision Technologies for Custom Application

How agricultural input suppliers operate differs significantly across Canada, especially in the context of custom application service offerings. Custom application services are an essential part of agricultural input suppliers' operations in Ontario, but not as much in the Prairie provinces. It was important to ask survey respondents about their dealership's custom application service offerings as differences in the role of dealerships in different parts of the country may help explain potential regional differences in precision agriculture technology adoption rates.

Adoption of Precision Agriculture Technologies by Retailers

The overall adoption of precision agriculture technologies by dealerships can be viewed in two ways. The first being in terms of if the dealership uses the technology for their own business needs (question 16 in Appendix II and question 14 in Appendix III). The second is in terms of whether the technology is made available to its customers (question's 18 in Appendix II and III). The first half of this section will focus on dealer's internal use of precision agriculture technologies, with the availability of precision technologies and services to customers detailed in the second half of this section.

Retailer Use of Precision Agriculture Technologies

Table 2 provides an overview of the dealerships use of precision agriculture technologies for the locations in the Prairie provinces, Ontario and those in multiple provinces. Ontario dealerships led the way in adoption, with some technologies having nearly double the adoption rates compared to Prairie dealerships. Ontario respondents indicated high levels of adoption rates for precision agronomic consulting services (68%), automatic guidance systems (65%) and satellite imagery (63%).

For a select number of technologies' dealerships in the Prairie provinces indicated higher rates of adoption than Ontario dealerships. This was the case for smart scouting using mobile applications where Alberta, Saskatchewan and Manitoba all had adoption rates of over 50% compared to 38% in Ontario. Manitoba dealerships also indicated higher adoption rates of UAV or drone imagery technologies, at 35% compared to 30% in Ontario.

Overall, the rate of precision agriculture technology adoption was similar across the Prairie provinces, except for a few technologies. Manitoba dealerships indicated much higher adoption rates for automatic boom section or nozzle control with 41% of respondents stating that their dealership uses the technology, compared to 6% and 13% of respondents in Alberta and Saskatchewan, respectively. This was similar for automatic guidance systems with 47% of Manitoba respondents indicating that their dealership uses the technology compared to 24% and 8% of respondents in Alberta and Saskatchewan.

Table 2. Overall Dealer Adoption of Precision Agriculture Technologies for Dealer Use by Province

Type of Technology	ALB	SASK	MAN	ONT	ONT*	Multi**
Any precision agronomic consulting services					68%	
Auto sprayer boom section or nozzle control	6%	13%	41%	55%	60%	11%
Chlorophyll/greenness sensors					25%	
Do not use precision technology	18%	29%	18%	27%	15%	44%
Field mapping with GIS to document work for billing/insurance/legal purposes					35%	
GPS guidance systems with automatic control (autosteer)	24%	8%	47%	55%	65%	33%
GPS guidance systems with manual control (light bar)	18%	13%	18%	9%	30%	11%
GPS to manage fleet vehicle logistics					45%	
Other soil sensors for mapping					10%	
Satellite/aerial imagery for internal dealership purposes	59%	46%	35%	64%	63%	33%
Smart scouting using mobile applications	53%	54%	53%	27%	38%	44%
Soil electrical conductivity (electromagnetic) mapping	12%	4%	12%	18%	20%	
Sprayer turn compensation			12%	9%	18%	
Telematics to exchange information					15%	
UAV or drone for internal dealership purposes	24%	13%	35%	36%	30%	11%
Y drops on fertilizer applicators			6%	36%	33%	

*Ontario is separated into Ontario responses from the CAAR survey and all responses from the OABA survey. *indicates OABA respondents. **Multi includes CAAR responses who indicated that their dealership operates in more than one province

When combining responses from both the OABA and CAAR surveys, 79% of respondents use precision agriculture technology (Figure 8). Satellite imagery (52%), smart scouting using mobile applications (44%), and GPS guidance systems (40%) were the three most widely used precision technologies that dealers across Canada. It is important to note that while asking dealerships about their own use of precision agriculture does provide valuable information regarding the overall adoption rate of precision agriculture technologies across Canada, it does not tell the whole story. That is why it was also crucial to also ask survey respondents what precision technologies and services they make available to their customers

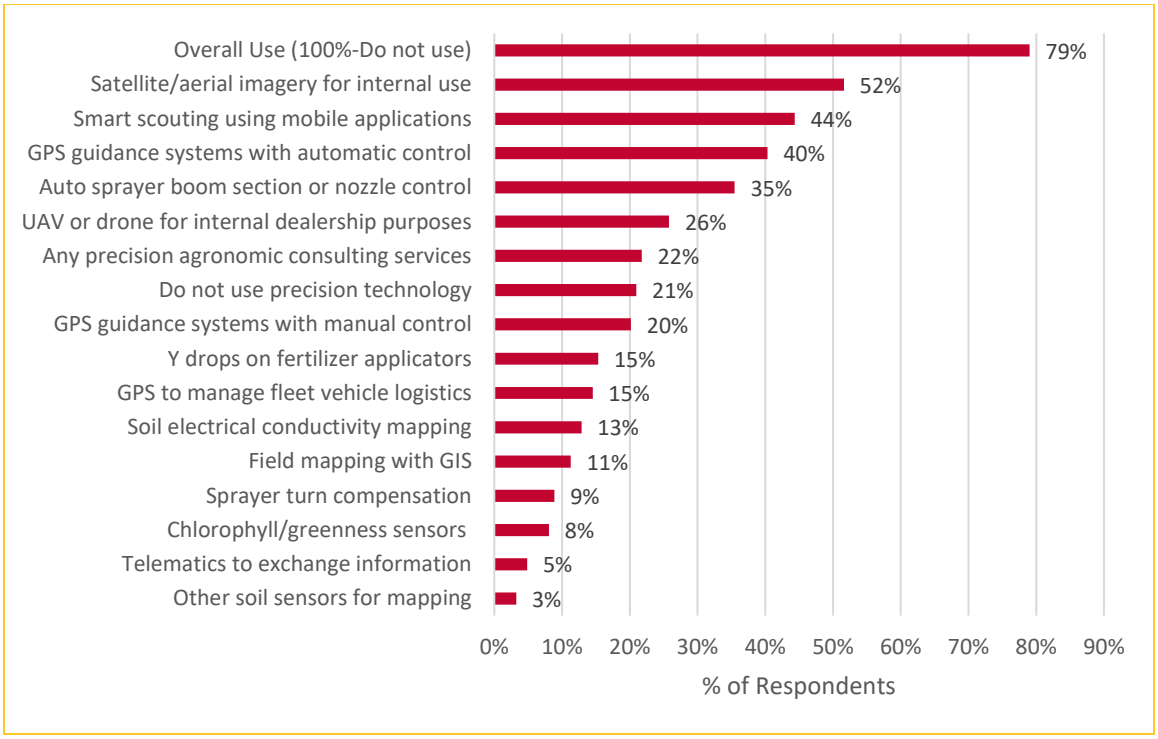


Figure 8. Overall Dealer Adoption of Precision Agriculture Technologies (OABA & CAAR combined)

Retailer offerings of Precision Agriculture Technologies and Services

The next part of this section on precision agriculture technology adoption by retailer looks at the precision agriculture technologies and services that retailers make available to their clients. Precision technologies and services are grouped in similar categories including geographic services, observational services, sales and analytical services, and variable rate services.

Geographic Services

Beginning with geographic services, the technologies and services reported here mainly focus on those used for guidance and mapping. Grid or zone soil sampling was the most commonly geographic service made available to customers, with 65% of respondent's indicating that their dealership makes this service available (Figure 9). Field mapping (with GIS), autosteer and grid of zone tissue sampling also are technologies and services made widely available, as greater than 50% of respondents reported that their dealership makes each of these technologies and services available to clients.

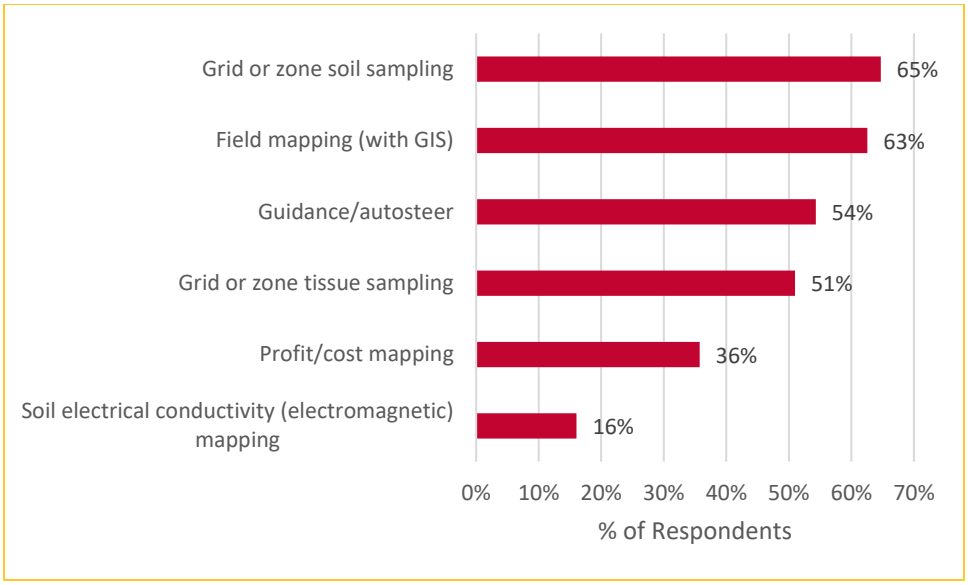


Figure 9. Retailer Offerings of Geographic Technologies and Services

In order to understand the general accuracy of the guidance applications used, respondents were asked which type of GPS correction method their guidance application (Figure 10). Utilizing the wide area augmentation system (WAAS) to augment GPS accuracy is most often used for retailer's guidance applications, with 43% of respondents using this method of GPS correction. The most accurate of the GPS correction methods included in the survey, purchasing corrections form a real time kinematic (RTK), was the preferred GPS correction method for 19% of retailer's guidance applications. Using a personal RTK base station for GPS correction of guidance application is more common among CAAR dealerships, than OABA dealerships, but overall this method was reported to be used by 15% of dealerships surveyed.

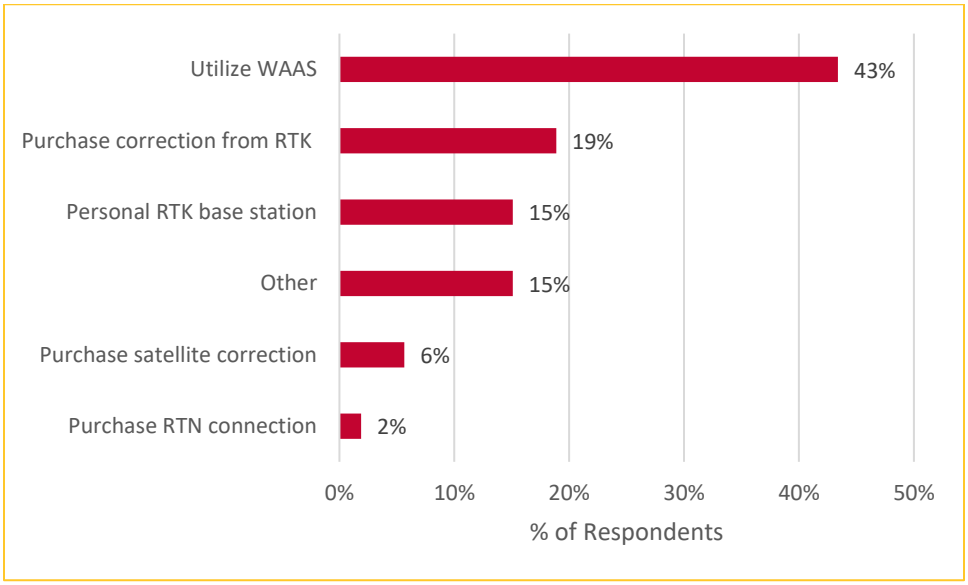


Figure 10. Type of GPS Correction used for Guidance Applications

Observational Services

Observational technologies and services collect field data using imagery or sensor networks that allow the producer to obtain more accurate information about the characteristics of their field. Satellite imagery is made available to customers by 62% of respondents' dealership's, making it the most widely adopted observational technology or service among dealerships included in the surveys (Figure 11). Unmanned aerial vehicle (UAV) or drone imagery, wired or wireless sensor networks, and chlorophyll sensors for nitrogen management, are reported to be adopted by 38%, 21%, and 20%, of respondents' dealership's, respectively.

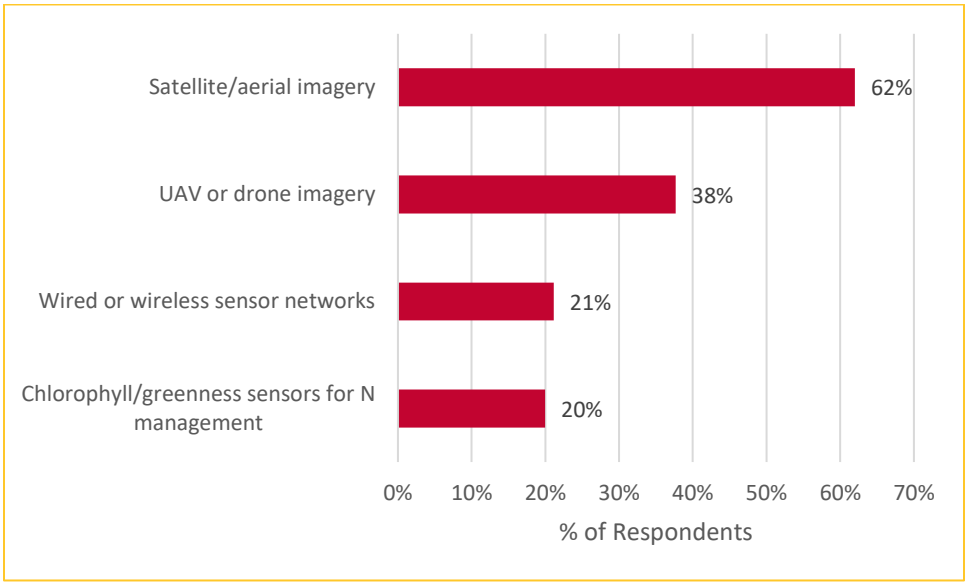


Figure 11 Retailer Offerings of Observational Technologies and Services

Sales and Analytical Services

Sales and analytical services include precision technologies or services that the retailer directly sells to the client. Nearly half (44%) of dealerships included in the surveys offer electronic records or maps to improve quality traceability, making this the most offered technology or service in this category, followed closely by yield monitors and other data analysis technologies and services which are offered by 37% of retailers (Figure 12). The remaining technologies and services, including, autosteer sales and support, yield monitor sales and support, telematics equipment and precision planter equipment are not made widely available to customers as only 13%, 13%, 8%, and 3%, respectively, of dealerships have these technologies available customers.

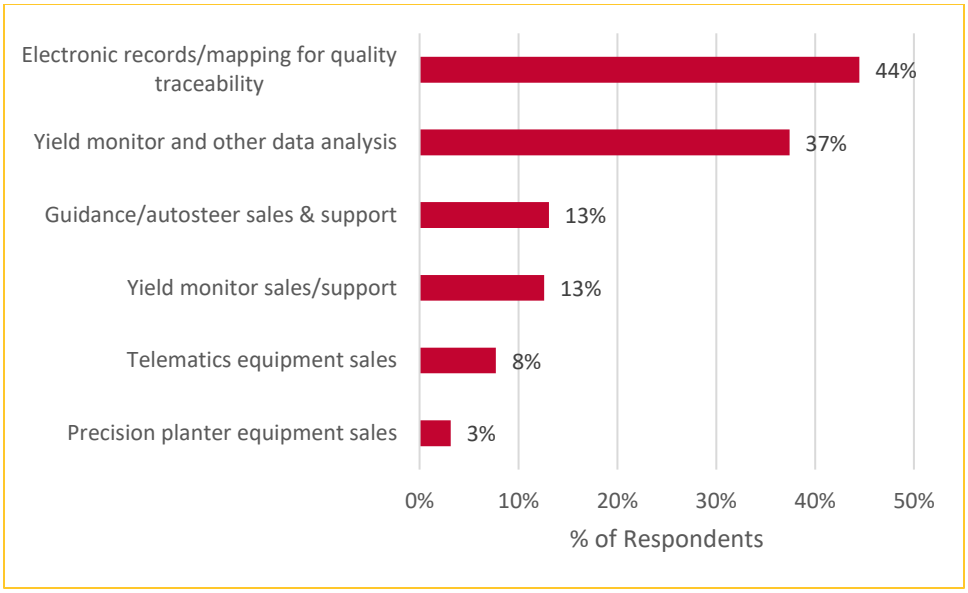


Figure 12 Retailer Offerings of Sales and Analytical Technologies and Services

Variable Rate Services

The final category of precision agriculture technologies and services that respondents were asked about their dealership's offerings of was variable rate technologies (VRT) and services. VRT services are commonly offered by dealerships, as shown in Figure 13. The most commonly available VRT service is fertilizer or lime prescriptions, followed by fertilizer application, which are made available to customers at 57% and 55% of dealerships surveyed. VRT seeding prescriptions, lime application, and pesticide application are made available to customers at 43%, 40%, and 22% of dealerships, respectively.

