Precision Agriculture in Ontario:

2017 Precision Agriculture Services Dealership Survey

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1. Introduction

For over 20 years, Purdue University's Department of Agricultural Economics has worked with CropLife America to undertake a survey of agriculture service providers that chronicles the development and adoption of precision agriculture practices and technologies. By replicating the survey in Ontario, the University of Guelph and our partner, the Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), aspires to do the same through the membership of the Ontario Agri Business Association (OABA). Aside from providing an accurate depiction on the use of precision agriculture in Ontario crop production, the survey will serve as a way to compare the previously mentioned metrics between Ontario and the USA.

Precision agriculture is a broad and flexible description of a combination of technologies and farming methods that have been developed, often as a result of the digitalization of agriculture, and which have evolved in accordance with increasing technological sophistication. It can be as simple as a producer adjusting farming practices for sections within a field based on personal experience, or as complex as comprehensive multi-factor analysis that can be used as a tool for making data-based decisions. The benefit of the technologies that it encompasses can be difficult to quantify and vary upon individual circumstances. However, the net benefits can arise through increased returns from either lower input use or higher yields and decreased environmental damages from fewer nutrients and pesticides applied to a reduced number of locations on the field. These purported net benefits have contributed to a growing demand for data related to precision agriculture services and technology in Ontario.

This report assesses the current adoption level of precision agriculture technologies for crop production in Ontario. 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 the extent to which precision agriculture technologies have been used by the service providers and the perceived profitability. 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. The systems to manage data by the retailers with their farm clients are then discussed followed by an assessment by the retailers on the use of precision agriculture by the farmers themselves. After a comparison of the Ontario results to the results from a similar survey conducted in the U.S. Midwest by Purdue University, the findings of the study are summarized and the implications are discussed.

2. Survey Design

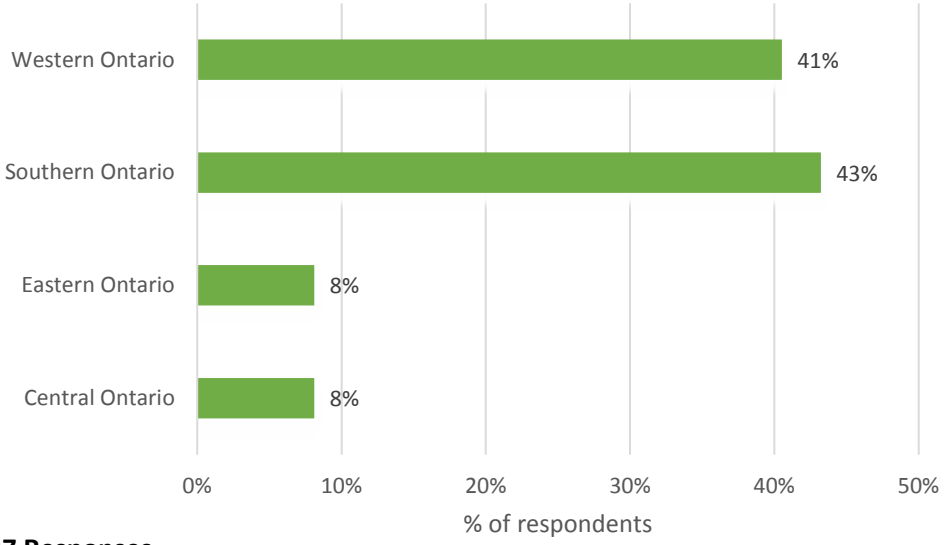
The Department of Agricultural Economics at Purdue University has conducted a survey of agriculture service providers in the U.S. Midwest for over 20 years with support from CropLife magazine. Results of past surveys chronicle the development and adoption of precision agriculture practices and technologies over this time period. Given the desire to obtain similar information on these new technologies in Ontario, the Department of Food, Agricultural and Resource Economics (FARE) at the University of Guelph collaborated with the survey developers at Purdue to send out a similar survey.

The Ontario survey was sent out electronically initially on June 28th, 2017 to the emails of 182 Ontario Agri Business Association (OABA) 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. Three 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, 62 were returned with useable data, yielding a response rate of 34 percent.

Dealerships were asked about their adoption of precision services, utilization of technologies, and the potential profitability of specific services/technologies. This assessment was in terms of the use of precision agriculture within their services provided to farmers but the respondents were also asked about the current adoption of precision agriculture technologies among their customers. The actual survey instrument can be found in Appendix II.

3. Characteristics of the Respondents

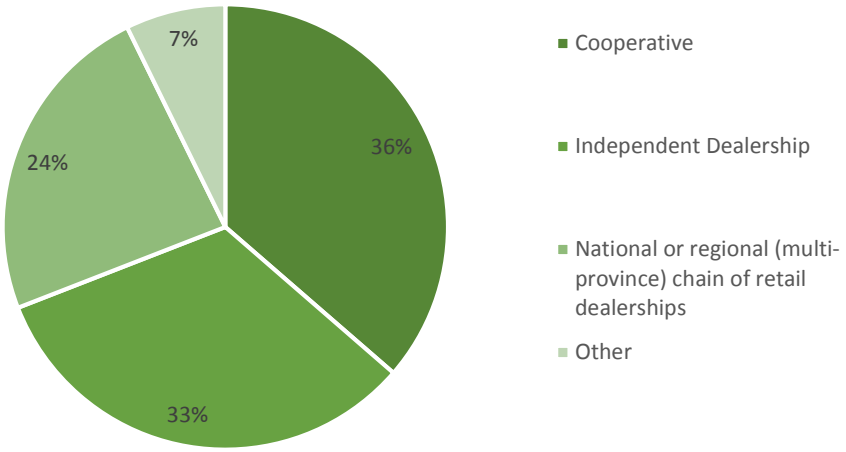
Respondents are categorized through alternative measures including geographic location. As expected, over 80% of the respondents operate in southern and western Ontario, which are the most agriculturally intensive regions of the province (Figure 1). (Note that although 62 agricultural service providers completed the survey, not all respondents answered all questions. For example, 37 out of the 62 indicated the geographic location of their operations (see Figure 1).) Of those that provided their postal code, 19 of 49 counties in Ontario were represented in the survey. These 19 counties included 16 of the 20 counties with the most farm capital in the province (reference).



37 Responses

Figure 1. Agriculture Regions Represented

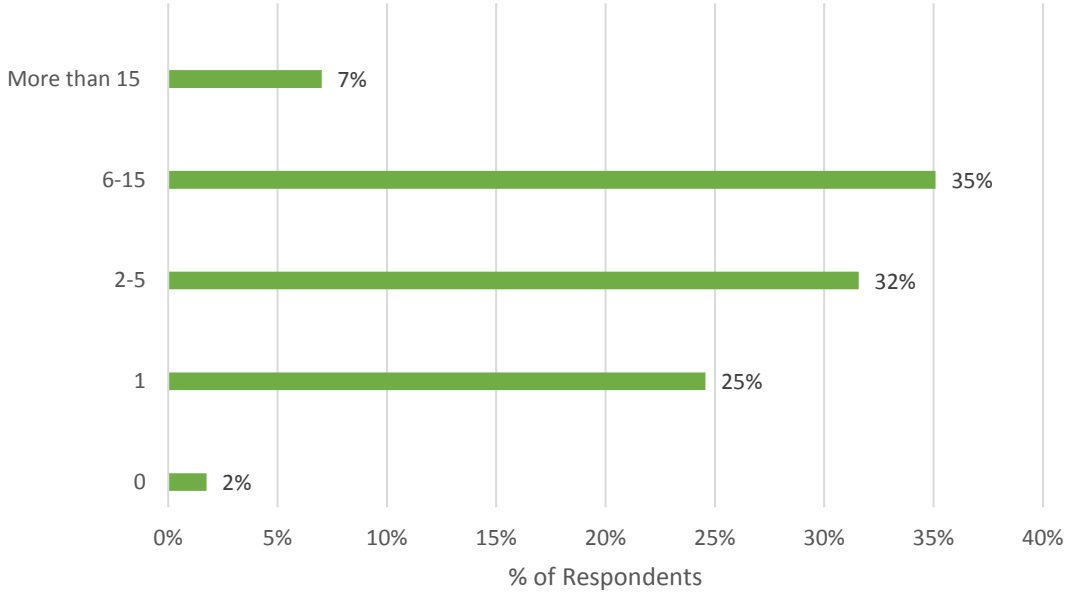
The survey attempted to identify the diversity within the OABA survey respondents by asking a variety of general questions about the business they were answering the survey on behalf of. They were asked how the respondent would identify their input supply business (Figure 2). Cooperatives (36%) and independent dealerships (33%) made up the majority of retailers responding, while multi-provincial chains made up just less than 24%. Just over 7% of respondents identified as being none of the given choices and perceived themselves as either a joint venture, a Canadian-owned limited company, and/or franchised.