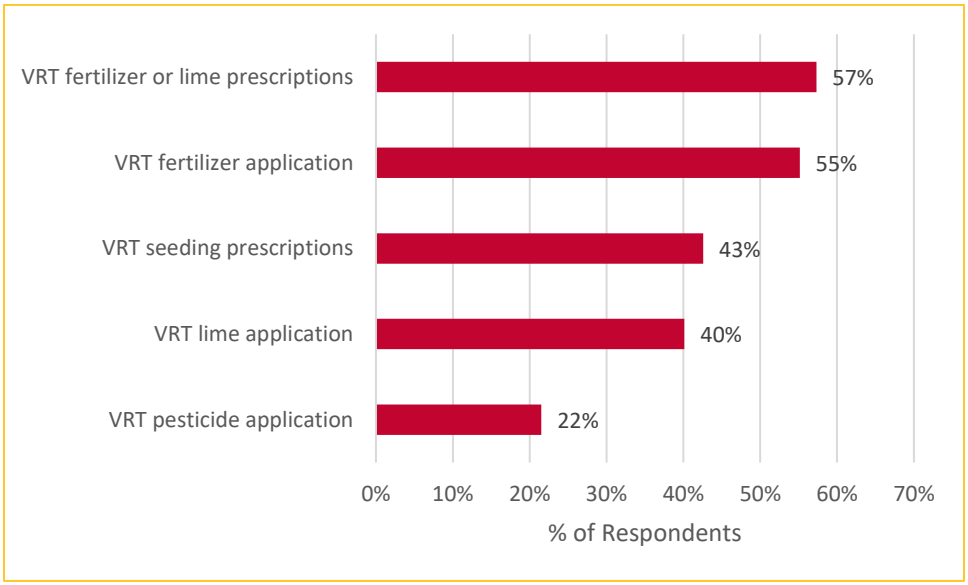


Figure 13 Retailer Offerings of Variable Rate Technologies and Services

As discussed in a previous section custom application services are not as common in the Prairie provinces compared to Ontario. So, while the adoption rates of precision agriculture technologies among dealerships in Ontario provide an accurate depiction of the overall precision agriculture technology adoption rates in the province, the same can not be said for Prairie provinces where custom application services are not as common and dealerships do not currently have a need for, or an incentive to offer, these technologies. Therefore, it was important to also ask respondents what their perception was of precision agriculture technology adoption rates among farmers in their area, a topic discussed in detail in a later section.

Soil Sampling

The next section of the report focuses on soil sampling. Soil sampling and testing can have a positive effect on crop production and nutrient management and for many retailers helping assist clients in managing their soil nutrients, is a large part of their business. Respondents were asked which type of soil sampling service they offered (Figure 14). Traditional whole field soil sampling was the most common technique offered, with 70% of survey respondents indicating that their retail outlet offers this soil sampling technique. Management zones and grid pattern soil sampling techniques were offered by 60% and 47% of respondents, respectively. 13% of respondents stated that their retail outlet does not offer soil sampling. OABA survey respondents were more likely to offer soil sampling services than respondents of the CAAR survey, with 92% of OABA respondents offering soil sampling services compared to 84% of CAAR survey respondents.

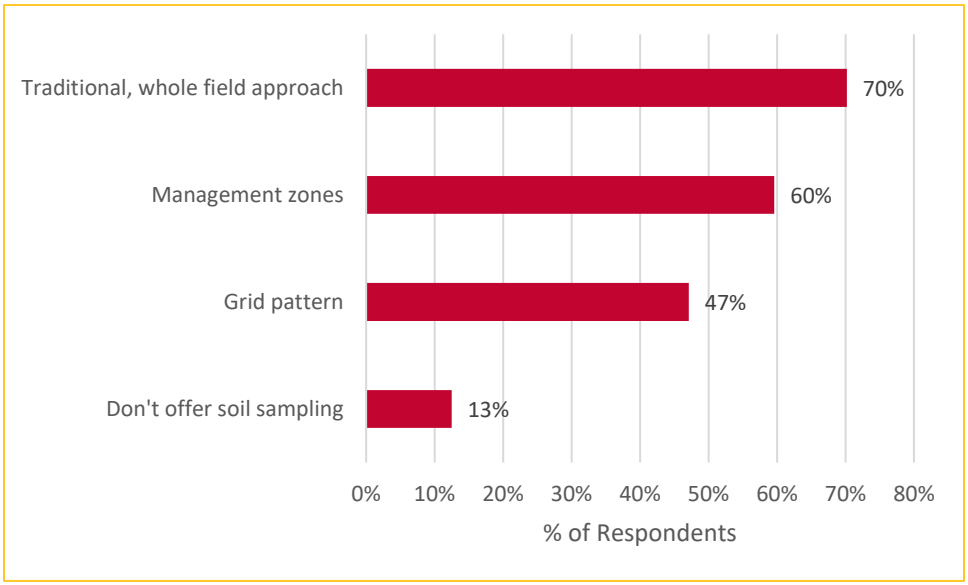


Figure 14. Soil Sampling Methods Offered

Among respondents who indicated that their dealership uses grid pattern soil sampling, 2.5-acre grid sizes were the most commonly used grid size among survey respondents (40%), followed closely by 2.51 – 5-acre grid sizes (36%) (Figure 15). 21% of respondents commonly use 1 - 2.49-acre grid sizes and only 2% used grid sizes of less than 1 acre. Larger grid sizes were more common among respondents of the CAAR survey with 65% of respondents indicating that their dealership uses grid sizes of 2.51 – 5 acres, compared to 16% of respondents of the OABA survey. This may be due to the larger size of farms in Western Canada.

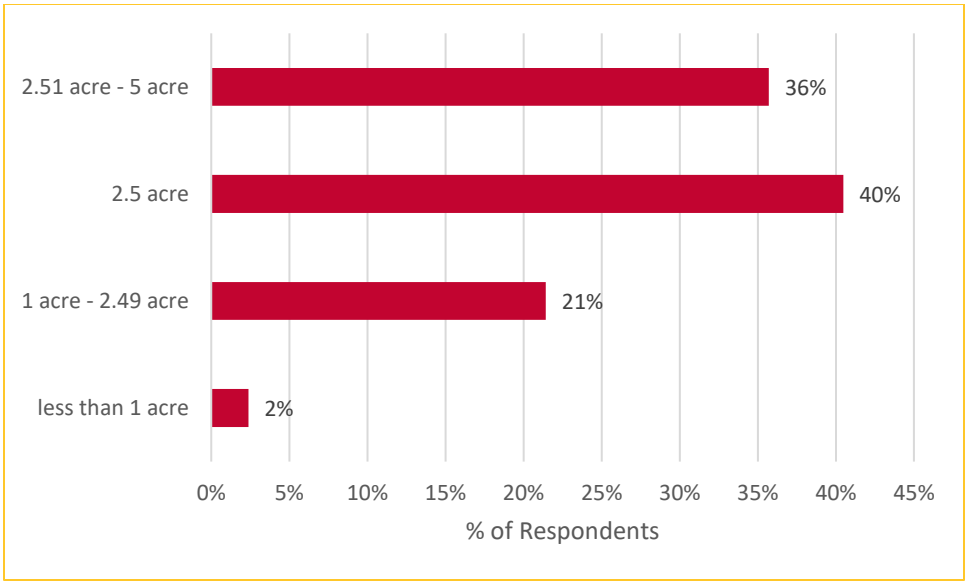


Figure 15. Grid Size Used for Grid Zone Soil Sampling

Among respondents who indicated that their dealership uses management zones for soil sampling, satellite or aerial imagery was the most common method used to determine management zones for both respondents of the OABA (52%) and CAAR (76%) survey (Figure 16) (Figure 17). Yield maps were used to determine management zones by 22% and 61% of OABA and CAAR survey respondents, respectively. Soil mapping units and electrical conductivity were used to determine management zones by 11% and 4% of OABA respondents and 21% and 18% of CAAR respondents, respectively. It is important to note that the CAAR survey differed from the OABA survey as CAAR respondents were able to select multiple answers to this particular question and OABA respondents could only select one.

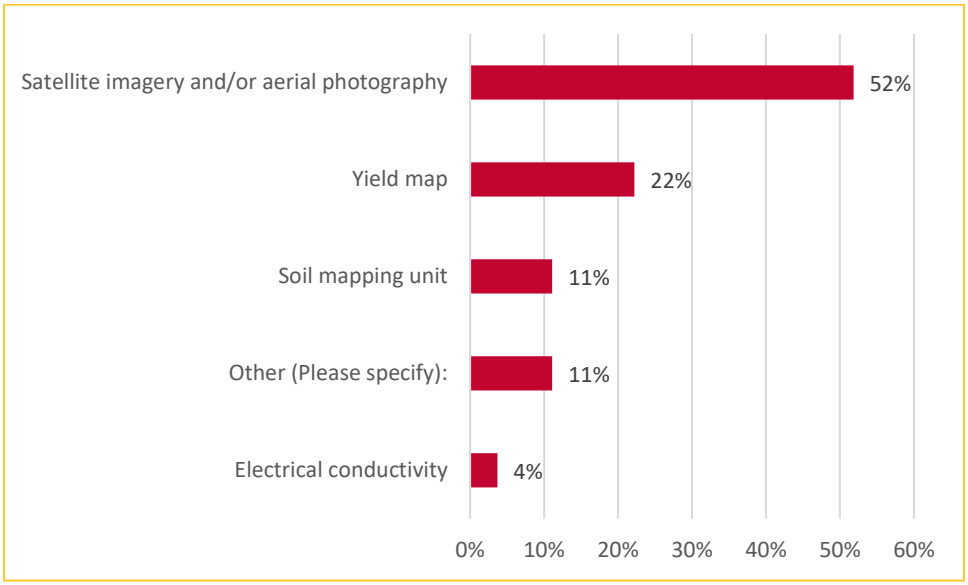


Figure 16. OABA Factors to Determine Management Zones (single answer)

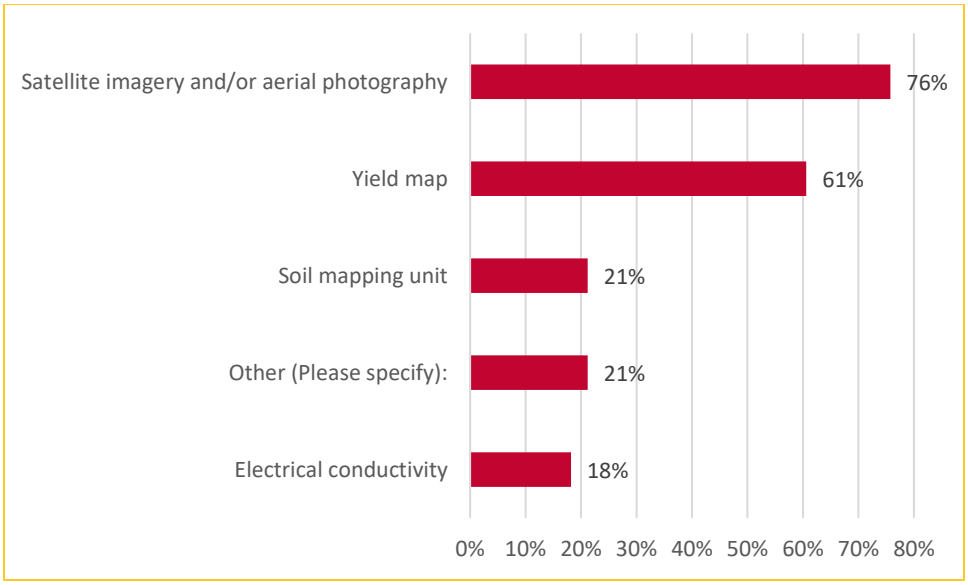


Figure 17. CAAR Factors to Determine Management Zones (multiple answers)

Client Data Management

Precision agriculture technologies generate vast amounts of data, whether that be data collected from yield monitors, guidance applications, drone imagery, or one of the many other precision agriculture technologies available. Although lots of data is collected from these technologies, it is often difficult to properly interpret the data so that it can be useful. This section of the report will explore how retailer's manage farm-level data, assist farmers in interpreting the data and examines the overall usefulness of the data generated by precision agriculture technologies.

Respondents were asked whether their company offered a data privacy agreement and/or a data terms and conditions agreement. These agreements formalize the retailer producer relationship and outline the terms under which retailers can collect, use and share farm-level data. Data privacy agreements are essential in establishing trust between the retailer and producer, as concerns over data privacy have been identified as barrier preventing further adoption of precision agriculture technologies, particularly in Western Canada (Table 3).

Figure 18 shows that 51% of respondents indicated that their company offers a data privacy agreement and/or a data terms and conditions agreement, while 31% did not and 18% were unsure whether they offered such an agreement. Interestingly in contrast to OABA respondents, respondents of the CAAR survey indicated a greater percentage of company's offering data privacy agreement and/or a data terms and conditions agreement, at 59% versus only 38% of OABA respondents.

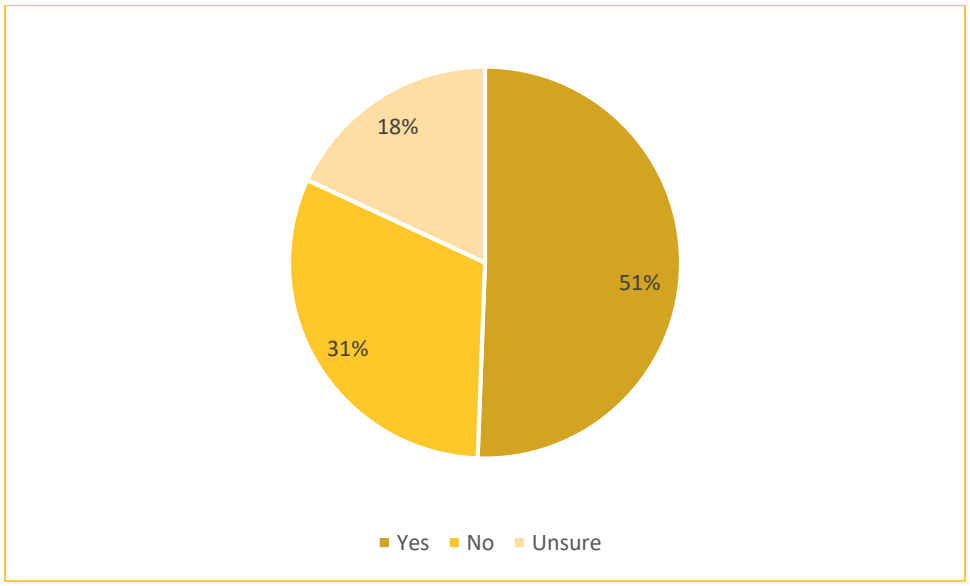


Figure 18. Percentage of Respondents Offering a Data Agreement

Additionally, respondents were also asked how they help their clients manage farm-level data (Figure 19). OABA retailers were more likely to assist their clients with managing their data with 93% of respondents stating that they assist farmers in some way with farm-level data, compared to only 70% of CAAR survey respondents. The most popular data management methods across both surveys is printing maps and archiving and managing data for future with 58% and 59% of respondents, respectively, indicating that they use these methods to help farms manage their data.

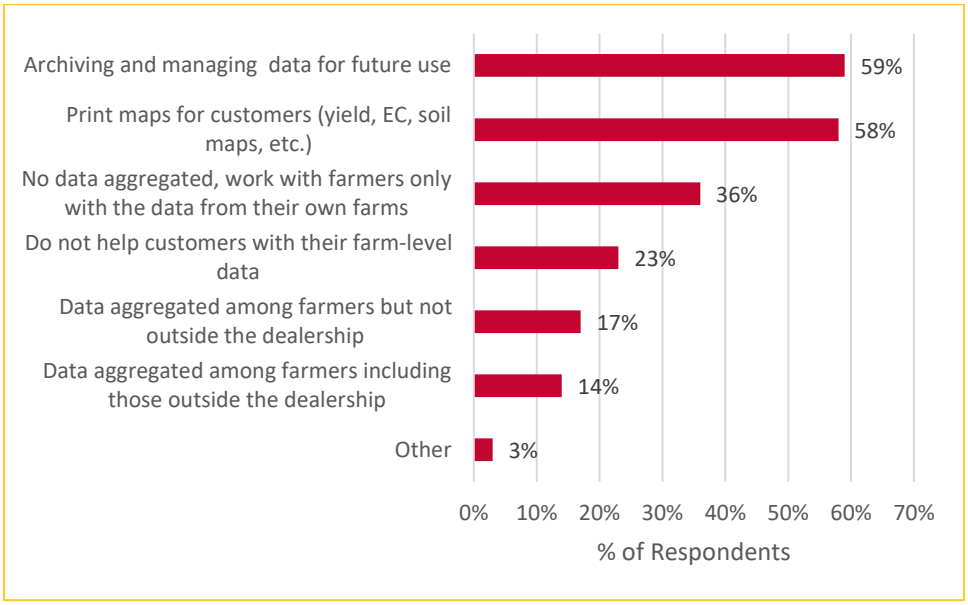


Figure 19. How Retailers Help Manage Farm-level Data

The aggregate data compiled from data collected on each customer's farm can help retailers make better recommendations when it comes to a variety of crop management decisions. To assess the influence that aggregate farm data has on these decisions' respondents were asked whether aggregate farm data has a major influence, some influence or no influence for several crop management decisions.

More than 50% of respondents of the OABA survey indicated that aggregate farm data has either some or major influence on all decisions that were asked about in the survey, the only exception to this was for irrigation decisions. This result was also true for the respondents of the CAAR survey, except that liming decisions and variable hybrid decisions were also included as not having greater than 50% of respondents indicate that aggregate farm data has a somewhat or major influence.

Nitrogen decisions were indicated as being the most influenced by aggregate data, with 87% of respondents reporting that aggregate data has either a somewhat of, or major influence on Nitrogen decisions (Figure 20). The second most likely decision to be influence by aggregate data was P and K decisions with 85% of respondents indicating that aggregate farm data has either a somewhat or a major influence on P and K decisions. The least likely decision to be influenced by aggregate farm data (aside from other) was irrigation decisions, with 75% of respondents stating that aggregate farm data has no influence irrigation decisions.

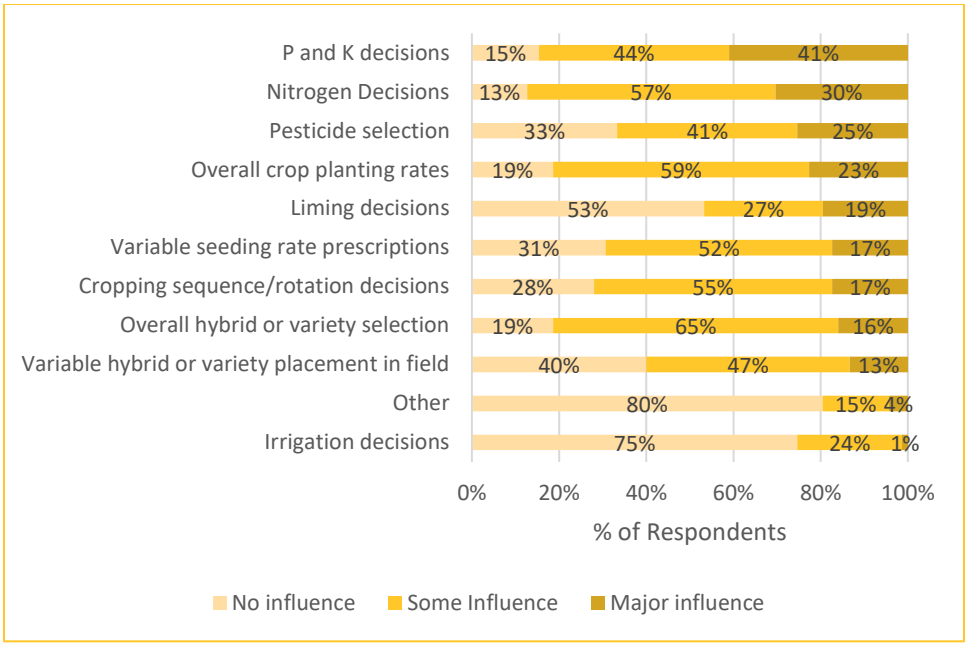


Figure 20. Data's Influence on Crop Management Decisions

4R Nutrient Stewardship Awareness

To date, Fertilizer Canada has launched its 4R Nutrient Stewardship Certification program in 5 provinces, Alberta, Manitoba, Ontario, New Brunswick, and Prince Edward Island, with other provinces working towards implementation. 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place) is a program designed to educate agri-retailers across Canada about the best management practices in fertilizer use in order to improve agricultural productivity, while minimizing the impact to the environment. It was important to ask retailers about the 4R program in the context of precision agriculture, because many of the recommend management practices utilize precision agriculture technologies or services in some form.

The first question relating to the 4R's that respondents were asked, was whether they were familiar with the 4R program. Between the both surveys 93% of respondents indicated that they were aware of the 4R nutrient stewardship program (Figure 21)

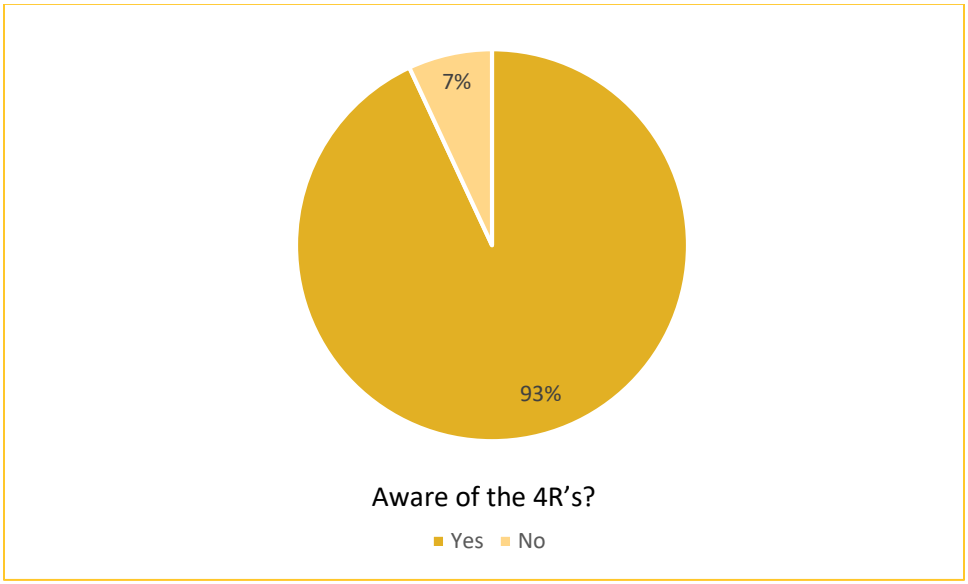


Figure 21. Awareness of 4R Nutrient Stewardship

Respondents of the OABA survey were then asked whether their awareness of the 4R Nutrient Stewardship program influences decisions related to the implementation of precision agriculture practices. 85% of respondents indicated that the 4R Nutrient Stewardship program has influence decisions surrounding the implementation of precision agriculture technologies (Figure 22).

The CAAR survey differed from the OABA survey in that respondents were instead asked whether their fertilizer recommendations complied with 4R nutrient stewardship guidelines, for each of the 4R's. The reason for this deviation was because of the expected lower adoption rate of precision agriculture technologies in Western Canada due to the low prevalence of custom application. However, both questions provide a similar understanding of the influence that 4R has on retailers.

For each of the 4R's, 90% or more of respondents of the CAAR survey indicated that their fertilizer recommendations comply with 4R guidelines (Figure 23). Although Fertilize Canada isn't exclusively targeting retailers with the 4R Nutrient Stewardship program, these results do suggest that there is a high degree of awareness of the 4R's throughout the industry.

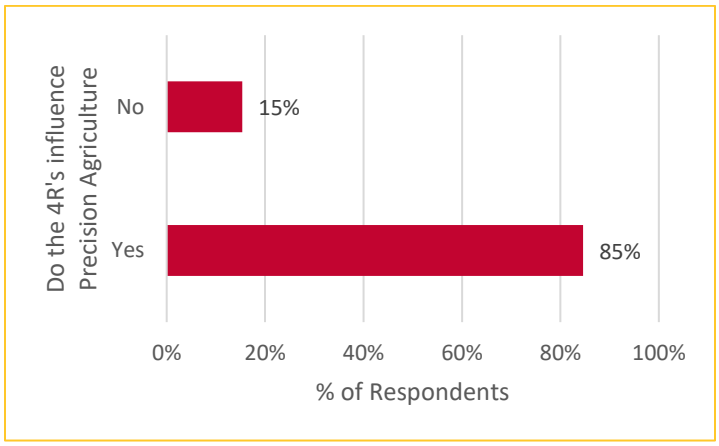


Figure 22. 4R's Influence on Precision Agriculture Implementation among OABA Respondents

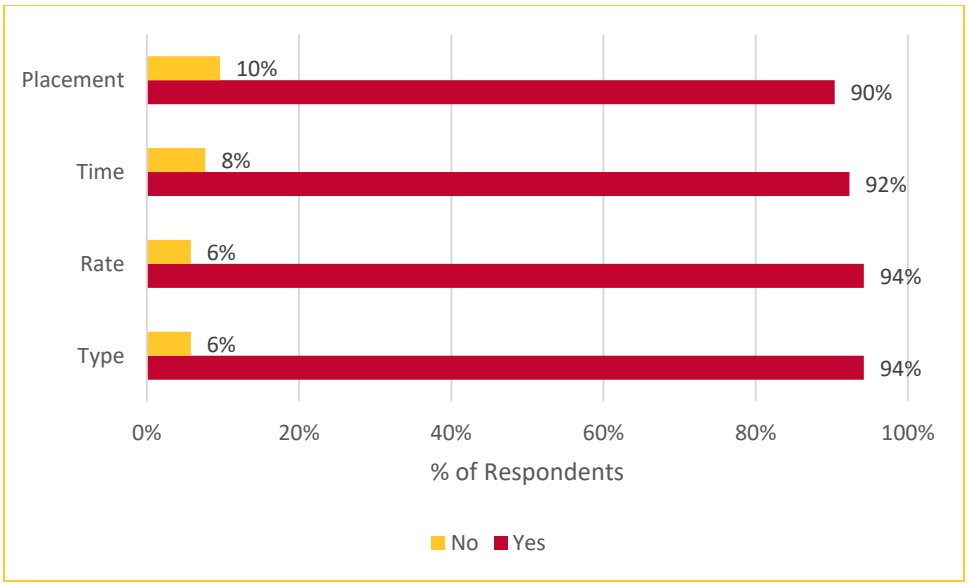


Figure 23. Fertilizer Recommendations Following 4R Guidelines for each of the 4R's among CAAR Respondents

Retailer's Perceived Adoption of Precision Agriculture Technologies by Farmers

Although the focus of both the CAAR and OABA surveys was to assess precision agriculture technology adoption by agricultural-input dealerships, it was important to also ask retailers about the perceived adoption of precision agriculture technologies by farmers. The use of these technologies by farmers may potentially alter the role the dealership has in their clients farming operations.

Figure 24 details the retailer's perceived adoption of precision agriculture technologies by farmers. Automatic guidance systems are believed to be most widely adopted by farmers, with retailers believe 75% of farmers use this technology. Yield monitors (64%) and sprayer section controls (52%) are both believed to be used by more than half of farmers. Robotics for harvesting and robotics for wedding are the least common precision agriculture technology believed to be adopted by farmers, with only 9% and 7%, of farmers believed to be using the technology, respectively. The majority of precision agriculture technologies are believed to be adopted by around 15% to 30% of farmers, suggesting that there is potential for further adoption of these technologies by farmers.

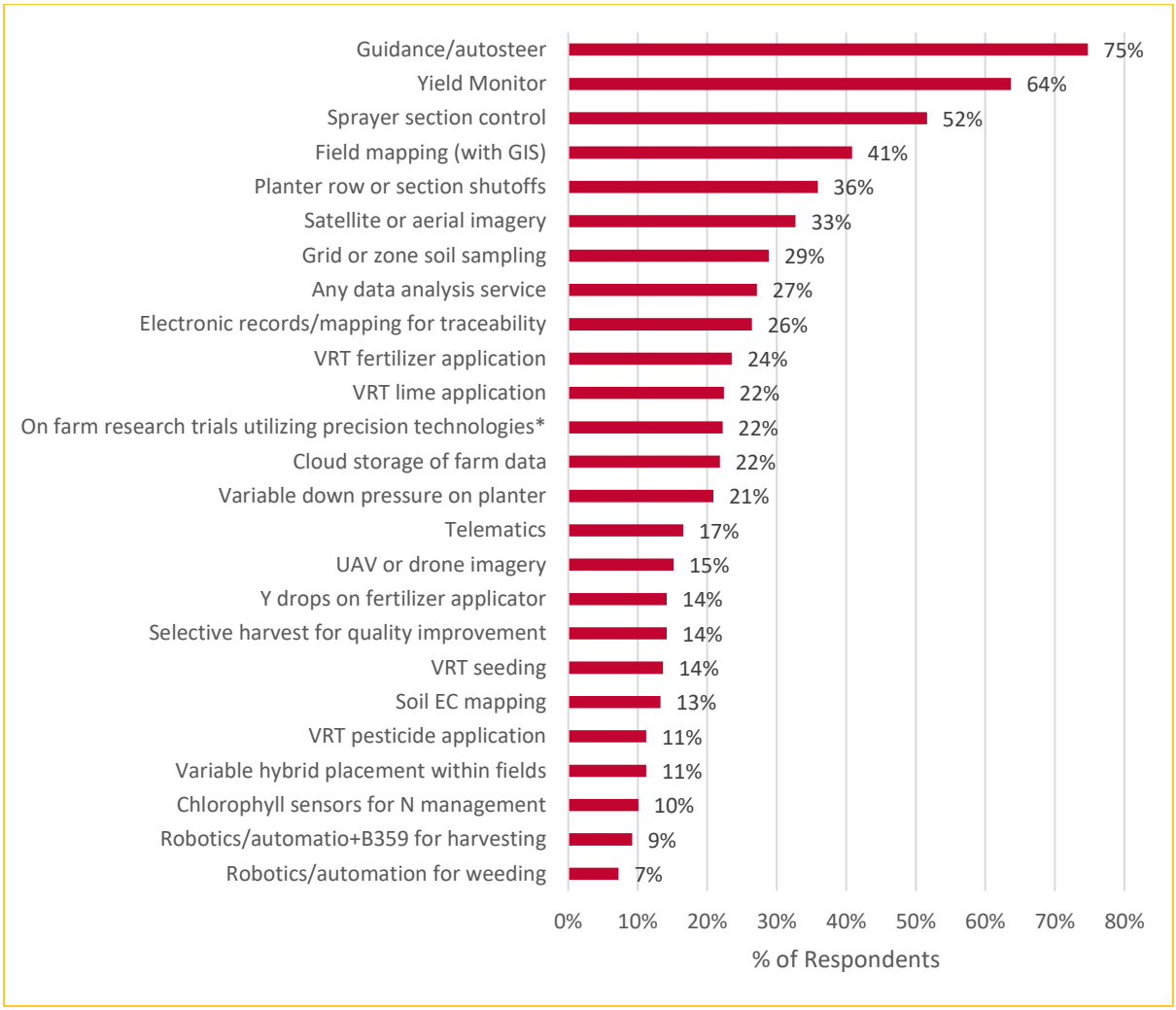


Figure 24. Producer Use of Precision Agriculture Technologies

**On farm research trials utilizing precision technologies,* was only included on CAAR survey

In addition to their perceived adoption of precision agriculture technologies, respondents were also asked about the potential barriers that prevents further adoption among farmers (Figure 25). The largest barriers believed to preventing more farmers from adoption precision agriculture technologies mainly deal with cost. 61% of respondents believe that farm income limits the use of the precision technologies. Another 44%, believe that the cost is greater than the benefits producers receive from using precision technologies. Topography and the soil types were not viewed as large barriers to adoption as 58% and 54% of respondents felt that these were not barriers preventing farmers from adopting precision technologies, respectively.