55 Responses

Figure 2. Business Type Diversity within the Survey Sample

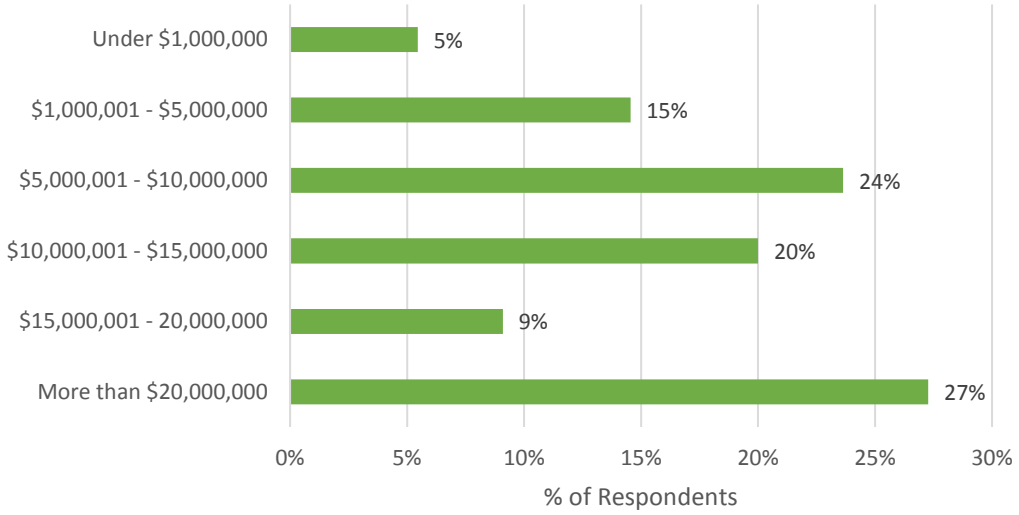
The size of the business was determined partially by the number of retail locations controlled by their organization (Figure 3). A large majority (74%) of those surveyed reported managing multiple retail outlets. One quarter of the respondents said that their organization only manages one outlet, while 2% of respondents stated that they did not manage an official retail location.



57 Responses

Figure 3. Number of Retail Outlets Owned or Managed

The survey also assessed size through the gross revenue that the respondent's business accrued from products and services in the previous year (Figure 4). Over one-quarter (27%) of retailers established that they have sales in excess of $20 million (CAD), while a majority (56%) reported that they brought in over $10 million (CAD) at their location.



55 Responses

Figure 4. Total annual agronomic products and services sales

Respondents were also asked to acknowledge their position with the company that they were responding on behalf of (Figure 5). The vast majority (78%) described themselves as either the owner, general manager, or location manager, while 37% reported to be agronomists/technical consultants. Beyond this, department managers, precision managers, or sales persons represented 10%, 3%, and 3%, of respondents, respectively. This is 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.

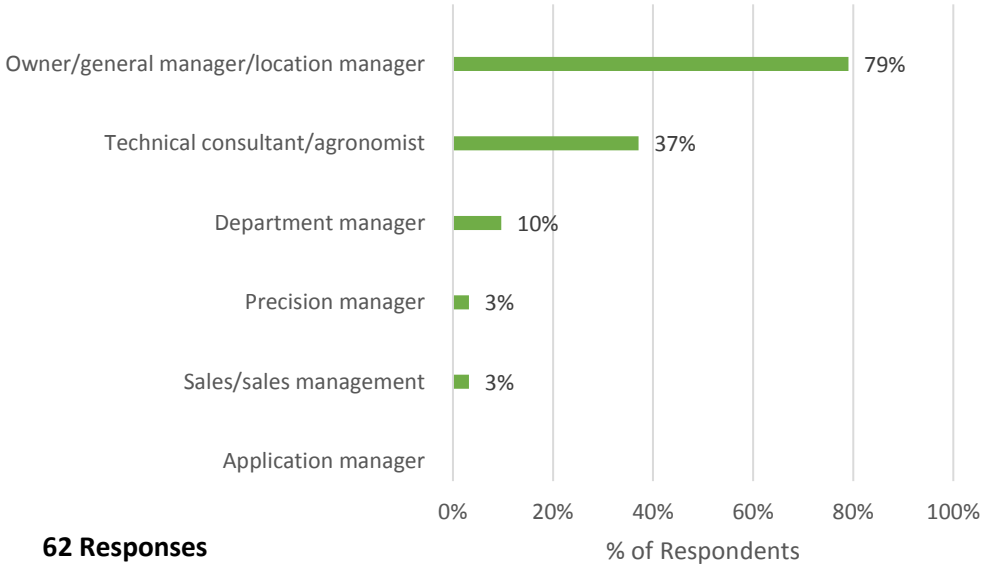


Figure 5. Respondent Position within their Company

The types of employees within the operation that are involved with precision agriculture are shown in Figure 6. Across all 58 respondents to the question, 227 agronomists, 209 applicators, 26 sales specialists, 25 data managers, 13 equipment technicians, and 4 technical support staff were directly employed by the companies of these respondents. Figure 7 shows the approximate employment in precision agriculture. Applicators and agronomists made up the vast majority of those identified as being employed in precision agriculture by the survey; 84% of respondents said that they had an agronomist employed at their company, while 77% of respondents said that they had an applicator employed. One to two data managers/analysts were reported to be employed by 34% of respondents, while 33% of respondents said that they employed at least one precision sales specialist, 12% said that they employed at least one precision equipment technician, and 10% reported that they employ 1-2 technical support staff.

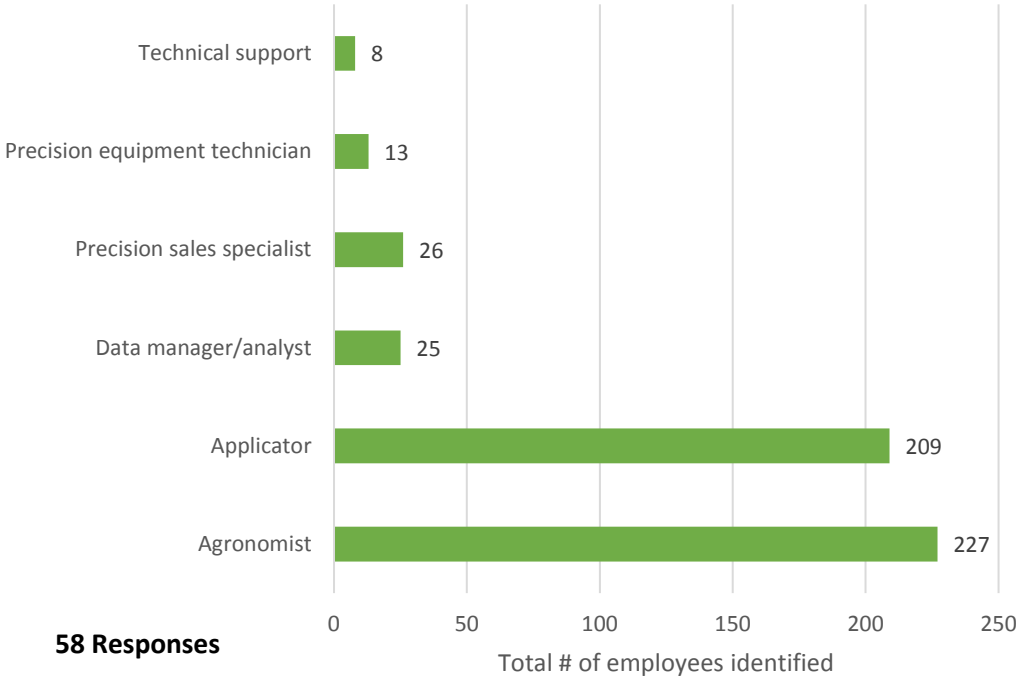


Figure 6. Types of Employees Directly Employed in Precision Agriculture

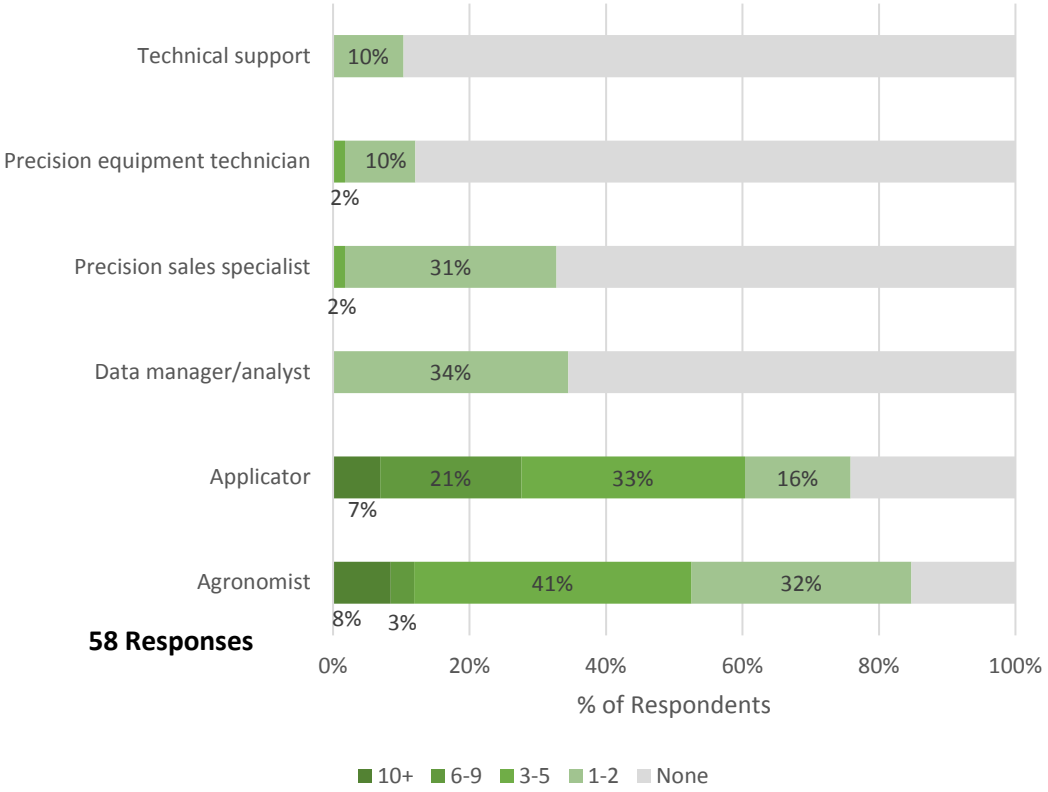


Figure 7. Approximate Employment in Precision Agriculture Jobs by Agricultural Retailers

A foundational aspect of many agriculture product and service retailers is the application of agricultural inputs for farmers, as can be seen below. Figure 8 represents the area of land that respondents report to custom apply fertilizer, pesticides, or seed to in a typical year for their business. Nearly half (46%) of those surveyed established that they custom apply over 50,000 acres in a year, with 13% applying over 100,000 acres.