At the provincial level, the barriers identified by dealerships in specific provinces that are preventing more farmers from adopting precision agriculture technologies were relatively uniform across all provinces (Table 5). Farm income was the barrier that the greatest percentage of dealerships in each province thought was preventing further adoption among farmers. The only exception to this was for dealerships located in multiple provinces. These respondents indicated that the cost of precision agriculture technologies was greater than the benefit that farmers received and that a lack of consumer confidence were the largest barriers preventing further adoption.

The major barriers that dealerships in Canada feel are preventing more farmers from adopting precision technologies are the exact same barriers that dealers surveyed in Purdue's 2019 precision agriculture survey identified to be preventing more USA farmers from adopting. Pressure on farm income limiting farm use, followed by the cost being greater than the benefit received, and a lack of consumer confidence, were the top three most agreed upon barriers preventing more farmers from adopting precision technologies among dealerships surveyed in Purdue's 2019 survey and in the CAAR and OABA surveys.

Based on the barrier's retailers perceive to be contributing the most to preventing farmers from adopting precision agriculture technologies, it would appear that if the price of these technologies was reduced, more farmers would adopt the technologies.

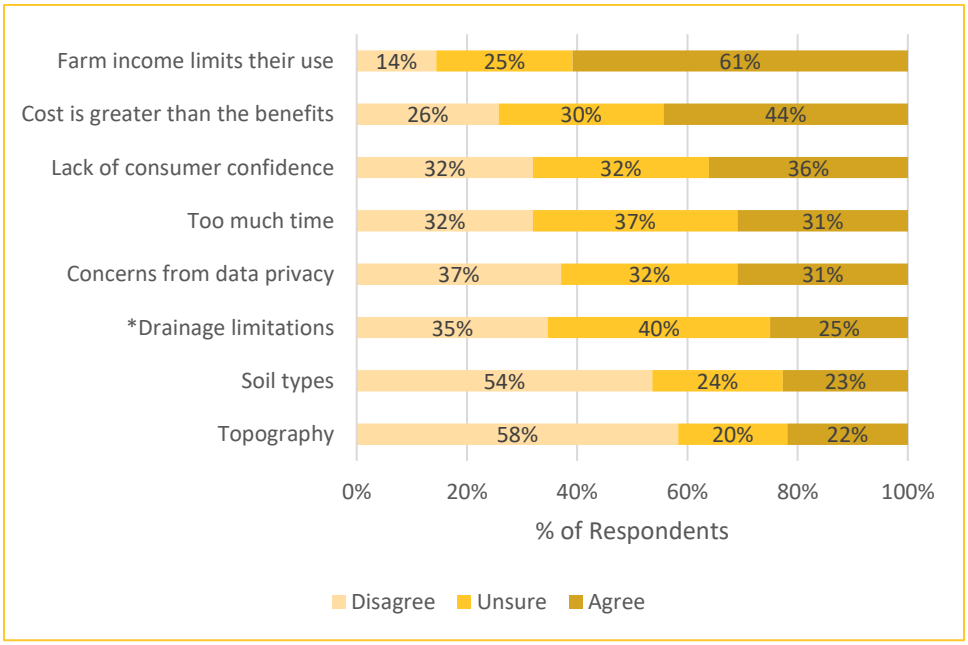


Figure 25. Retailer Identified Barriers to Clients' Adoption of Precision Agriculture Technologies

**Drainage limitations mean some technologies don't make sense,* was only asked about on the CAAR survey

Table 3. Retailer Identified Barriers to Farm Adoption of Precision Agriculture by Province

Barrier	% of Respondents who agree or strongly agree					
	Alberta	Saskatchewan	Manitoba	Ontario	Ontario*	Multi**
Concerns from data privacy	17%	24%	53%	33%	24%	45%
Cost is greater than the benefits	33%	48%	41%	67%	36%	55%
Drainage limitations mean that some technologies don't make sense	17%	29%	24%	0%	N/A	45%
Farm income limits their use	67%	81%	65%	78%	44%	36%
Lack of consumer confidence	50%	43%	24%	33%	28%	55%
Soil types	17%	24%	35%	22%	16%	36%
Too much time	42%	48%	18%	22%	20%	30%
Topography	25%	24%	18%	22%	16%	45%

*Ontario is separated into Ontario responses from the CAAR survey and all responses from the OABA survey. *indicates OABA respondents. **Multi includes CAAR responses who indicated that their dealership operates in more than one province

Investment in Precision Agriculture Technologies

Survey respondents were asked a question regarding their planned investment in precision/site specific technology for the current growing season (2019). The amount a dealership invests in precision agriculture reveals the emphasis that the dealership places on future adoption of precision agriculture technologies and gives an indication of the financial stability of the company.

Dealerships in the Prairies tend to be larger than dealerships in Ontario. This difference is demonstrated in respondents' answers to a question asked early on in the surveys about the total retail sales of agronomic products and services at their dealership in 2018 (Appendix II Q4, Appendix III Q7). To reflect this difference respondents of the CAAR survey were asked to select their planned investment in precision agriculture from a list of larger dollar amounts than respondents of the OABA survey. The breakdown of planned investments based on a dealership's 2018 sales for CAAR respondents is shown in Table 4 and in Table 5 for OABA respondents.

Observed for both CAAR and OABA dealerships was the positive relationship between 2018 retail sales and investment in precision agriculture technology (Table 3, Table 4). The more sales a dealership had in 2018 the more they were planning on investing in precision agriculture technology in 2019. 49% of CAAR respondents who indicated that their dealership had more than $75 million in sales indicated that their dealership planned to invest more than $50,000 in precision agriculture technologies in 2019, compared to only 6% of dealerships that had $2 - $10 million in sales. Additionally, 70% of OABA survey respondents who indicated that their dealership had more than $20 million in a sales in 2018, stated that their dealership plans to invest more than $20,000 in precision agriculture technology for 2019, compared to only 34% of dealerships that had $10 - $15 million in sales.

Table 4. Relationship Between Sales and Investment in Precision/Site Specific Technology (CAAR)

	Retail Sales						
2019 investment in precision/site specific technology	< 2 million	2 - 10 million	10 - 25 million	25 - 50 million	50 - 75 million	> 75 million	Total
None	4	9	3	2	1	5	24
< $25,000	6	14	10	5	0	3	38
$25,001 - $50,000	3	4	2	1	0	1	11
$50,001 - $100,000	2	0	0	2	2	2	8
$100,001 - $250,000	0	1	0	2	0	4	7
> $250,000	0	1	0	0	1	1	3
Total	15	29	15	12	4	16	

Table 5. Relationship Between Sales and Investment in Precision/Site Specific Technology (OABA)

2019 investment in precision/site specific technology	Retail Sales						
	< 1 million	1 - 5 million	5 - 10 million	10 - 15 million	15 - 20 million	> 20 million	Total
None	1	0	1	1	2	1	6
< $10,000	0	2	2	4	2	0	10
$10,001 - $25,000	1	1	1	1	1	2	7
$25,001 - $50,000	0	1	1	3	1	4	10
$50,001 - $100,000	0	0	0	1	0	1	2
More than $100,000	0	0	1	0	0	2	3
Total	2	4	6	10	6	10	

Table 6 details the level of planned investment in precision agriculture technologies among dealerships surveyed for 2019. Ontario had the greatest percentage of dealerships surveyed indicate that they would be investing some amount into precision/site specific technology in 2019, at 84%. Ontario was followed closely by Alberta and Manitoba which had 82% and 81% of dealership indicate that they would be investing into precision/site specific technology in 2019. Only 63% of dealerships in Saskatchewan and 64% of dealerships located in multiple provinces indicated that they would be investing in precision agriculture. Interestingly, 27% of respondents representing dealerships located in multiple provinces indicated that their dealership would be investing greater than $100,000 into precision/site specific technologies for 2019. This was higher than the percentage of dealerships from Alberta (6%), Saskatchewan (3%), Manitoba (14%), and Ontario (8%) that also indicated that they planned to invest greater than $100,000. This may suggest that dealer with locations in multiple provinces will either exhibit low adoption rates of precision agriculture technologies or high rates of adoption.

Overall, the most common level of planned investment was between $1-$25,000, with 43% of respondents between both surveys indicating that this was the range that their dealership planned to invest in precision agriculture technologies for 2019 (Figure 26). 33% of respondents stated that their dealership planned to invest more than $25,000, and the remaining 23% of respondents stated that they do not plan to invest in precision/site specific technology at all.

Table 6. Investment in precision/site specific technology by province

Investment in precision/site specific technology	Location of Dealership						Total (#)
	Alberta	Sask.	Manitoba	Ontario	Ontario*	Multi**	
None	18%	37%	19%	18%	16%	36%	30
$1 - $25,000	59%	47%	38%	36%	45%	18%	55
$25,001 - $50,000	6%	13%	10%	27%	26%	9%	21
$50,001 - $100,000	12%	0%	19%	0%	5%	9%	9
> $100,000	6%	3%	14%	18%	8%	27%	13
Total (#)	17	30	21	11	38	11	128

*Ontario is separated into Ontario responses from the CAAR survey and all responses from the OABA survey. *indicates OABA respondents. **Multi includes CAAR responses who indicated that their dealership operates in more than one province

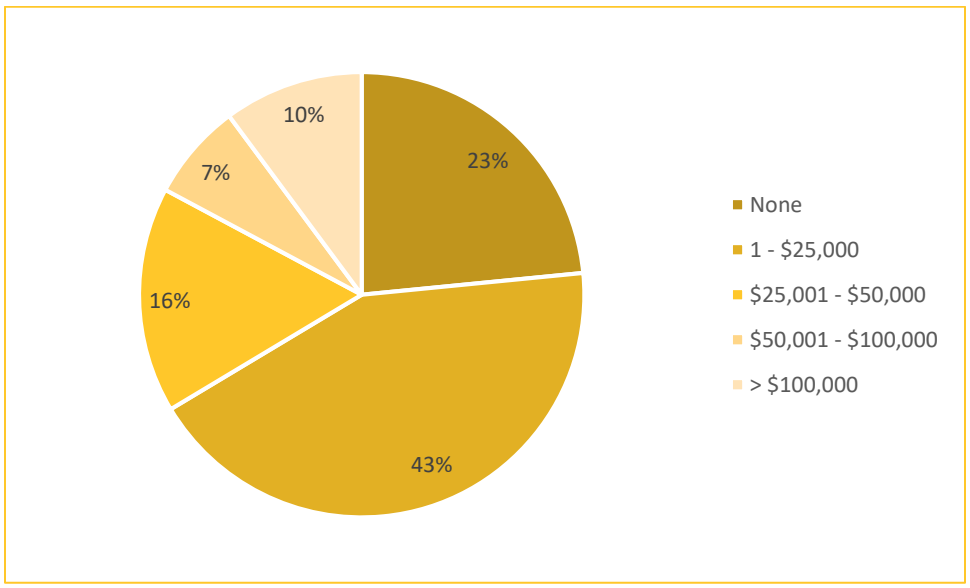


Figure 26. Planned Investment in Precision/Site Specific Technologies

Future Adoption of Precision Agriculture Technologies

Unlike an earlier section of the report that detailed the adoption rates of precision agriculture technologies used by dealerships, this section will outline the precisions technologies and services available to a dealer's customers now and in the future. For a variety of precision technologies and services respondents were asked whether or not these technologies and services are made available to the dealership's customers and whether the dealership plans to make them available to customers by 2021 (Figure 27). The current and future availability of precision agriculture by province is available in table 7.

Variable rate fertilizer application is the most common precision service offered to customers, with 72% of respondents indicating that their dealership makes this service available to customers. Grid or zone soil sampling, satellite imagery, field mapping and variable rate fertilizer or lime prescriptions were also popular technologies and/or services, with over 60% of respondents indicating that they are available to customers.

By 2021 the availability of profit/cost mapping and electronic records or maps for quality traceability are expected to increase by 22% and 21%, respectively. This will make these two services available at over 60% of dealerships. Dealerships are expected to increase their offerings of most other precision technologies and services by around 10% – 15%.

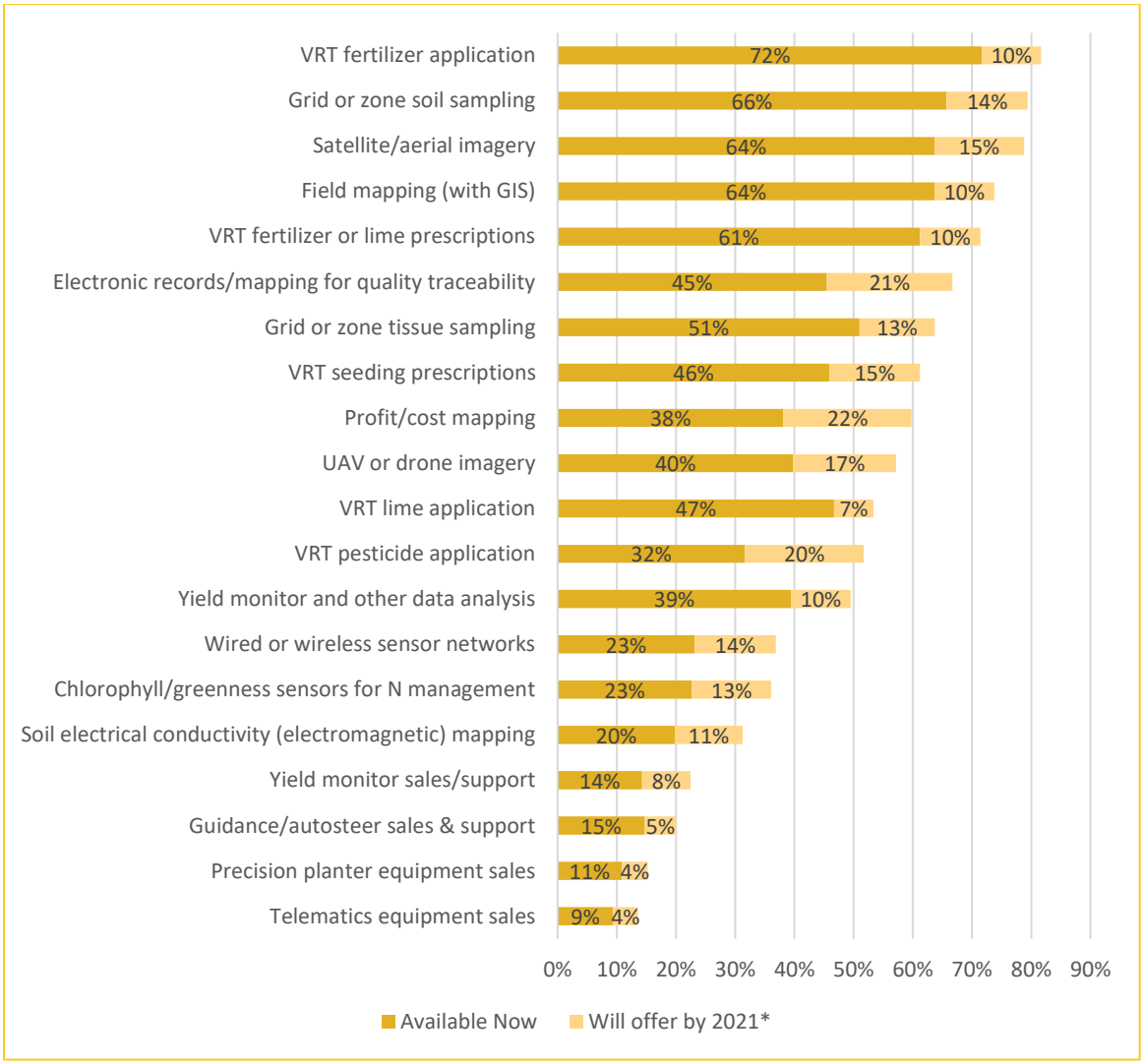


Figure 27. Future Adoption of Precision Technologies by Dealerships

**CAAR survey asked by 2021 and the OABA survey asked by 2020*

Respondents were also asked a follow up question about what the potential barriers preventing the dealership from offering more precision agriculture technologies and services to customers, (Figure 28). Across both survey the most agreed upon barrier to future precision agriculture technology and service offerings is that it is difficult to demonstrate value to the customer, with 56% of respondents agreeing or strongly agreeing that this is a barrier. Equipment changing quickly (54%), a low willingness to pay among customers (51%), and a shortage of skilled employees (50%) were three other barriers were the majority of respondents agreed that these were major barriers preventing further offerings of precision agriculture technologies and services.

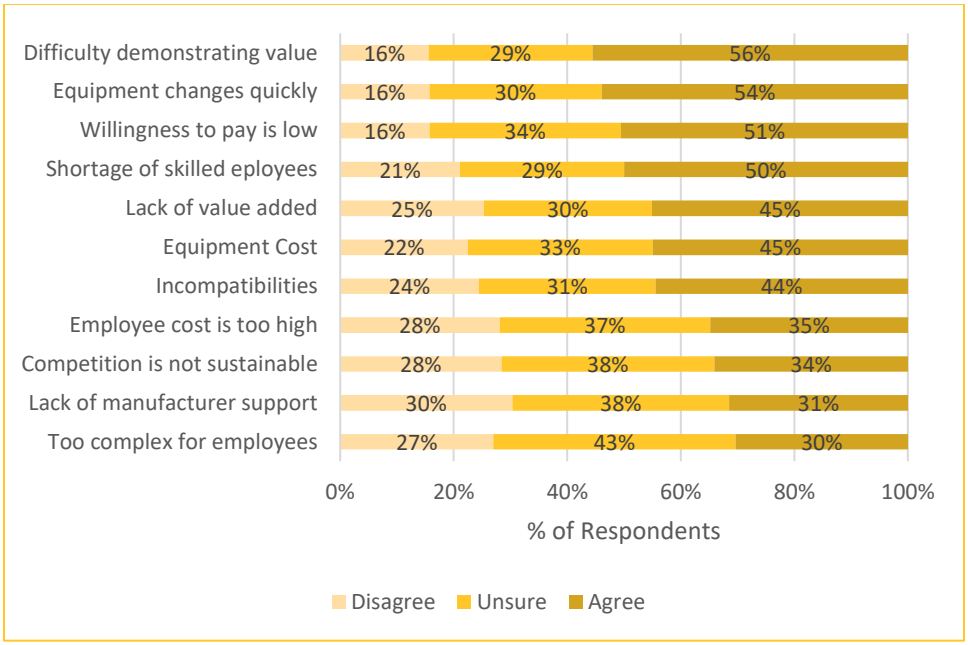


Figure 28. Retailer Self-Identified Barriers to Future Adoption of Precision Agriculture Technologies

The major barriers cited by Canada dealerships that prevent them from offering more precision agriculture technologies and services are similar to those that USA dealership indicated were major barriers in Purdue's 2019 survey. The most widely agreed upon barriers among respondents of Purdue's survey were that there is a low willingness to pay for the services and that the equipment need to offer the services changes to quickly. These were also the two most agreed upon barriers among the respondents of the Canadian surveys.

Regionally there were differences in what dealerships located in specific provinces indicated were major barriers to future adoption (Table 8). Of Ontario dealerships only 16% agreed or strongly agreed that the precision agriculture equipment was too complex for employees, compared to over 35% of respondents in Alberta, Saskatchewan and Manitoba, respectively. Additionally, 24% of Ontario dealership felt that a lack of value added was a major barrier from further precision agriculture adoption compared to over 50% in each of the Prairie provinces respectively. These regional differences may suggest that there needs to be more education on the benefits of precision agriculture and how to use the technologies in Western Canada.

Table 7. Future Adoption of Precision Technologies by Province

Technology/Service	% of Respondents											
	ALB		SASK		MAN		ONT		ONT*		Multi	
	Now	By 2021	Now	By 2021	Now	By 2021	Now	By 2021	Now	By 2020	Now	By 2021
Chlorophyll/greenness sensors for N management	15%	15%	5%	30%	27%	47%	14%	29%	37%	47%	11%	11%
Electronic records/mapping for quality traceability	36%	50%	24%	62%	33%	60%	43%	71%	73%	77%	44%	78%
Field mapping (with GIS)	79%	79%	41%	64%	53%	53%	57%	86%	86%	86%	33%	67%
Grid or zone soil sampling	64%	86%	48%	78%	40%	47%	71%	86%	87%	90%	70%	70%
Grid or zone tissue sampling	50%	71%	39%	61%	20%	40%	57%	57%	73%	77%	50%	50%
Guidance/autosteer sales & support	0%	0%	5%	20%	13%	13%	57%	57%	21%	21%	0%	0%
Precision planter equipment sales	0%	0%	14%	29%	33%	33%	0%	0%	3%	7%	0%	0%
Profit/cost mapping	43%	57%	30%	50%	27%	47%	29%	71%	57%	73%	0%	38%
Satellite/aerial imagery	64%	71%	52%	76%	53%	73%	86%	86%	80%	83%	56%	78%
Soil electrical conductivity (electromagnetic) mapping	8%	8%	10%	25%	13%	20%	14%	43%	30%	40%	13%	25%
Telematics equipment sales (Farmobile, Trimble etc.)	8%	8%	10%	15%	20%	27%	14%	29%	3%	3%	0%	0%
UAV or drone imagery	21%	43%	29%	52%	40%	60%	43%	57%	63%	63%	13%	38%
VRT fertilizer application	20%	20%	50%	67%	78%	100%	80%	100%	83%	87%	33%	67%
VRT fertilizer or lime prescriptions	54%	62%	45%	68%	33%	47%	71%	86%	87%	87%	50%	50%
VRT lime application	0%	0%	17%	17%	0%	22%	40%	80%	73%	73%	33%	33%
VRT pesticide application	40%	40%	29%	57%	13%	50%	40%	80%	33%	47%	0%	0%
VRT seeding prescriptions	50%	64%	32%	64%	36%	50%	43%	57%	67%	73%	13%	13%
Wired or wireless sensor networks	15%	23%	14%	43%	29%	36%	14%	43%	34%	41%	13%	25%
Yield monitor and other data analysis	38%	38%	27%	50%	40%	40%	43%	57%	50%	57%	0%	22%
Yield monitor sales/support	8%	8%	24%	43%	20%	27%	14%	14%	3%	7%	0%	22%

Table 8. Retailer Self-Identified Barriers to Future Adoption of Precision Agriculture Technologies by Province

Barrier	% of Respondents who agree or strongly agree					
	Alberta	Saskatchewan	Manitoba	Ontario	Ontario*	Multi
Competition is not sustainable	18%	39%	29%	13%	48%	30%
Difficulty demonstrating value	58%	61%	53%	63%	48%	60%
Employee cost is too high	18%	50%	40%	25%	36%	30%
Equipment changes quickly	27%	61%	47%	88%	56%	50%
Equipment Cost	55%	56%	33%	63%	36%	40%
Incompatibilities	33%	56%	40%	63%	36%	60%
Lack of manufacturer support	42%	56%	27%	13%	24%	22%
Lack of value added	50%	61%	53%	44%	24%	60%
Shortage of skilled employees	33%	67%	33%	50%	68%	30%
Too complex for employees	36%	44%	40%	38%	16%	20%
Willingness to pay is low	27%	61%	33%	75%	56%	50%

Summary

Precision agriculture encompasses a wide range of technologies and services but can be broadly grouped into four categories of technologies and services including, geographic, observational, sales and analytical, and variable rate. Regardless of the exact precision technology or service, precision agriculture provides both retailers and producers with accurate and up to date data of their crops and allows for precise management of crops.

In order to assess the overall adoption of precision agriculture technologies in Canada, members of the Ontario Agri Business Association (OABA) or the Canadian Association of Agri-Retailers were surveyed on their own use and offerings of precision agriculture technologies and services as well their perception of farmers use of these technologies.

Several major storylines emerged from the results of both the OABA and CAAR survey, most notable is the role that custom application services play in the adoption of precision agriculture technologies. In Ontario dealerships commonly custom apply crop inputs on behalf of the farmer, in the Prairie provinces this practice is not as common. Custom application services make use of precision technologies and because of the lack of custom application offerings among Prairie dealerships, there is a large regional difference in adoption of precision agriculture between Ontario and the Prairies.

There is potential for future adoption of precision agriculture technologies for both dealerships and farmers, however barriers do exist. These barriers largely relate to the cost of the precision agriculture and the value propositions of these services. As both dealers and farmers become more educated about the benefits of precision agriculture and the costs associated with precision agriculture fall, the overall adoption of precision agriculture will increase.

Appendix I: Glossary

CORS (Continually Operating Reference Station): Coordinated by National Geodetic Survey of National Oceanic and Atmospheric Administration (NOAA) Survey-grade GPS receiver is positioned in a fixed position providing continuous RTK-correction for receivers with Internet-accessible capabilities.

DGPS (Differential GPS): refers to techniques used to enhance accuracy, integrity, reliability, and availability of GPS data. The following are all examples of DGPS:

GPS (Global Positioning System): The satellite-navigation network maintained by the United States Department of Defense. Also, the term "GPS" is often treated more generically to refer to any device that depends on navigation satellites for functionality. The entire world's system is referenced as the Global Navigation Satellite System, or GNSS.

Personal RTK base station (fixed or portable): Line of sight correction. Grower positions stationary base station in the best location to cover his acreage or moves a portable base around with from field to field to get the best signal. It can be more expensive than using a service but better positioned for an individual's needs.

RTK (Real Time Kinematic): refers to highly accurate, highly repeatable positioning. With RTK, a base station receiver is placed on a stable mount, allowing multiple GPS rover receivers to utilize this type of correction within a limited range of the base station.

RTK array/cluster (Deere, Trimble, etc.): Annual subscription with cost and point accuracy varying with the service and technologies being used

RTN (real time network): Generic term for a correction service offering more reliability than a single-station RTK. Several CORS or RTK base stations are connected in a "mesh" so correction data can be used from multiple locations to increase accuracy, reliability, and the distance covered. RTN offered by several companies, however often associated with a subscription fee.

Satellite correction (OmniSTAR XP, StarFire 2, etc.): Service offered by several companies using a correction. Some services are free while others require a subscription and the receiver in the tractor to be specific to the company offering the service

UAV (Unmanned aerial vehicle): refers to an aircraft (also referred to a drone) which is controlled remotely by an operator, and it can carry various kinds of cameras such as multispectral and hyperspectral, thereby acquiring aerial images of a field.

VRT (Variable Rate Technology): refers to technologies that allow farm inputs to be applied at different rates across a field, without manually changing rate settings on equipment or having to make multiple passes over an area.

WAAS (Wide Area Augmentation System): Free service offered through Federal Aviation Administration (FAA); ground-based reference stations plus 2 geostationary satellites; and point accuracy: 9-15 feet; Pass-to-pass accuracy: 6-12 inches.

Appendix II: OABA Survey Instrument

Dear agricultural retailer,

Since 1981, CropLife dealerships and Purdue University in Indiana have partnered to undertake a survey that chronicles the development and adoption of precision agriculture. Two years ago, the University of Guelph, along with our sponsor, OMAFRA, undertook a similar survey in partnership with the Ontario Agri-Business Association (OABA). The survey results help academics and farmers better understand the development and adoption of precision agriculture techniques by dealers like you from across Ontario. We were thrilled to receive a great response rate in the past, and your continued participation is appreciated.

Your business and/or business branch is being contacted to complete this survey due to your organization's membership in the OABA, and the fact that you have been identified within it as an entity who may benefit from the use of precision agriculture technologies. Please note that your participation is completely voluntary and that results will be made available following the completion of the survey to the OABA. All raw data will be kept confidential, but due to the nature of cyber security, the confidentiality of data in transit over the internet cannot be guaranteed. As a team, we will take all necessary precautions to minimize this risk. All data collected is anonymous, and if at any point you wish to exit the survey without completing it in its entirety, your answers will not be recorded in any way.

Because we value your time, we have tried to make the survey as concise as possible. We estimate that the survey will take approximately 10 minutes. To complete it, please follow the onscreen instructions and/or prompts, entering your answers and clicking next and submit to record your answers. By clicking submit, you will be unable to withdraw submitted information once complete.

This survey has been reviewed by the Research Ethics Board for compliance with federal research ethics guidelines involving human participants. Please use the print function to print as a way to document your consent to complete the survey. If you have any questions regarding your rights and welfare as a research participant in this study (REB17-05-037), please contact the Director of Research ethics at reb@uoguelph.ca or (519) 824-4120 Ext. 56606.

Thank you for your participation!

Dr. Alfons Weersink

Department of Food, Agricultural and Resource Economics University of Guelph

519-824-4120 Ext. 52766

Q1 Which best describes your business?

- ○ Agricultural retail input supplier (1)
- ○ Farm equipment dealer (2)
- ○ Agricultural consultant agency (3)
- ○ Other (Please specify): (4) _____

Q2 Which best describes your input supply business?

- ○ Cooperative (1)
- ○ Independent dealership (2)
- ○ National or regional (multi-province) chain of retail dealerships (3)
- ○ Other (Please specify): (4) _____

Q3 Your primary responsibility within your company is best described as:

- ○ Owner/general manager/location manager (1)
- ○ Departmental manager (2)
- ○ Precision manager (3)
- ○ Technical consultant/agronomist (4)
- ○ Sales/sales management (5)
- ○ Application manager (6)
- ○ Other (Please specify): (7) _____

Q4 What were the total annual retail sales (in CAD) of agronomic products and services (fertilizer, chemicals, seed, services) at your location in 2018?

- ○ Under $1,000,000 (1)
- ○ $1,000,001 - $5,000,000 (2)
- ○ $5,000,001 - $10,000,000 (3)
- ○ $10,000,001 - $15,000,000 (4)
- ○ $15,000,001 - 20,000,000 (5)
- ○ More than $20,000,000 (6)

Q5 How many total retail outlets does your company own or manage?

- ○ 0 (1)
- ○ 1 (2)
- ○ 2-5 (3)
- ○ 6-15 (4)
- ○ More than 15 (5)

Q6 How many of each work roles does your business employ at your location?

_____ Applicator—Runs the equipment that applies pesticides and fertilizers to farmer's fields. (1)

_____ Agronomist—Provides recommendations on crop and soil management to farmers. (2)

_____ Precision sales specialist—Works specifically with precision equipment sales and support. (3)

_____ Precision equipment technician—Installs precision equipment; troubleshoots and repairs ON SITE. (4)

_____ Technical support—Works REMOTELY to troubleshoot precision equipment/software. (5)

_____ Data manager/analyst—Manages agronomic data from the dealership and customer's farms. (6)

Q7 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, edible beans, etc.) (1)

_____ hay and forages (2)

_____ nursery or greenhouse (3)

_____ tree fruits & nuts (4)

_____ berries (strawberries, blueberries, raspberries, etc.) (5)

_____ grapes (6)

_____ Other: [please specify] (7)

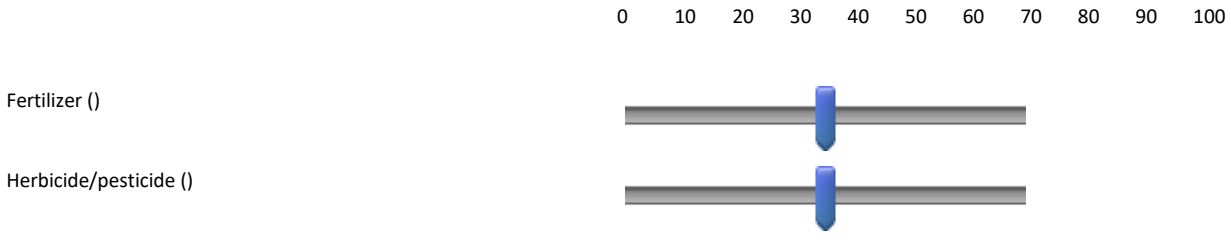
Q8 How much will your retail outlet be investing in precision/site-specific technology during 2019?