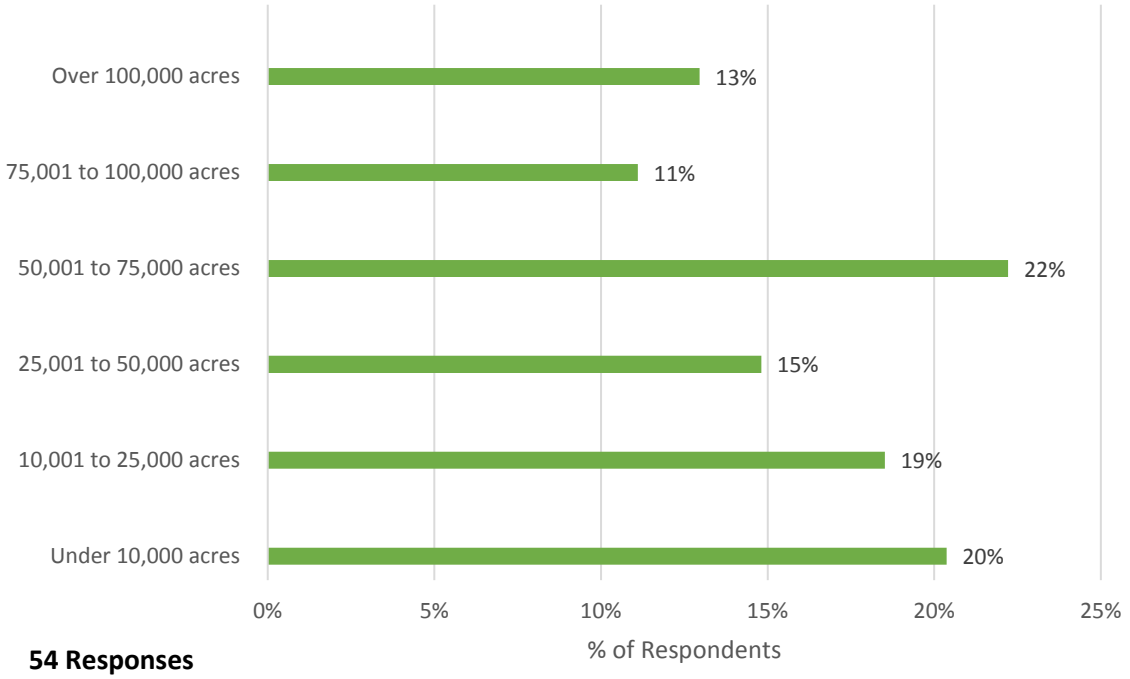
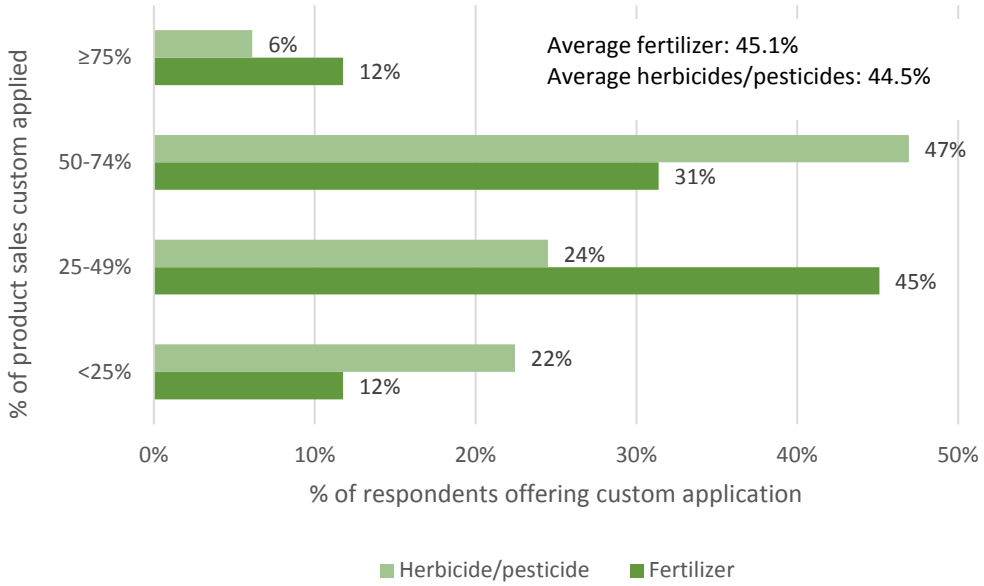


Figure 8. Area Custom Applied in a Typical Year

Survey recipients were further asked to indicate what percentage of both pesticides and fertilizers they sell are custom applied. On average, respondents reported that 45% of fertilizer sold was custom applied, while 45% of herbicides and/or pesticides they sold were custom applied on land managed by the purchaser of the inputs. Over half of the total number of respondents (53%) reported that they custom spray more than half (31% custom applying 50-74% and 12% exceeding that metric) of their pesticides, while slightly less than half (43%) report that they custom apply more than half of their fertilizer sales. This data is shown in Figure 9.



54 Responses

Figure 9. Custom Application of Fertilizer and Herbicides/Pesticides

4. Adoption of Precision Agriculture Technologies by Retailers

Since a significant portion of Ontario cropland on which precision agriculture technologies could be employed are directly serviced by the agricultural retailers surveyed, the overall adoption rate of these technologies can be assessed by analyzing the respondents use of precision technologies. In this section, we examine what technologies are being offered by the agricultural crop retailers, how much are they being used, and are they profitable? We begin with an overview of overall adoption, followed by a more thorough review of the data for four specific categorizations of services and their associated technologies. These four categories are: geographic services, observational services, analytical services and sales, and variable rate services.

4.1. Overall Adoption

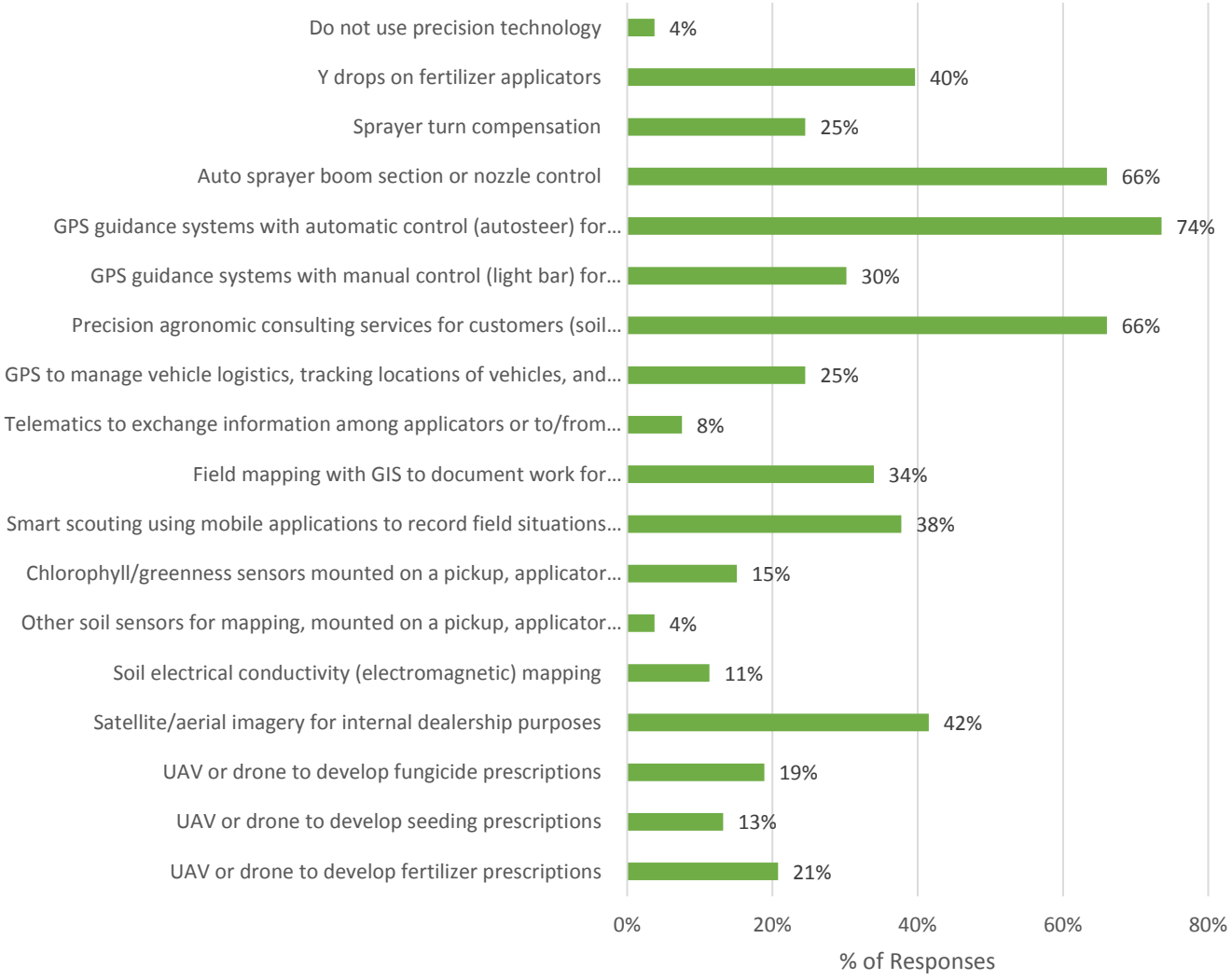
The overall adoption of precision agricultural technologies is viewed in terms of whether the dealership uses the technology (question 14 of the survey in Appendix II and illustrated in Figure 10) and whether the site-specific or precision service is offered by the dealership to its customers (question 16 of the survey in Appendix II and illustrated in Figure 11). Thus, it is expected the adoption rates will be higher for general use by the company than for specific services offered.

An indication of the widespread use of precision agriculture in some form for crop production is that only 4% of respondents report not using precision agriculture at all within their business. Precision spraying technology, such as Y-drops, sprayer turn compensation, and automatic boom or section control, are reported to be used by 40%, 25%, and 66% of respondents, respectively. Automatic guidance systems and light bar guidance systems are reported to be used by 74% and 30%, respectively, while 66% of those surveyed say they provide some type of precision agronomic consulting service.

Survey respondents also reported using some aspects of precision technologies themselves to aid in their business operations by managing vehicle logistics (25%), exchanging information among applicators or office locations (8%), and using GIS for billing, financial, or legal purposes (34%).

In order to provide some level of precision agriculture consulting service, there must be data available for a consultant to base their precision prescription. Data collection technologies, such as mobile device scouting, chlorophyll sensors, onboard soil mapping, soil electrical conductivity mapping, and satellite/aerial imagery were reported to be used by 38%, 15%, 4%, 11% and 42% of respondents respectively. UAV (unmanned aerial vehicle) observations were

also used to develop fungicide, seeding, and fertilizer prescription, as 19%, 13% and 21% of respondents reported using each, respectively.



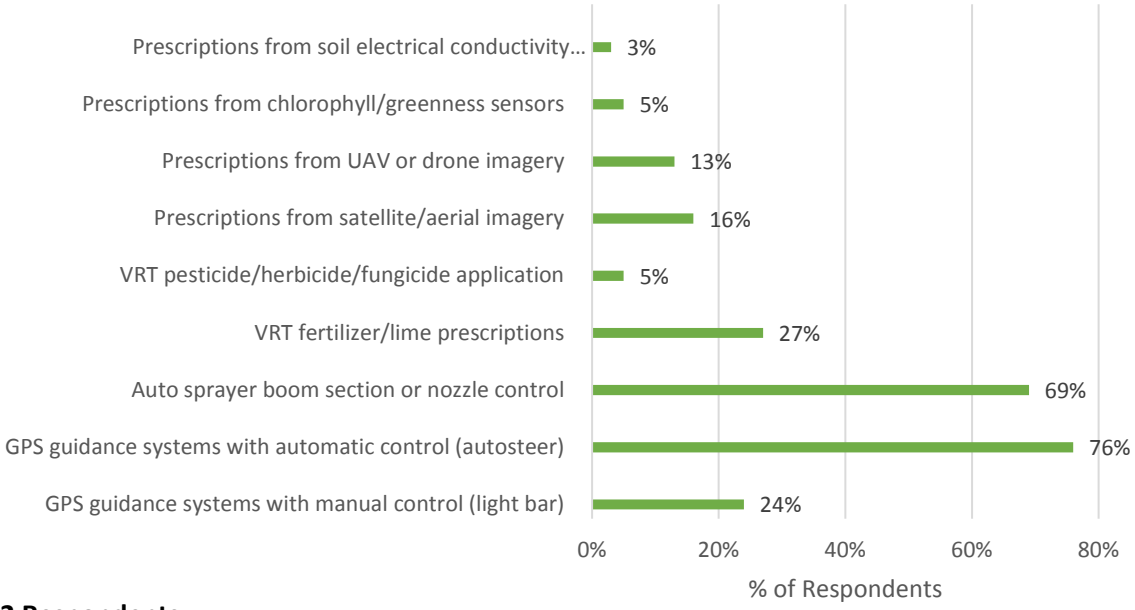
53 Responses

Figure 10. Adoption of Precision Technologies

Although the agricultural retailer applies on behalf of the farmer approximately half of the fertilizer and pesticides purchased by farmers, custom application does not always make use of precision technologies. For a variety of reasons not discussed in-depth in this report, precision technology is often not requested by the farmer from the agricultural input service provider even when the service if available. To measure the adoption rate of precision technology for crop inputs, survey respondents were asked what percentage of their total custom applied area used specific precision agriculture technologies (Figure 11).

Prescriptions from data collecting technologies can assess fertility or pest levels within a management zone and can thus be used to determine the appropriate fertilizer or chemical spraying rate per acre for either traditional uniform application methods or variable rate application approaches. Respondents were asked what percentage of their custom applications used data collecting technologies. Soil electric conductivity mapping were reported as being used for 3%, chlorophyll/greenness sensors for 5%, UAV or drone imagery for 13.1%, and satellite/aerial for 16% of custom applied acres.

Automatically controlled steering systems (autosteer) and sprayer booms with automatic section or nozzle control were by far the most frequently used types of precision technologies for custom applications, with each reported as being used on average for 77.0% and 69.4% of custom applications, respectively. GPS guidance using a light bar indicator was surveyed to be used for 24.3% of custom acres, while respondents answered that VRT fertilizing and/or lime and VRT spraying were used for 27.7% and 5.4% of custom acres, respectively.