- None (1)
- $1 – $10,000 (2)
- $10,001 - $25,000 (3)
- $25,001 - $50,000 (4)
- $50,001 - $100,000 (5)
- More than $100,000 (6)

Q9 In a typical year how many total acres does your retail outlet custom apply (fertilizer, chemicals, seeding – total acres including multiple applications)?

- Under 10,000 acres (1)
- 10,001 to 25,000 acres (2)
- 25,001 to 50,000 acres (3)
- 50,001 to 75,000 acres (4)
- 75,001 to 100,000 acres (5)
- Over 100,000 acres (6)

Q10 In 2018, approximately what percentage of the sales for each product were custom applied?



Q11 In 2018, Fertilizer Canada launched its 4R Nutrient Stewardship Certification Program in Ontario. 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place) is a program designed to allow agri-retailers in Ontario to reduce agricultural impacts to the environment while increasing crop productivity.

Are you familiar with this program?

- ○ Yes (1)
- ○ No (4)

Q12 Does your awareness of 4R nutrient stewardship influence decisions related to the implementation of precision agriculture practices?

- ○ Yes (1)
- ○ No (2)

Q13 Which of the following soil sampling services does your retail outlet offer? (Select all that apply)

- ☐ Traditional, whole field approach (1)
- ☐ Grid pattern (2)
- ☐ Management zones (3)
- ☐ Don't offer soil sampling (4)

Q14 What grid size is most commonly used when doing grid pattern soil sampling?

- ○ less than 1 acre (1)
- ○ 1 acre - 2.49 acre (2)
- ○ 2.5 acre (3)
- ○ 2.51 acre - 5 acre (4)
- ○ Don't know (5)

Q15 By what factor are management zones determined?

- ○ Soil mapping unit (1)
- ○ Yield map (2)
- ○ Electrical conductivity (3)
- ○ Satellite imagery and/or aerial photography (5)
- ○ Other (Please specify): (4) _____

Q16 In which of the following ways does your dealership use precision technology?

- ☐ Any precision agronomic consulting services for customers (soil sampling with GPS, GIS field mapping, etc.) (1)
- ☐ GPS guidance systems with manual control (light bar) for fertilizer/chemical application/planting (2)
- ☐ GPS guidance systems with automatic control (autosteer) for fertilizer/chemical application/planting (3)
- ☐ Auto sprayer boom section or nozzle control (4)
- ☐ Sprayer turn compensation (5)
- ☐ Y drops on fertilizer applicators (6)
- ☐ Satellite/aerial imagery for internal dealership purposes (7)
- ☐ UAV or drone for internal dealership purposes (8)
- ☐ Soil electrical conductivity (electromagnetic) mapping (9)
- ☐ Other soil sensors for mapping, mounted on a pickup, applicator or tractor (example: pH sensor) (10)
- ☐ Chlorophyll/greenness sensors using NDVI or NDRE mounted on a pickup, applicator or tractor (CropSpec, GreenSeeker, OptRx, etc.) (11)
- ☐ Field mapping with GIS to document work for billing/insurance/legal purposes (12)

- [ ] Telematics to exchange information among applicators or to/from office locations (13)
- [ ] GPS to manage fleet vehicle logistics, tracking locations of vehicles, and guiding vehicles to the next site (14)
- [ ] Smart scouting using mobile applications to record field situations and locations (15)
- [ ] Do not use precision technology (16)

Q17 What type of GPS correction do you use for your guidance applications?

- ○ Utilize WAAS (Wide Area Augmentation System) (1)
- ○ Purchase satellite correction (i.e., OmniSTAR XP or HP, StarFire 2) (2)
- ○ Personal RTK base station (fixed or portable) (3)
- ○ Purchase correction from RTK array/cluster (i.e., Deere, Trimble) (4)
- ○ Purchase RTN (Real Time Network) connection (i.e., Trimble ARS Now, Leica iMAX) (5)
- ○ Other (6) _____

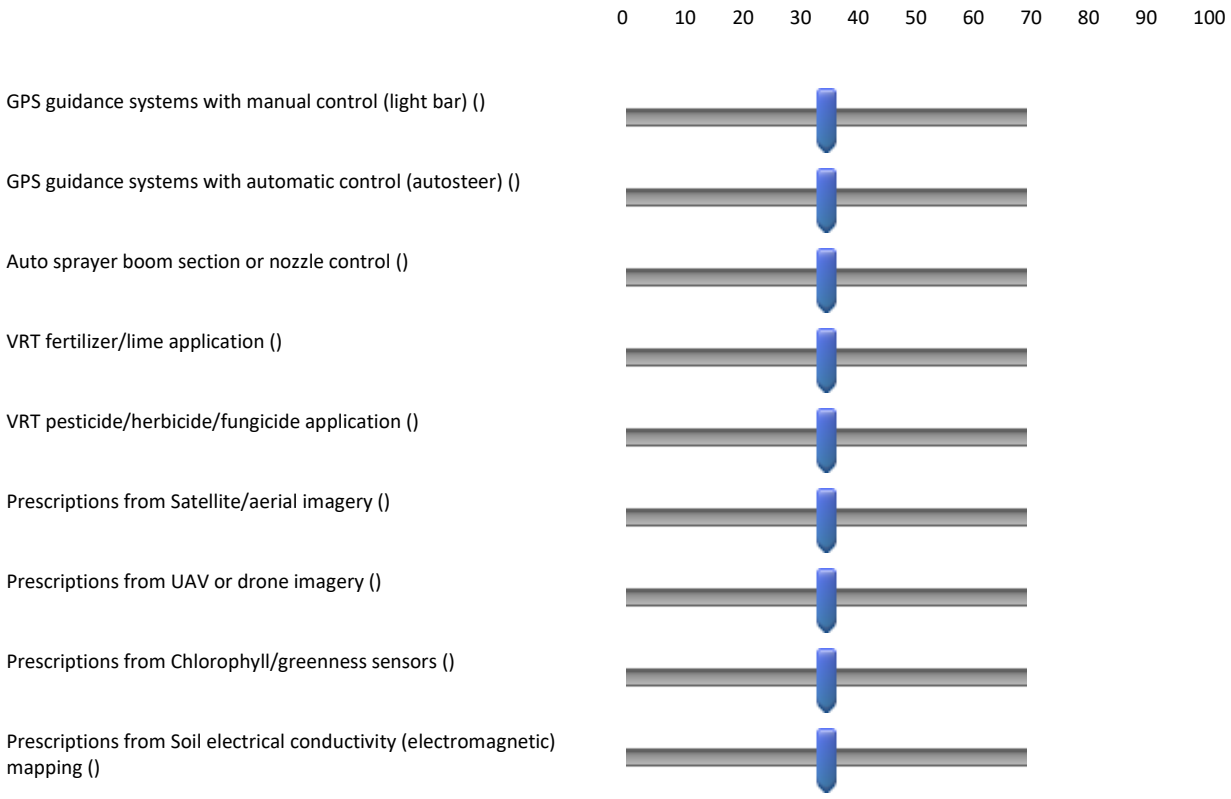
Q18 Which “site-specific” (precision) services/products will you offer in the following time periods?

This question, and others, uses the acronym "VRT", which is shortened from "Variable rate technology".

	Don’t offer now, but did (1)	Available Now (2)	Will offer by 2020 (3)	Never offered or don’t know (4)
Field mapping (with GIS) (1)	○	○	○	○
Profit/cost mapping (17)	○	○	○	○
Soil electrical conductivity (electromagnetic) mapping (13)	○	○	○	○
Grid or zone soil sampling (12)	○	○	○	○
Grid or zone tissue sampling (18)	○	○	○	○
Chlorophyll/greenness sensors for N management (14)	○	○	○	○
UAV or drone imagery (10)	○	○	○	○
Satellite/aerial imagery (9)	○	○	○	○
Wired or wireless sensor networks (20)	○	○	○	○
VRT fertilizer or lime prescriptions (2)	○	○	○	○
VRT fertilizer application (3)	○	○	○	○
VRT lime application (4)	○	○	○	○
VRT pesticide application (5)	○	○	○	○
VRT seeding prescriptions (6)	○	○	○	○
Electronic records/mapping for quality traceability (19)	○	○	○	○
Guidance/autosteer sales & support (11)	○	○	○	○
Precision planter equipment sales (15)	○	○	○	○
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.) (16)	○	○	○	○

Yield monitor sales/support (7)	○	○	○	○
Yield monitor and other data analysis (8)	○	○	○	○

Q19 In 2018, approximately what percentage of your total custom application (total acres, all products) used:



Q20 For the following services that you offer, currently how profitable is each specific service for your dealership?

	Not breaking even (1)	Breaking even (2)	Making a profit (3)	Don't know (4)	Don't offer this (5)
Field mapping (with GIS) (1)	○	○	○	○	○
Profit/cost mapping (17)	○	○	○	○	○
Grid or zone plant tissue sampling (18)	○	○	○	○	○
Soil EC mapping (13)	○	○	○	○	○
Grid or zone soil sampling (12)	○	○	○	○	○

Chlorophyll/greenness sensors (14)	○	○	○	○	○
Wired or wireless sensor networks (20)	○	○	○	○	○
Satellite/aerial imagery (9)	○	○	○	○	○
UAV or drone imagery (10)	○	○	○	○	○
VRT fertilizer or lime prescriptions (4)	○	○	○	○	○
VRT fertilizer application (3)	○	○	○	○	○
VRT lime applications (2)	○	○	○	○	○
VRT pesticide application (5)	○	○	○	○	○
VRT seeding prescriptions (6)	○	○	○	○	○
Electronic records/mapping for quality traceability (19)	○	○	○	○	○
Guidance/autosteer sales & support (11)	○	○	○	○	○
Precision planter equipment sales (15)	○	○	○	○	○
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.) (16)	○	○	○	○	○
Yield monitor sales/support (7)	○	○	○	○	○
Yield monitor and other data analysis (8)	○	○	○	○	○

Q21 How do you help manage the farm-level data (i.e., yield maps, soil tests, EC, satellite imagery) of your farmer-customers to assist in their decision-making?

- ☐ Print maps for customers (yield, EC, soil maps, etc.) (1)
- ☐ No data aggregated among farmers, work with farmers only with the data from their own farms (2)
- ☐ Data aggregated among farmers but not outside the dealership (3)

- [ ] Data aggregated among farmers including those outside the dealership (4)
- [ ] Archiving and managing yield, soil test, and other data for future use (5)
- [ ] Other (Please specify): (6) _____
- [ ] Do not help customers with their farm-level data (7)

Q22 Does your company have a customer data privacy statement and/or data terms & conditions agreement?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Q23 What crop management decisions are being influenced by aggregate data from your customer's farms?

	No influence (1)	Some Influence (2)	Major influence on decision (3)
Nitrogen Decisions (1)	○	○	○
P and K decisions (2)	○	○	○
Liming decisions (3)	○	○	○
Overall hybrid or variety selection (4)	○	○	○
Variable hybrid or variety placement in field (5)	○	○	○
Overall crop planting rates (6)	○	○	○
Variable seeding rate prescriptions (7)	○	○	○
Pesticide selection (herbicides, insecticides, or fungicides) (8)	○	○	○
Cropping sequence/rotation decisions (9)	○	○	○
Irrigation decisions (10)	○	○	○
Other (11)	○	○	○

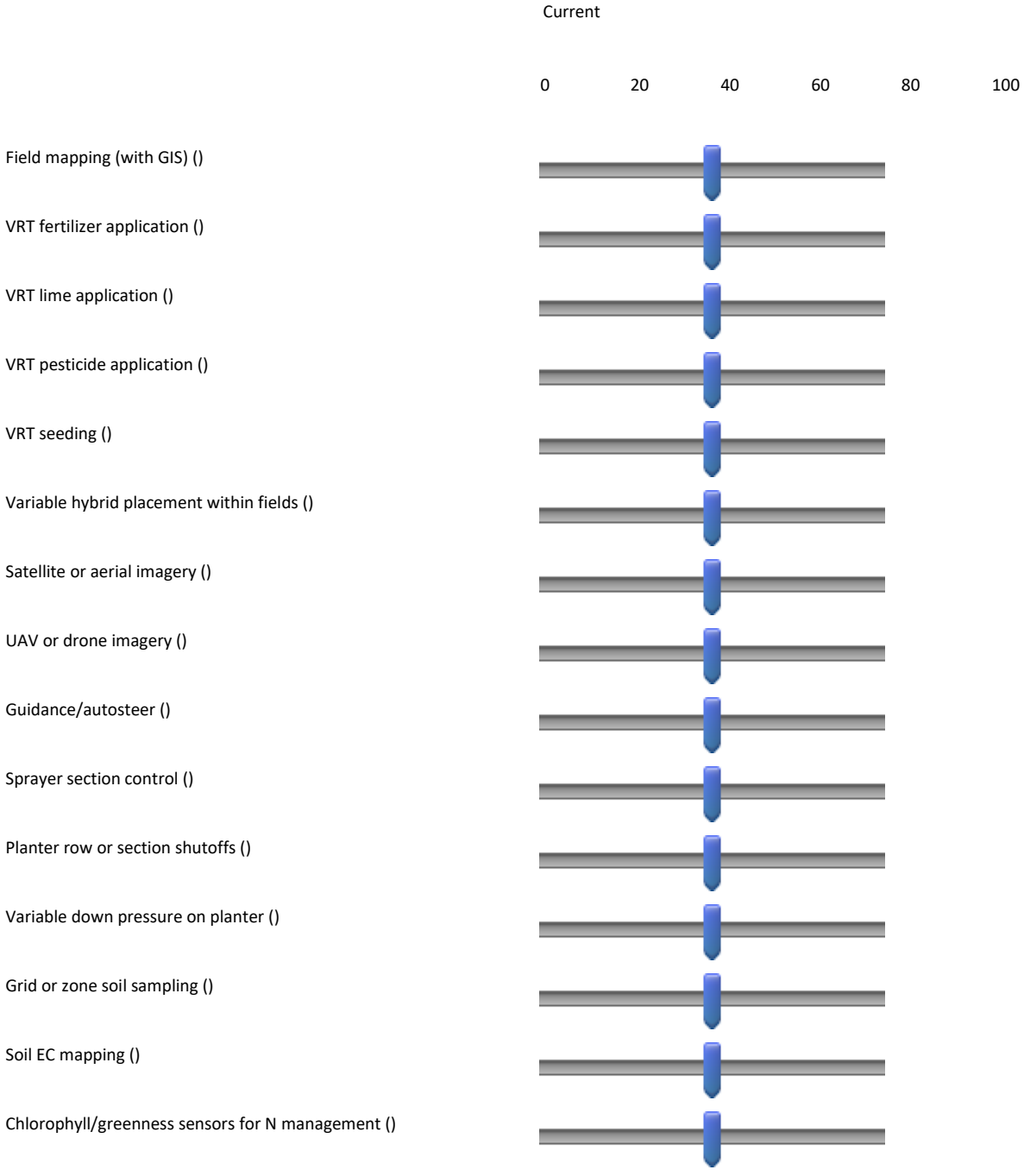
Q24 As you look at the current and future precision situation in your local market, what emerging precision technologies have the greatest potential to impact your business?

_____

Q25 What is the postal code of you business?

_____

Q26 *Please answer the following question regardless to whether you offer any precision services.* Approximately what percentage of the total acreage in your market area (all growers, not just your current customers) is currently using the following agricultural practices?