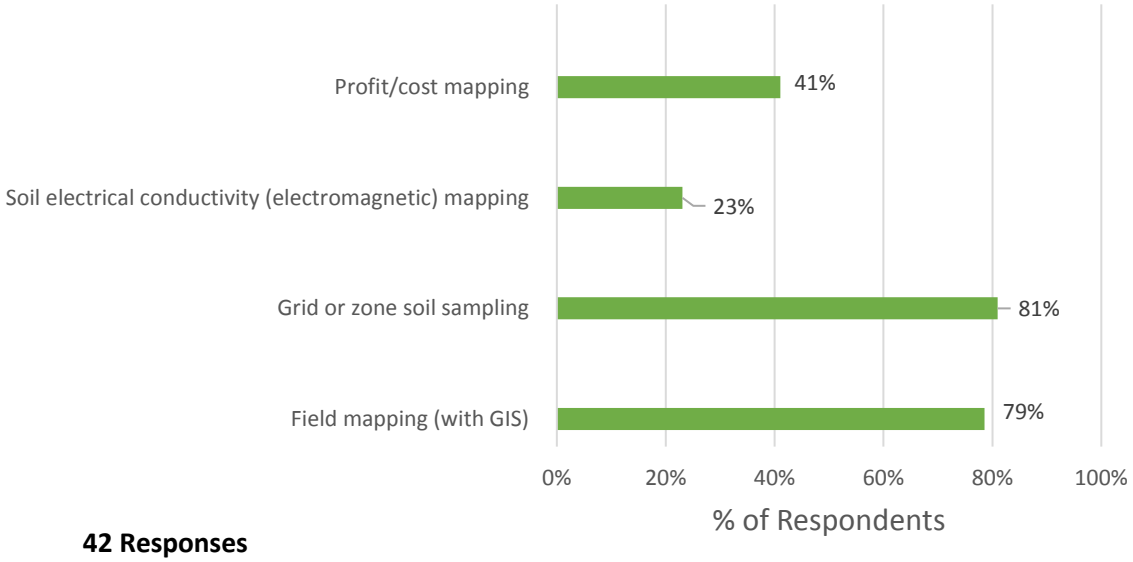


42 Respondents

Figure 11. Use of Precision Technologies for Custom Application

4.2. Geographic Services

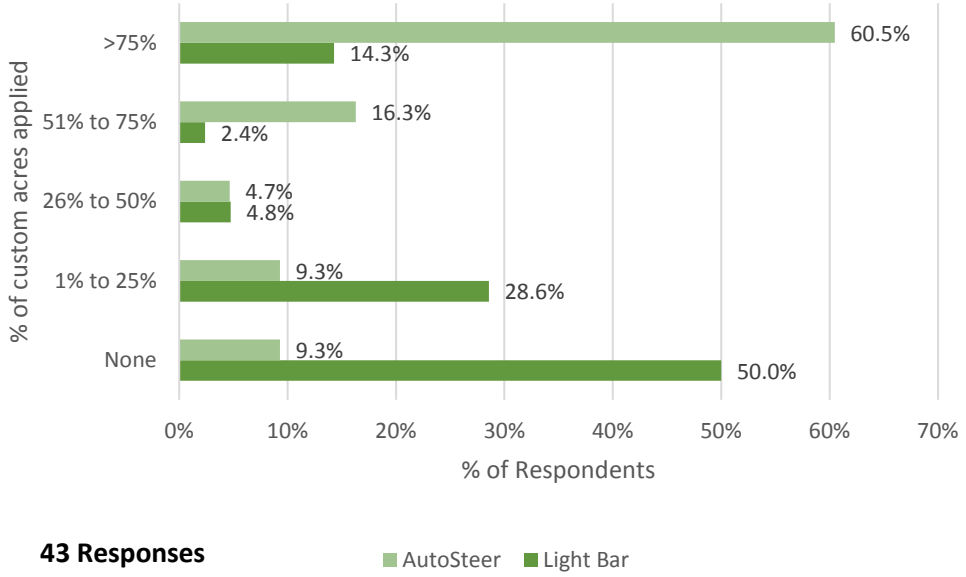
While geographic services encompass many precision technologies, this section focuses largely on guidance, and mapping technologies and/or services. Around 80% of respondents offer field mapping through GIS or soil sampling either through a grid or zone approach (see Figure 12). Net return mapping is offered by 41% of the responding retailers while soil EC (electrical conductivity) mapping is offered by around one-quarter of respondents.



42 Responses

Figure 12. Geographic Services Adoption Rate

As noted in the previous section, a majority of the respondents use a GPS guidance system. Of those agricultural retailers who used GPS guidance systems, the extent to which these guidance systems are reported to be used is illustrated in Figure 13. While 60% of respondents report to use automatic steering for over 75% of their custom application, almost all (>90%) report to using automatic steering for at least some of their custom application. Although 50% of custom applied acres do not use light bar guidance systems, 28% of those that do (14% of overall acres) use this type of guidance for over 75% of their custom applied acres.



43 Responses

Figure 13. Extent of Guidance Technology's Use

The accuracy of these guidance technologies can vary widely, with some technologies being accurate to less than 1 m, and other being accurate to less than 2 cm. Respondents were asked what type of guidance they used in order to better understand the general accuracy of their systems (Figure 14). The Wide Area Augmentation System (WAAS), used to augment GPS accuracy was reported to be used for 57% of guidance applications, while 12% used some type of purchased satellite correction service, and 5% purchased some real-time network (RTN) connection. RTK, the highest accuracy of the guidance technologies mentioned, was used by 26% of respondents. It is also notable that none of those surveyed reported having mounted their own personal RTK base station.

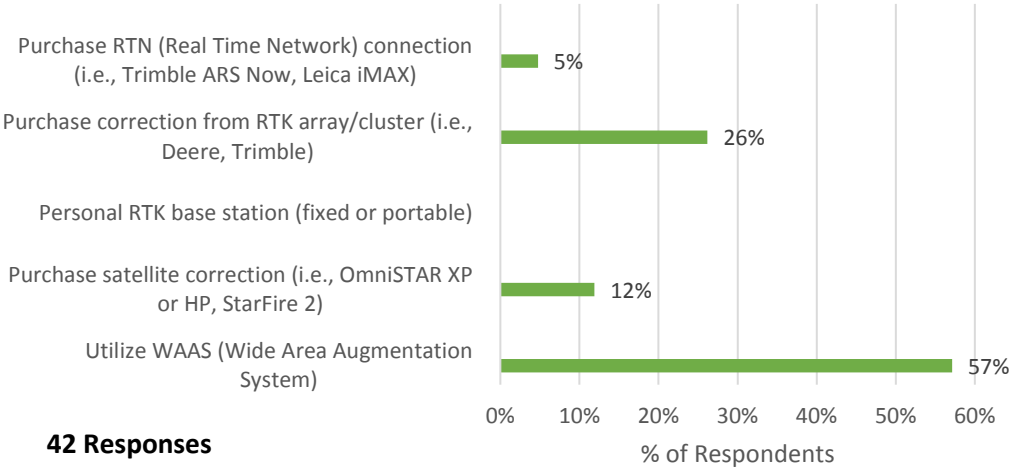


Figure 14. Type of Guidance Technology

The specific types of custom application that these geographic technologies are used for, and whether a specific technology is used more or less for some activities is not known from the survey data itself, but the profitability of geographic services is known, and is represented in Figure 15. These mapping services were widely reported by respondents as either breaking even or being profitable. There was also a larger number of respondents who indicated that they offered the technology at their retail outlet. Respondents indicated at a higher rate than any other technology that soil sampling services were either breaking even or turning a profit. Field mapping, soil EC mapping, and profit/cost maping were similarily reported as being either profitable or breaking even at 68%, 67%, and 53%, respectively, by those surveyed.

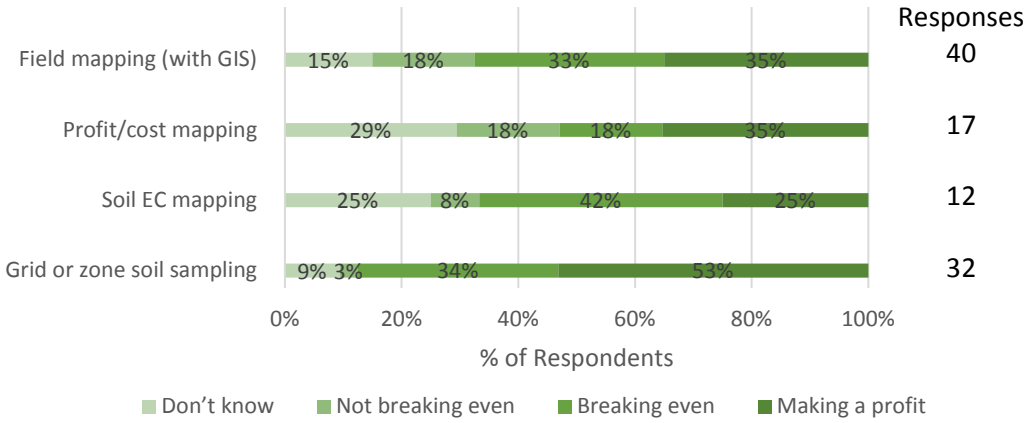


Figure 15. Profitability of Geographic Services

4.3. Observational Services

Observational services are associated with technologies that collect data from the field. This section willl look at what services are offered, how much they are actually used, and the way the collected data is later used.

Approximately two-thirds of the respondents offer satellite and/or aerial imagery to gather information on field or crop characteristics. Chlorophyll sensing is offered by 39% of respondents, and a similar percentage of respondents offer UAV or drone imagery.

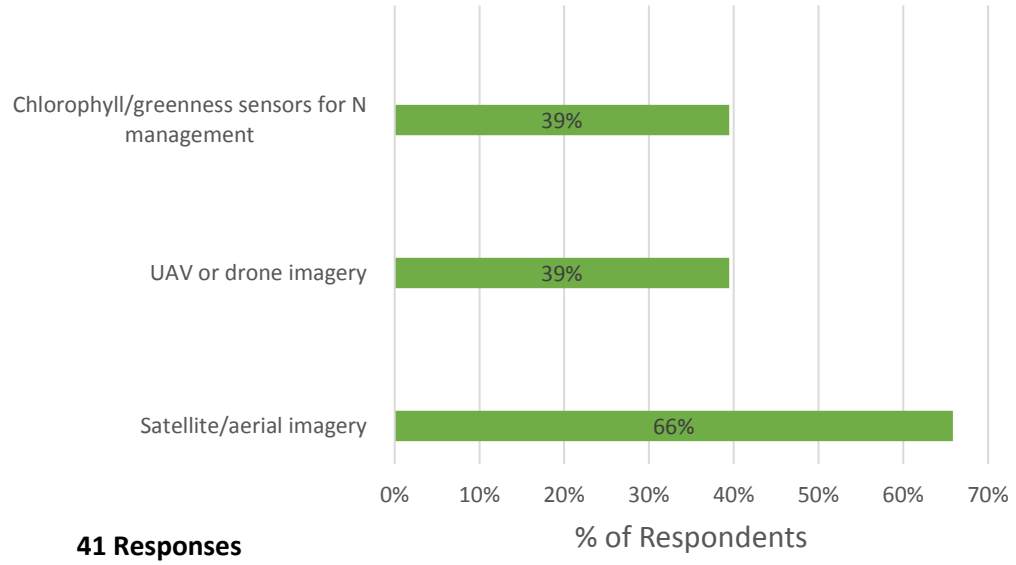


Figure 16. Observational Services Adoption Rate

Approximately two-thirds of respondents said satellite imagery was at least breaking even, and consistent with the relatively high adoption rate noted above. A similar percentage of respondents incidated that chlorophyl/greeness sensory services were breaking even or profitable. Drone imagery was the only one of the three observational service technologies that was reported to be unprofitable by a larger percentage than those breaking even or profitable (42% vs. 37%).

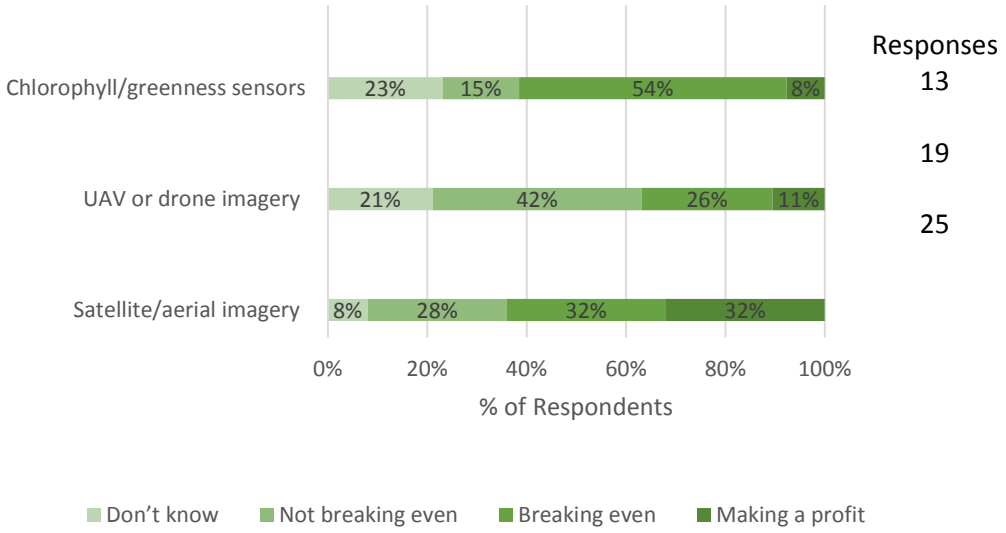


Figure 17. Profitability of Observational Technology

Management zones and grid pattern soil sampling are two common formats for precision prescriptions to be based upon. Survey recipients were asked what types of soil sampling they offered. Traditional whole field soil sampling was the most common technique offered (77%), while 64% and 53% of respondents offered management zones and grid pattern sampling, respectively (Figure 18). While management zones and grid pattern sampling are acknowledged as being non-mutually exclusive, the survey did not provide for this option.

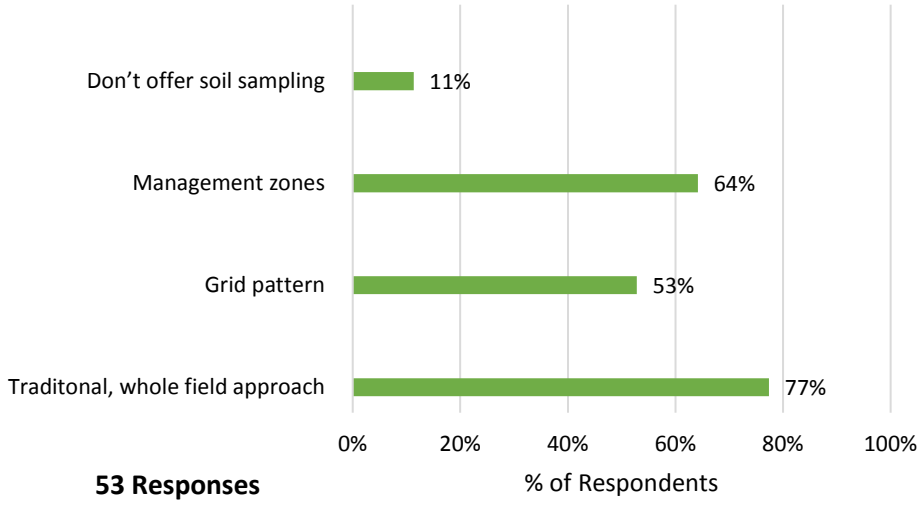


Figure 18. Types of Soil Sampling Offered

Those agricultural retailers who offer grid sampling were then asked what size of grid sampling they used most often. Half of those using grid sampling said that they used a 2.50-acre sized

grid sampling area, while 36% said they used 2.51 to 5 acre sized grids, and 14% said they used 1 to 2.49 acre sized grids (Figure 19). None used a grid sampling area less than 1 acre.

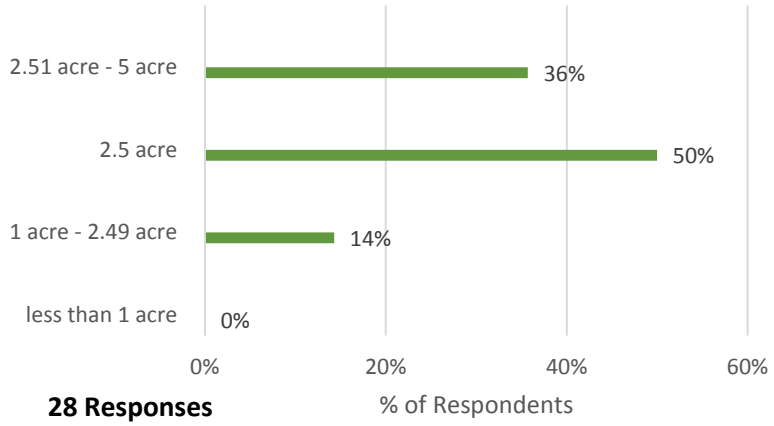


Figure 19. Most Commonly Used Soil Sampling Grid Size

For those input service providers that offer management zones for soil sampling, yield maps were used by 38% of respondents to determine the size and location of a management zone (Figure 20). Satellite or aerial imagery was used by 29% to define management zones, while 9% and 3% of respondents shared that soil mapping units and electrical conductivity, respectively, were the determining factor for zones. Respondents also indicated many other factors by which zone were identified. These included, topography, normalized difference vegetation indexes (NDVIs), and customer knowledge.

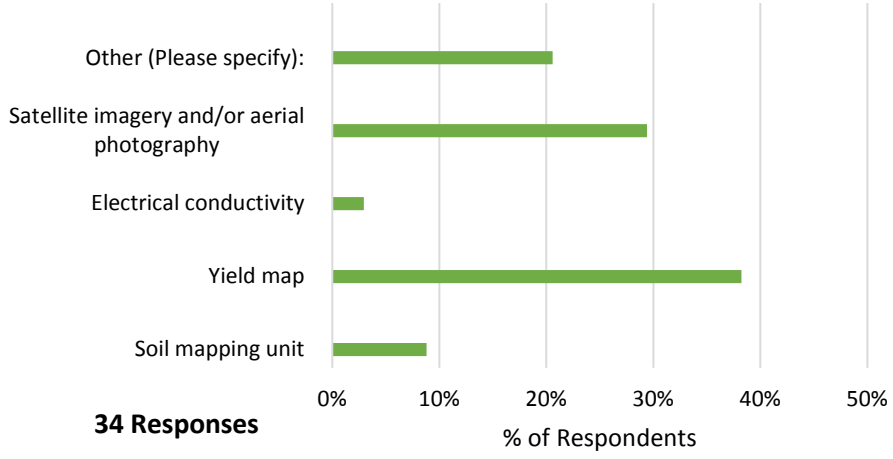


Figure 20. Method Used to Identify Management Zones

4.4. Sales and Analytical Services

This section will focus mainly the data collected regarding sales and analytical services and the technology that is associated with them. Figure 21 shows that telematic equipment sales is offered by 3% of respondents, while 3% of respondents offer precision planter sales, 3% of respondents offer guidance/autosteer sales and support, 51% of respondents offer yield monitor and other data analysis, and 17% of respondents offer yield monitor sales and/or support.

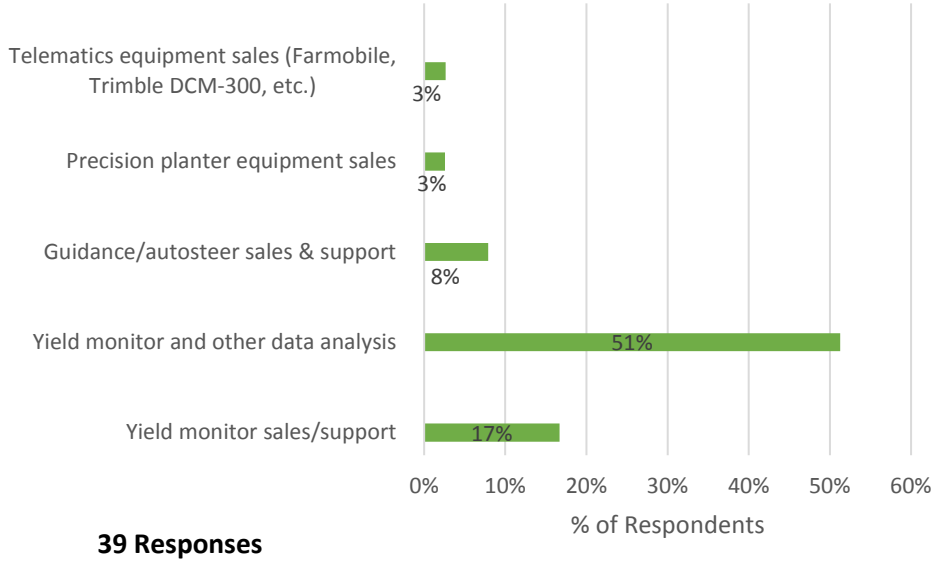


Figure 21. Adoption Rate of Sales and Analytical Services

Most respondents indicate sales and analytical services were also profitable (see Figure 22), although slightly less so than variable rate services, and also with a lower accuracy due to a smaller number of respondents reporting to offer them. Telematics, as well as guidance system sales were reported to be profitable or breaking even, as reported by 50% and 70%, respectively, while only 20% reported precision planter equiptment sales as being profitable. Yield moniter and other data analysis was reported as breaking even or profitable by 70% of repondents, and yield moniter sales and support were reported as breaking even or profitable by 44% of respondents. Worth noting is that as discussed in section 4.1, 66% of respondents report to offer some form of precision consulting service to their customers.