Yield Monitor ()

Telematics ()

Cloud storage of farm data ()

Y drops on fertilizer applicator ()

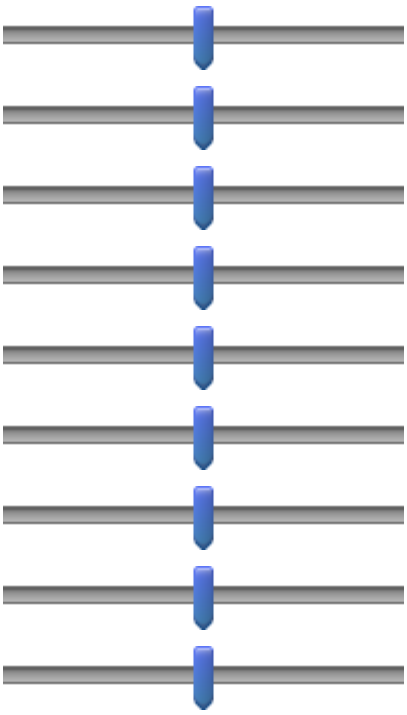
Any data analysis service (Encirca, FieldView, FBN, FarmServer, etc.) ()

Robotics/automation for weeding ()

Robotics/automation for harvesting ()

Electronic records/mapping for quality traceability ()

Selective harvest for quality improvement ()



Q27 As you think about the potential for precision agriculture in your market area, 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).*

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
The cost of precision services to my customers is greater than the benefits many receive (1)	○	○	○	○	○
My farmers are interested in precision services, but pressure on farm income in my area limits their use (2)	○	○	○	○	○
The topography (i.e., rolling ground, etc.) in my area limits use of precision services by farmers (3)	○	○	○	○	○
Soil types in my area limit the profitability of precision agricultural practices for my customers (4)	○	○	○	○	○
Interpreting and making decisions with precision agricultural information takes	○	○	○	○	○

too much of my customer's time (5)					
Customers lack confidence in the agronomic recommendations made based on site-specific data (e.g., yield maps, GPS soil sampling, remote sensing) (6)	○	○	○	○	○
Customer concerns with data privacy limit their participation (7)	○	○	○	○	○
The cost of the equipment required to provide precision services limits our precision offerings (8)	○	○	○	○	○
The cost of the employees who can provide precision services is too high for precision ag to be profitable (9)	○	○	○	○	○
It is difficult to find employees who can deliver precision agricultural services (10)	○	○	○	○	○
Incompatibilities across types of precision equipment and technology (different data formats, inability to share information) limit my ability to offer precision services (18)	○	○	○	○	○
The equipment required to deliver precision services is too complex for many of my employees to use (17)	○	○	○	○	○
The equipment needed to provide precision services changes quickly, increasing my costs (16)	○	○	○	○	○
The fees we can charge for precision services are not high enough to make	○	○	○	○	○

precision services profitable (11)					
Lack of manufacturer support for precision services limits our ability to provide such services (12)	○	○	○	○	○
Creating a precision program that adds significantly more value for the grower than a traditional agronomic program is difficult for us (13)	○	○	○	○	○
Demonstrating the value of precision services to our growers is a challenge (14)	○	○	○	○	○
Our competitors price precision agricultural services at levels that are not profitable for us (15)	○	○	○	○	○

Appendix III: CAAR Survey Instrument

Intro Dear agricultural retailer,

Since 1981, CropLife dealerships and Purdue University in Indiana have partnered to undertake a survey that chronicles the development and adoption of precision agriculture. This summer, we are collaborating with the Canadian Association of Agri Retailers to deliver a similar survey in Canada.

We are requesting that you complete this survey as you may benefit from the use of precision agriculture technologies. Your participation is voluntary, anonymous and as confidential as possible, given cyber security limitations.

The survey asks relevant questions about your company, its relationship with precision agriculture, perceptions about farmers use of precision agriculture technology, and agronomic questions related to precision agriculture technology. We estimate that the survey will take approximately 15 minutes. To complete it, please follow the onscreen instructions and/or prompts, entering your answers and clicking next and submit to record your answers. By clicking submit, you will be unable to withdraw submitted information once complete.

This survey has been reviewed by the University of Guelph Research Ethics Board for compliance with federal research ethics guidelines involving human participants. Please use the print function to print as a way to document your consent to complete the survey. If you have any questions regarding your rights and welfare as a research participant in this study (REB17-05-037), please contact the Director of Research ethics at reb@uoguelph.ca or (519) 824-4120 Ext. 56606. Thank you for your participation!

Dr. Alfons Weersink

Department of Food, Agricultural and Resource Economics

University of Guelph

519-824-4120 Ext. 52766

Email What is your email address?

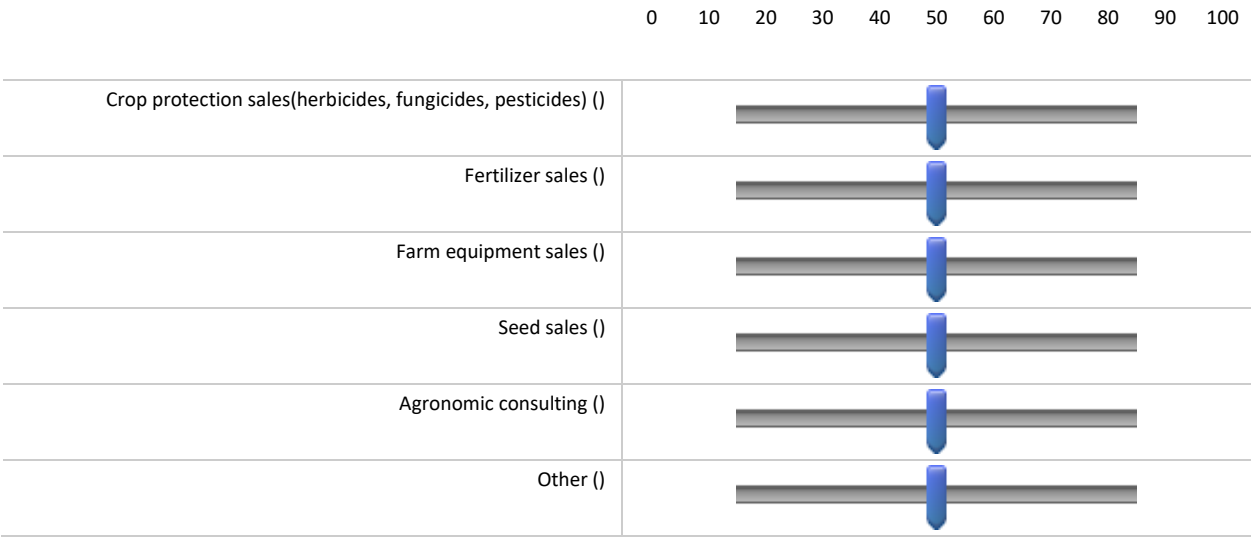
Please note that this information will only be used to prevent duplicate responses. Your email address will not be shared and will not be used by researchers to contact you.

_____

Q1 What province(s) is your business located in? (select all that apply)

- ☐ Alberta (1)
- ☐ British Columbia (5)
- ☐ Manitoba (3)
- ☐ New Brunswick (8)
- ☐ Nova Scotia (7)
- ☐ Ontario (6)
- ☐ PEI (10)
- ☐ Quebec (9)
- ☐ Saskatchewan (2)
- ☐ Other (4) _____

Q2 Approximately what percentage of your business' revenue in 2018 could be attributed to the following categories? (sum should add to 100%)



Q3 Which model best describes your business?

- ○ Cooperative (1)
- ○ Independent dealership (2)
- ○ National or regional (multi-province) chain of agri-retailers (3)
- ○ Other (Please specify): (4) _____

Page Break

Q4 Your primary responsibility within your company is best described as:

- ○ Owner/general manager/location manager (1)
- ○ Departmental manager (2)
- ○ Precision manager (3)
- ○ Technical consultant/agronomist (4)
- ○ Sales/sales management (5)
- ○ Application manager (6)
- ○ Consultant (8)
- ○ Other (Please specify): (7) _____

Q5 How many of each work role does your business employ at your location?

_____ Applicator—Runs the equipment that applies pesticides and fertilizers to farmer's fields. (1)
_____ Agronomist—Provides recommendations on crop and soil management to farmers. (2)
_____ Precision sales specialist—Works specifically with precision equipment sales and support. (3)
_____ Precision equipment technician—Installs precision equipment; troubleshoots and repairs ON SITE. (4)
_____ Technical support—Works REMOTELY to troubleshoot precision equipment/software. (5)
_____ Data manager/analyst—Manages agronomic data from the dealership and customer's farms. (6)

Q6 How many total retail outlets does your company own or manage?

- ○ 0 (1)
- ○ 1 (2)
- ○ 2-5 (3)
- ○ 6-15 (4)
- ○ 16-30 (6)
- ○ 31-50 (5)
- ○ More than 50 (7)

Q7 What were the total annual retail sales (in CAD) of agronomic products and services (chemicals, fertilizer, seed, consulting, technical support etc.) at your location in 2018?

- ○ Under $2,000,000 (1)
- ○ $2,000,001 - $10,000,000 (2)
- ○ $10,000,001 - $25,000,000 (3)
- ○ $25,000,001 - $50,000,000 (4)
- ○ $50,000,001 - 75,000,000 (5)
- ○ More than $75,000,000 (6)

Q8 Does your business offer any of the following custom application services?

- ☐ Fertilizer application (1)
- ☐ Chemical crop protection application (2)
- ☐ Lime application (3)
- ☐ Our location does not offer custom application services (4)

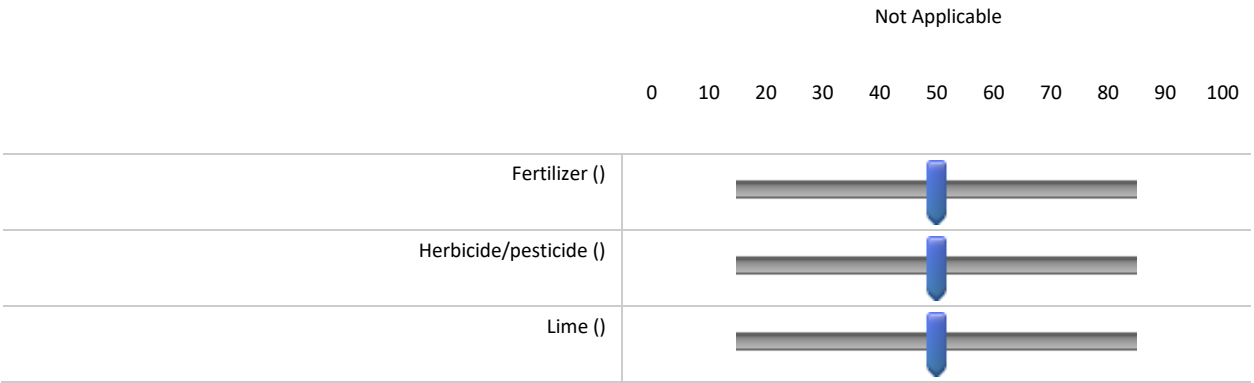
Q9 How much will your retail outlet be investing in precision/site-specific technology during 2019 for use by your business?

- ○ None (1)
- ○ 0 - $25,000 (2)
- ○ $25,001 - $50,000 (3)
- ○ $50,001 - $100,000 (5)
- ○ $100,001 - $250,000 (7)
- ○ More than $250,000 (8)

Q10 In a typical year how many total acres does your retail outlet custom apply (fertilizer, chemicals, seeding – total acres including multiple applications)?

- ○ Under 25,000 acres (1)
- ○ 25,001 to 50,000 acres (3)
- ○ 50,001 to 100,000 acres (4)
- ○ 100,001 to 150,000 acres (8)
- ○ Over 150,000 acres (6)

Q11 In 2018, approximately what percentage of the sales for each product at your retail outlet were custom applied?



Q12 What type of pricing structure do you use for custom application services?

- ○ Per acre (2)
- ○ Per hour (1)
- ○ Other (3) _____

Q13 Some agriculture retailers currently include the price of some services, such as crop scouting, into their crop input (fertilizer, chemical lime, etc.) prices.

Does your location include these types of services in the price of your agriculture input products, or do you price them separately?

- ○ They are included in our pricing (2)
- ○ They are priced separately (1)

Q14 In which of the following ways does your dealership use precision technology?

- ☐ Do not use precision technology (16)
- ☐ Any precision agronomic consulting services for customers (soil sampling with GPS, GIS field mapping, etc.) (1)
- ☐ Auto sprayer boom section or nozzle control (4)
- ☐ Sprayer turn compensation (5)
- ☐ Telematics to exchange information among applicators or to/from retail office or farm locations (13)
- ☐ Y drops on fertilizer applicators (6)
- ☐ GPS guidance systems with manual control (light bar) for fertilizer/chemical application/planting (2)
- ☐ GPS guidance systems with automatic control (autosteer) for fertilizer/chemical application/planting (3)
- ☐ GPS to manage fleet vehicle logistics, tracking locations of vehicles, and guiding vehicles to the next site (14)
- ☐ Satellite/aerial imagery for internal dealership purposes (7)
- ☐ UAV or drone imagery for internal dealership purposes (8)
- ☐ Soil electrical conductivity (electromagnetic) mapping (9)
- ☐ Other soil sensors for mapping, mounted on a pickup, applicator or tractor (example: pH sensor) (10)
- ☐ Chlorophyll/greenness sensors using NDVI or NDRE mounted on a pickup, applicator or tractor (CropSpec, GreenSeeker, OptRx, etc.) (11)
- ☐ Field mapping with GIS to document work for billing/insurance/legal purposes, etc. (12)
- ☐ Smart scouting using mobile applications to record field situations and locations (15)

Q15 Do you intend on using precision agriculture technology in the future?

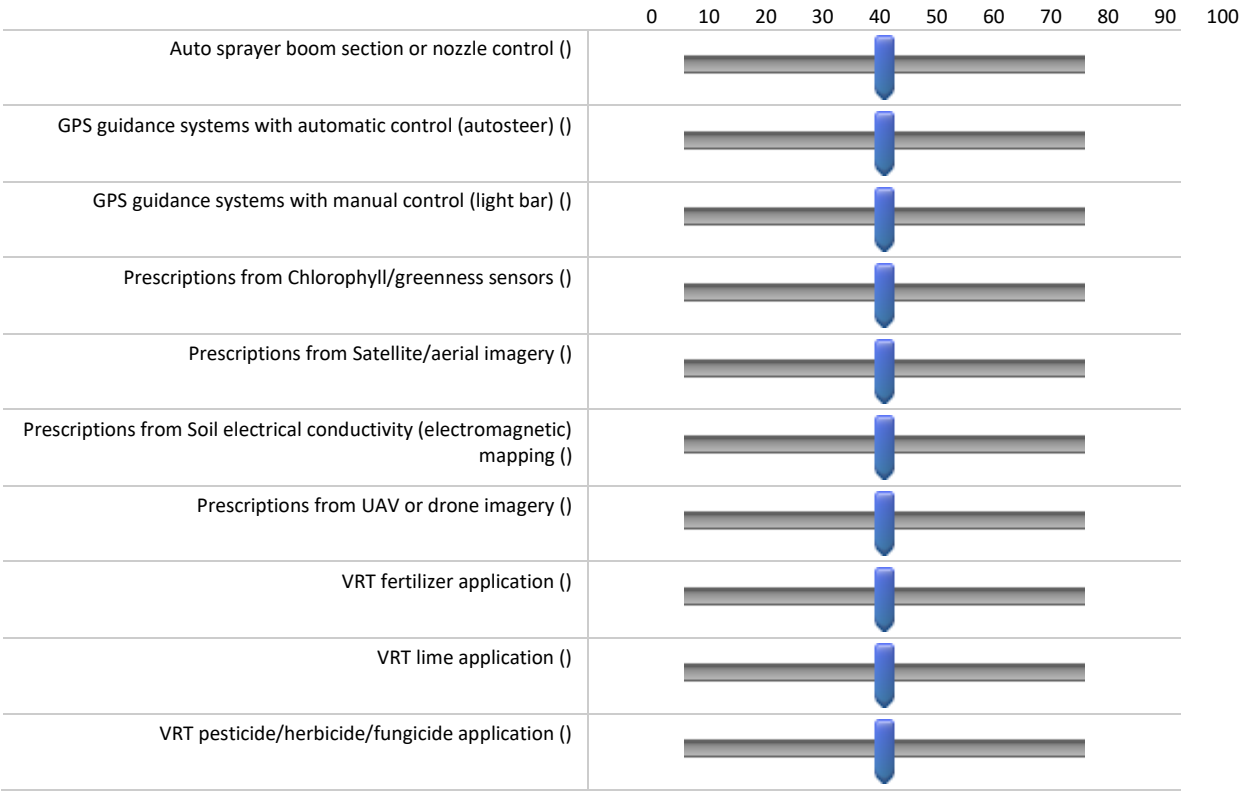
- ○ Yes (1)
- ○ Maybe (2)
- ○ No (3)

Q16 What type(s) of GPS correction do you use for your guidance applications?