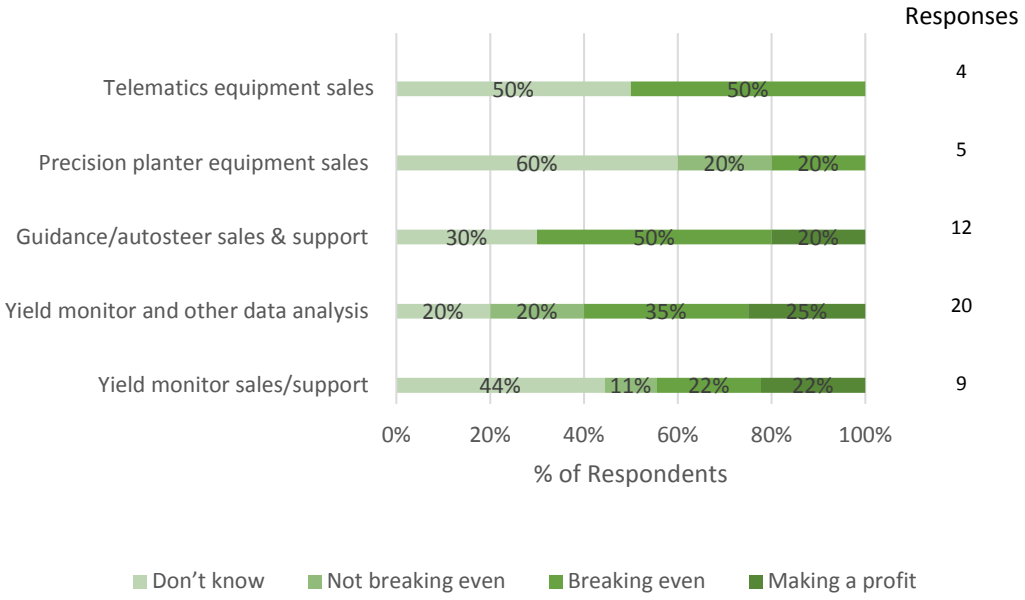


Figure 22. Profitability of Sales and Analytical Services

4.5. Variable Rate Services

This section will focus mainly the data collected regarding variable rate services and the technology that is associated with them. Figure 23 shows that VRT seeding prescriptions are offered by 58% of respondents, while 66% of respondents offer VRT lime application, 32% of respondents offer VRT pesticide/herbicide/fungicide application, 88% of respondents offer VRT fertilizer application, and 74% of respondents offer VRT lime or fertilizer prescriptions.

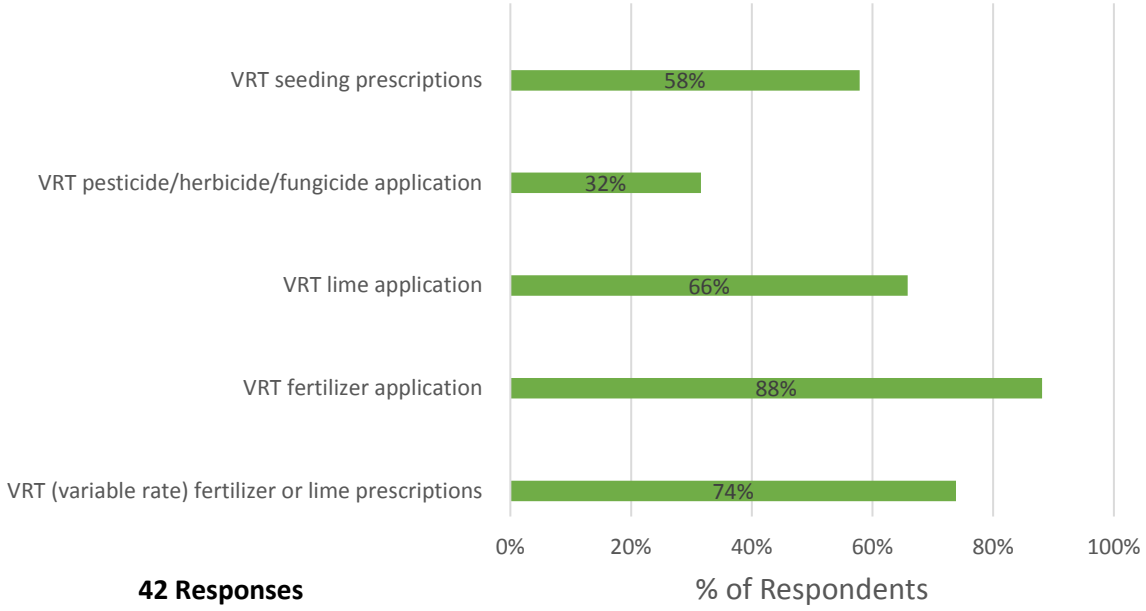


Figure 23. Variable Rate Technology/Services Adoption Rate

The profitability of variable rate (VRT) services is depicted in Figure 24. All variable rate services that were asked about were reported to be breaking even or profitable by at least 50% of respondents. VRT lime application, fertilizer, and pesticide/herbicide were reported to be breaking even or profitable by 81%, 69%, and 50% respectively. VRT perscriptions were also widely reported as being profitable, with 77% of those offering seeding prescriptions breaking even or profitable, while 71% of those offering fertilizer or lime percriptions were reporting to be breaking even or profitable.

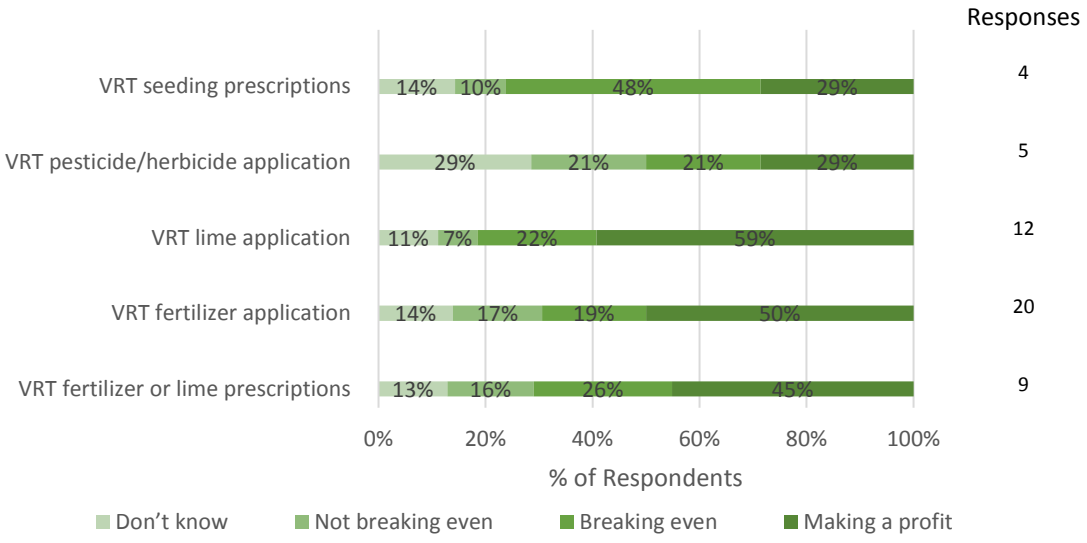


Figure 24. Profitability of Variable Rate Services

5. Client Data Management

While data collected in the field can be a valuable tool for producers and retailers alike, it only becomes practically useful after it has been interpreted properly. The analysis of the field data permits prescriptions be determined, zones to be adjusted or created, and future practices to be modified. How retailers treat farm data, how they use it, and how they assist farmers in rendering it useful is explored in this section.

The retailers were asked whether their business had a customer data privacy statement and/or a data terms and conditions agreement with their farm clients. These types of agreements are typically used to outline the relationship the company has with the client, the terms under which they are able to collect data, use a client's pre-existing data, or share data with a third-party. These documents are fundamental in establishing a relationship of trust between a client and a business. As noted reported by respondents in section 7 customers' concerns regarding data privacy is an identified barrier to technology adoption. As seen in Figure 25, fully 50% of respondents said that their company had a customer data privacy statement and/or a data terms and conditions agreement, while 39% said they did not and 11% were unsure if they had one.