- ☐ Personal RTK base station (fixed or portable) (3)
- ☐ Purchase correction from RTK array/cluster (i.e., Deere, Trimble) (4)
- ☐ Purchase RTN (Real Time Network) connection (i.e., Trimble ARS Now, Leica iMAX) (5)
- ☐ Purchase satellite correction (i.e., OmniSTAR XP or HP, StarFire 2) (2)
- ☐ Utilize WAAS (Wide Area Augmentation System) (1)
- ☐ Other (6) _____

Q17 In 2018, approximately what percentage of your total custom application (total acres, all products) used:

This question, and others, uses the acronym "VRT", which is shortened from "Variable rate technology".



Q18 Which precision services/products will you offer in the following time periods?

	Available Now (2)	Will offer by 2021 (3)	Don't intend to offer (4)
Field mapping (with GIS) (1)	○	○	○
Grid or zone soil sampling (12)	○	○	○
Grid or zone tissue sampling (18)	○	○	○
Profit/cost mapping (17)	○	○	○
Soil electrical conductivity (electromagnetic) mapping (13)	○	○	○

Chlorophyll/greenness sensors for N management (14)			
Satellite/aerial imagery (9)			
UAV or drone imagery (10)			
Wired or wireless sensor networks (20)			
Electronic records/mapping for quality traceability (19)			
Guidance/autosteer sales & support (11)			
Precision planter equipment sales (15)			
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.) (16)			
Yield monitor sales/support (7)			
Yield monitor and other data analysis (8)			
VRT fertilizer or lime prescriptions (2)			
VRT fertilizer application (3)			
VRT lime application (4)			
VRT pesticide application (5)			
VRT seeding prescriptions (6)			

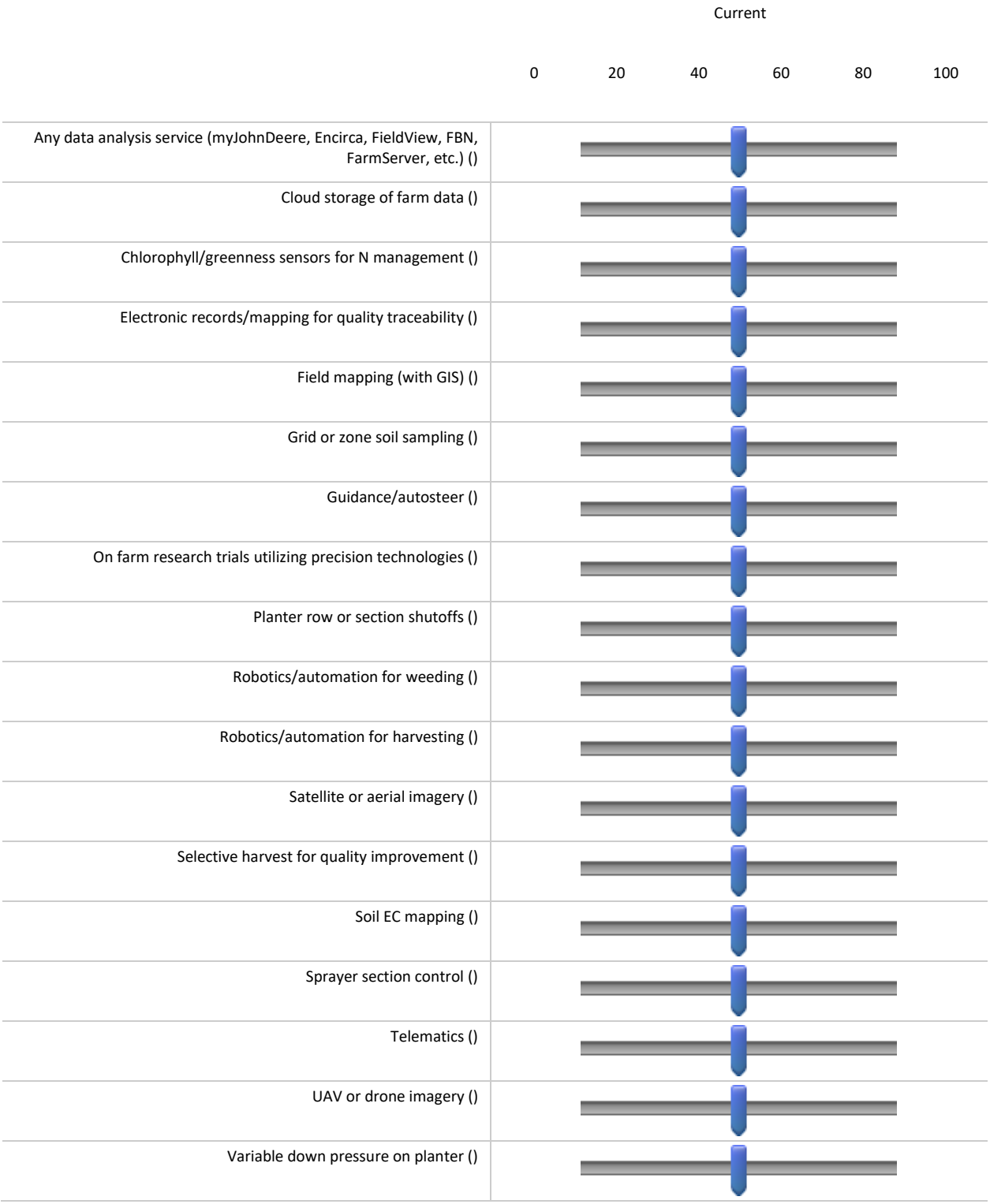
Q19 Please assess the level of importance of the following technologies to increasing precision revenue in the future.

Please rate the following technologies on a scale from 1 (least important) to 5 (most important).

	1 (2)	2 (3)	3 (4)	4 (6)	5 (7)
Field mapping (with GIS) (1)	○	○	○	○	○
Grid or zone plant tissue sampling (18)	○	○	○	○	○
Grid or zone soil sampling (12)	○	○	○	○	○
Profit/cost mapping (17)	○	○	○	○	○
Soil EC mapping (13)	○	○	○	○	○
Chlorophyll/greenness sensors (14)	○	○	○	○	○
Satellite/aerial imagery (9)	○	○	○	○	○
UAV or drone imagery (10)	○	○	○	○	○
Wired or wireless sensor networks (20)	○	○	○	○	○
Electronic records/mapping for quality traceability (19)	○	○	○	○	○
Guidance/autosteer sales & support (11)	○	○	○	○	○
Precision planter equipment sales (15)	○	○	○	○	○
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.) (16)	○	○	○	○	○

Yield monitor sales/support (7)	○	○	○	○	○
Yield monitor and other data analysis (8)	○	○	○	○	○
VRT fertilizer or lime prescriptions (4)	○	○	○	○	○
VRT fertilizer application (3)	○	○	○	○	○
VRT lime applications (2)	○	○	○	○	○
VRT pesticide application (5)	○	○	○	○	○
VRT seeding prescriptions (6)	○	○	○	○	○

Q20 *Please answer the following question regardless to whether you offer any precision services.* What is your perception of the adoption of these precision agriculture practices by **all growers** (not just your customers) in your market area? Please indicate this as an approximate percentage of the total acreage farmed.



Variable hybrid placement within fields ()	
VRT seeding ()	
VRT fertilizer application ()	
VRT lime application ()	
VRT pesticide application ()	
Yield Monitor ()	
Y drops on fertilizer applicator ()	

Q21 As you think about the potential for precision agriculture in your market area, what are the primary barriers that you think are preventing more **farmers** from adopting or expanding their use of precision agricultural services? *Please rate the following statements on a scale from 1 (strongly disagree) to 5 (strongly agree).*

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
Customer concerns with data privacy limit their participation (7)	○	○	○	○	○
Customers lack confidence in the agronomic recommendations made based on site-specific data (e.g., yield maps, GPS soil sampling, remote sensing) (6)	○	○	○	○	○
Drainage limitations mean that some technologies don't make sense (20)	○	○	○	○	○
Interpreting and making decisions with precision agricultural information takes too much of my customer's time (5)	○	○	○	○	○

My farmers are interested in precision services, but pressure on farm income in my area limits their use (2)	○	○	○	○	○
Soil types in my area limit the profitability of precision agricultural practices for my customers (4)	○	○	○	○	○
The cost of precision services to my customers is greater than the benefits many receive (1)	○	○	○	○	○
The topography (i.e., rolling ground, etc.) in my area limits use of precision services by farmers (3)	○	○	○	○	○

Q22
As you think about the potential for precision agriculture in your market area, what are the primary barriers preventing **your business** from offering more precision services?

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

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
Creating a precision program that adds significantly more value for the grower than a traditional agronomic program is difficult for us (9)	○	○	○	○	○
Demonstrating the value of precision services to our growers is a challenge (10)	○	○	○	○	○
Lack of manufacturer support for retail precision services limits our ability to provide such services (8)	○	○	○	○	○

It is difficult to find employees who can deliver precision agricultural services at retail locations (3)	○	○	○	○	○
Incompatibilities across types of precision equipment and technology (different data formats, inability to share information) limit my retail location's ability to offer precision services (4)	○	○	○	○	○
Our competitors price precision agricultural services at levels that are not profitable for us (11)	○	○	○	○	○
The cost of the employees who can provide precision services is too high for precision ag to be profitable for retailers (2)	○	○	○	○	○
The cost of the equipment required to provide precision services limits our (retail) precision offerings (1)	○	○	○	○	○
The fees we can charge for precision services are not high enough to make retail precision services profitable (7)	○	○	○	○	○
The equipment required to deliver precision services is too complex for many of my retail employees to use (5)	○	○	○	○	○
The equipment needed to provide precision services changes quickly, increasing my retail costs (6)	○	○	○	○	○

Q23 The following questions will ask about how you make agronomic recommendations related to precision agriculture.

Q24 How do you help manage the farm-level data (i.e., yield maps, soil tests, EC, satellite imagery) of your farmer-customers to assist in their decision-making?

- ☐ Do not help customers with their farm-level data (7)
- ☐ Archiving and managing yield, soil test, and other data for future use (5)
- ☐ Data aggregated among farmers but not outside the dealership (3)
- ☐ Data aggregated among farmers including those outside the dealership (4)
- ☐ No data aggregated among farmers, work with farmers only with the data from their own farms (2)
- ☐ Print maps for customers (yield, EC, soil maps, etc.) (1)
- ☐ Other (Please specify): (6) _____

Q25 Does your company have a customer data privacy statement and/or data terms & conditions agreement?

- ○ Yes (1)
- ○ No (2)
- ○ Unsure (3)

Q26 What crop management decisions are being influenced by aggregate data from your customer's farms?

	No influence (1)	Some Influence (2)	Major influence on decision (3)
Cropping sequence/rotation decisions (9)	○	○	○
Irrigation decisions (10)	○	○	○
Liming decisions (3)	○	○	○
Nitrogen Decisions (1)	○	○	○
Overall hybrid or variety selection (4)	○	○	○
Overall crop planting rates (6)	○	○	○
P and K decisions (2)	○	○	○
Pesticide selection (herbicides, insecticides, or fungicides) (8)	○	○	○
Variable hybrid or variety placement in field (5)	○	○	○
Variable seeding rate prescriptions (7)	○	○	○
Other (11)	○	○	○

Q27 The majority of your fertilizer recommendations are made for which crop

- Canola (1)
- Corn (4)
- Soybeans (5)
- Wheat (6)
- Other (2) _____

Q28 What is the expected yield of the above crop if no fertilizer is applied under normal growing conditions?

_____ bu/acre (1)

Q29 What is the expected yield of the above crop if your typical fertilizer recommendation is applied under normal growing conditions?

_____ bu/acre (1)

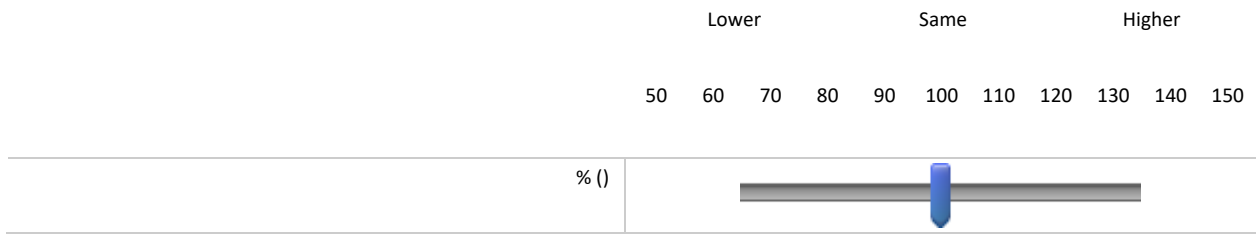
Q30 Assuming yield potential is the basis for making fertilizer recommendations, rank the importance of other factors on adjusting fertilizer rate from 1 (most important) to 6 (least important):

_____ crop price (4)
_____ environmental factors (5)
_____ fertilizer price (3)
_____ projected weather (1)
_____ results from previous years (2)
_____ other (7)

Q31 What is the expected **yield change** (in percentage, please indicate + or -) in the following scenarios:

_____ if the fertilizer application rate is 50% of the yield maximizing rate (1)
_____ if the fertilizer application rate is 75% of the yield maximizing rate (4)
_____ if the fertilizer application rate is 90% of the yield maximizing rate (5)
_____ if the fertilizer application rate is 110% of the yield maximizing rate (6)

Q32 The fertilizer rate that maximizes profit is ___ percentage of the rate that maximizes yield



Q33 As precision tools become more mainstreamed to farmers and business how do you see the role of an agronomist changing?

- [ ] More valuable (1)
- [ ] About the same (2)
- [ ] Less valuable (4)
- [ ] Our company will need to hire more agronomists (3)
- [ ] Less agronomists required (6)
- [ ] Farmers will need to hire their own agronomists (7)

Q34 Which of the following soil sampling services does your retail outlet offer? (Select all that apply)

- [ ] Traditional, whole field approach (1)
- [ ] Grid pattern (2)
- [ ] Management zones (3)
- [ ] Don't offer soil sampling (4)

Q35 What grid size is most commonly used when doing grid pattern soil sampling?

- ○ less than 1 acre (1)
- ○ 1 acre - 2.49 acre (2)
- ○ 2.5 acre (3)
- ○ 2.51 acre - 5 acre (4)
- ○ Don't know (6)

Q36 By what factor are management zones determined?

- ☐ Soil mapping unit (1)
- ☐ Yield map (2)
- ☐ Electrical conductivity (3)
- ☐ Satellite imagery and/or aerial photography (5)
- ☐ Other (Please specify): (4) _____

Q37 How do the rate recommendations change relative to a single uniform rate for the whole field in each of the following instances for variable rate fertilizer application?

	-50 -40 -30 -20 -10 0 10 20 30 40 50
Low yielding management zone ()	
High yielding management zone ()	

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Q38 In 2016, Fertilizer Canada launched its 4R Nutrient Stewardship Certification Program in Alberta and Manitoba, with Saskatchewan working towards its implementation. 4R Nutrient Stewardship (Right Source @ Right Rate, Right Time, Right Place) is a program designed to aid agri-retailers in reducing the environmental impacts from agricultural inputs while increasing crop productivity.

Are you familiar with this program?

- ○ Yes (1)
- ○ No (4)

Q39 Do your fertilizer recommendations comply with 4R nutrient stewardship guidelines?

	Yes (1)	No (2)
Type (1)	○	○
Rate (2)	○	○
Time (4)	○	○
Placement (5)	○	○

Q40
One 4R practice that can reduce fertilizer GHG emissions by up to 75% is the use of nitrogen inhibitors. Urease inhibitors and nitrification inhibitors are two examples of this.

Are nitrogen inhibitors part of your nutrient recommendations?

○ Yes (1)

○ No (2)

Q41 As you look at the current and future precision situation in your local market, what emerging precision technologies have the greatest potential to impact your business (positive or negative, list all)?

_____

Q42 What is the postal code of your business?

_____