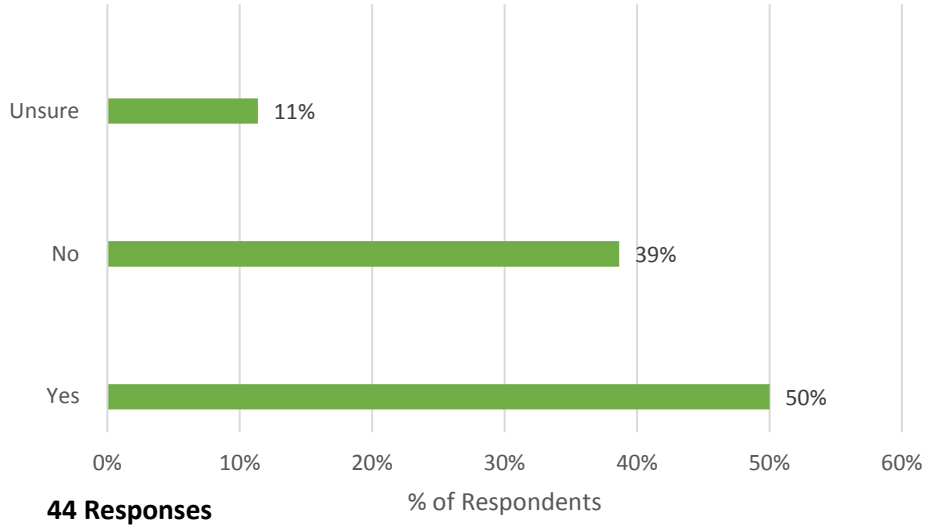


Figure 25. Percentage of Respondents with a Data Agreement

Respondents were also asked how they assisted their clients in managing their farm-level data to assist in a farming business' decision making. A majority said they printed maps (77%) or archived data for future use (52%), while 18% of respondents reported working with farmers by using data aggregated from other producers within their dealership and 5% reported using data aggregated also from producers outside of the dealership (Figure 26). Some respondents said that their customers did not need help with their data (7%) and 34% said that they work only on an individual basis when aggregating data for a client.

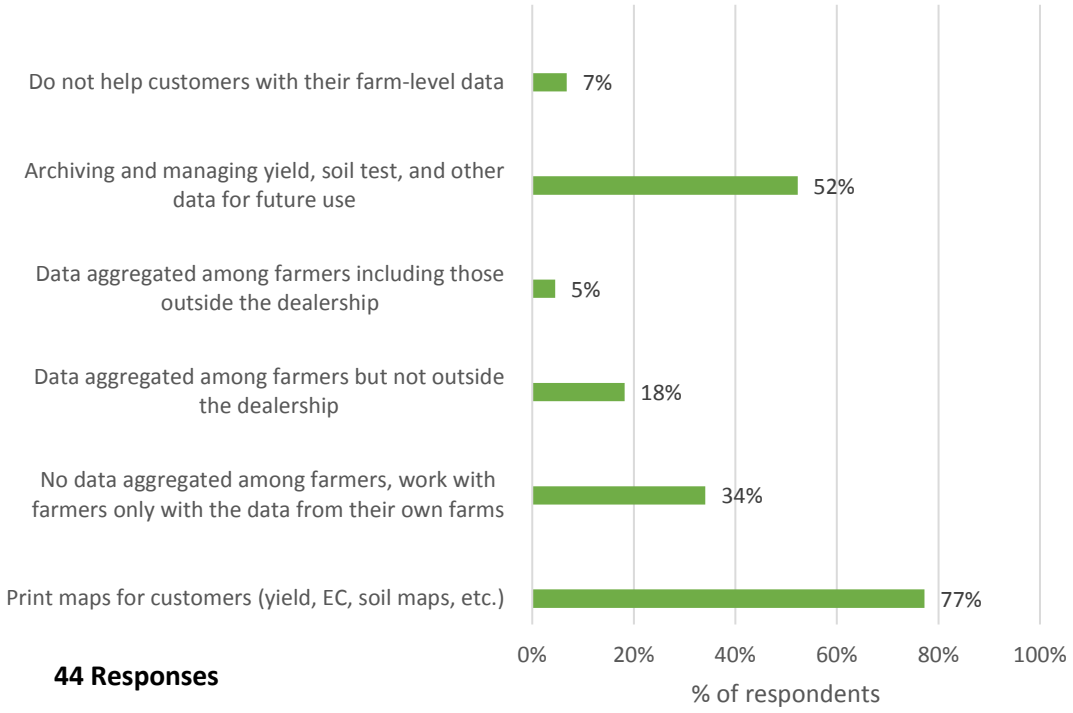


Figure 26. Client Data Management Methods

This data can provide excellent insight when it comes to making various recommendation and decisions surrounding farming practices. The survey asked recipients for what purpose farm-level data was harnessed. The responses can be seen in Figure 27. All of the farming recommendations or decisions that were asked about in the survey, except irrigation decisions, were reported by over 50% of respondents to be somewhat or majorly influenced by farm data.

Phosphorous and potassium application decisions were the most likely crop management practices to be influenced by farm data; 88% of respondents reported that the collected field data had some influence on P and K rates and nearly half said it had a major influence. The data impacted the other cropping practices to some extent. Nitrogen application decisions (84%), hybrid or variety selection (83%), planting rates (83%), hybrid/variety placement (79%), variable seeding rate prescriptions (73%), crop rotation decisions (71%), pesticide selection (69%), and liming decisions (61%) were influenced by data collected through precision agriculture technologies. Irrigation decisions were only reported to be influenced by 18% of

respondents as expected given the relatively low use of irrigation in the province with the exception of vegetable and fruit crops.

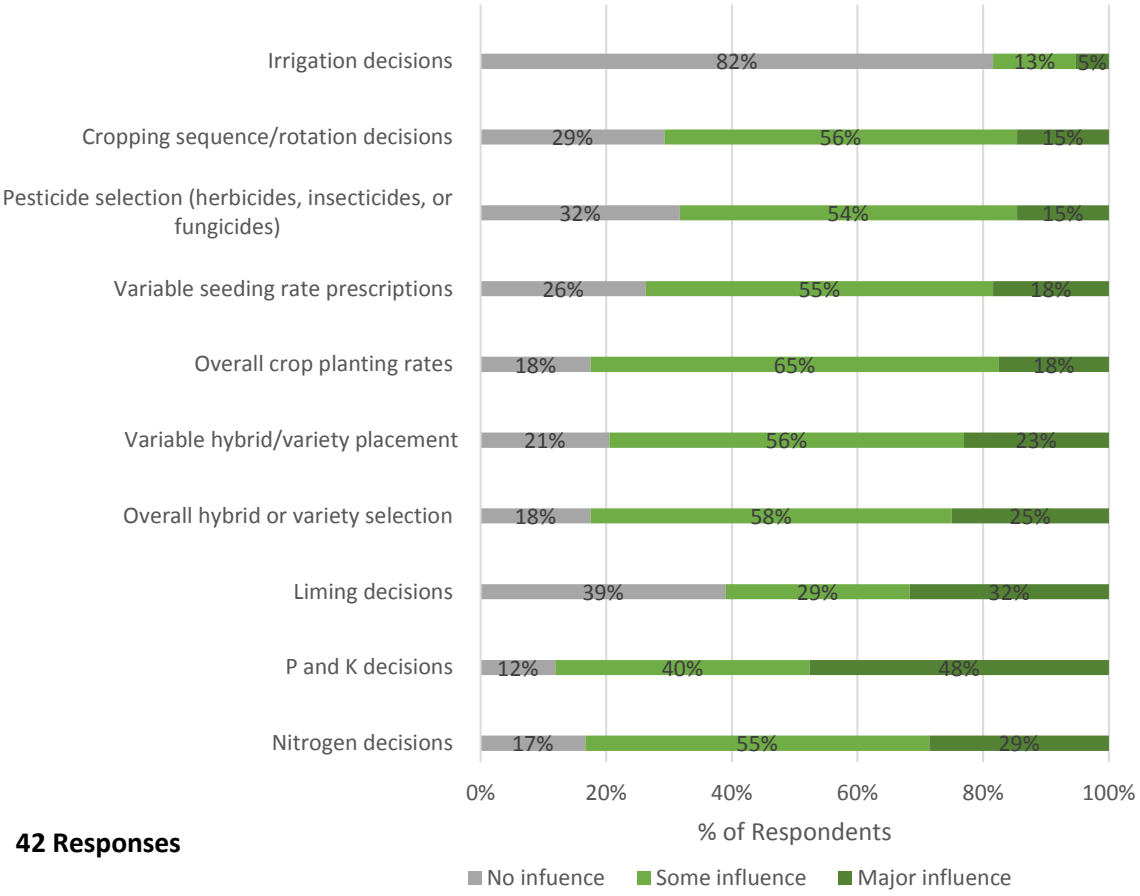


Figure 27. Influence of Farm Data on Decision Making

6. Retailers' Perceptions of Adoption of Precision Agriculture Technologies by Farmers

The prevalence of precision agricultural technologies is projected to continually become more dominant among farmers in the next three years, with some technologies expected to more than double in terms of acres that they are used on. This potentially has broad ranging implications for OABA members, technology producers, farmers, and the agriculture industry as a whole.

Respondents were first asked what percentage of the total acreage in their market area (acreage of all growers, not just their current customers) are currently using each precision agricultural technologies, as well as what percent will be using each of them three years from now. An illustration of the responses can be seen below (Figure 28). Note: the projected use by 2020 represents an additional percentage of the total survey respondents, not the percentage increase from a base of the current use (now). The sum of both the "now" and "2020" groups will yield the total future use by producers.

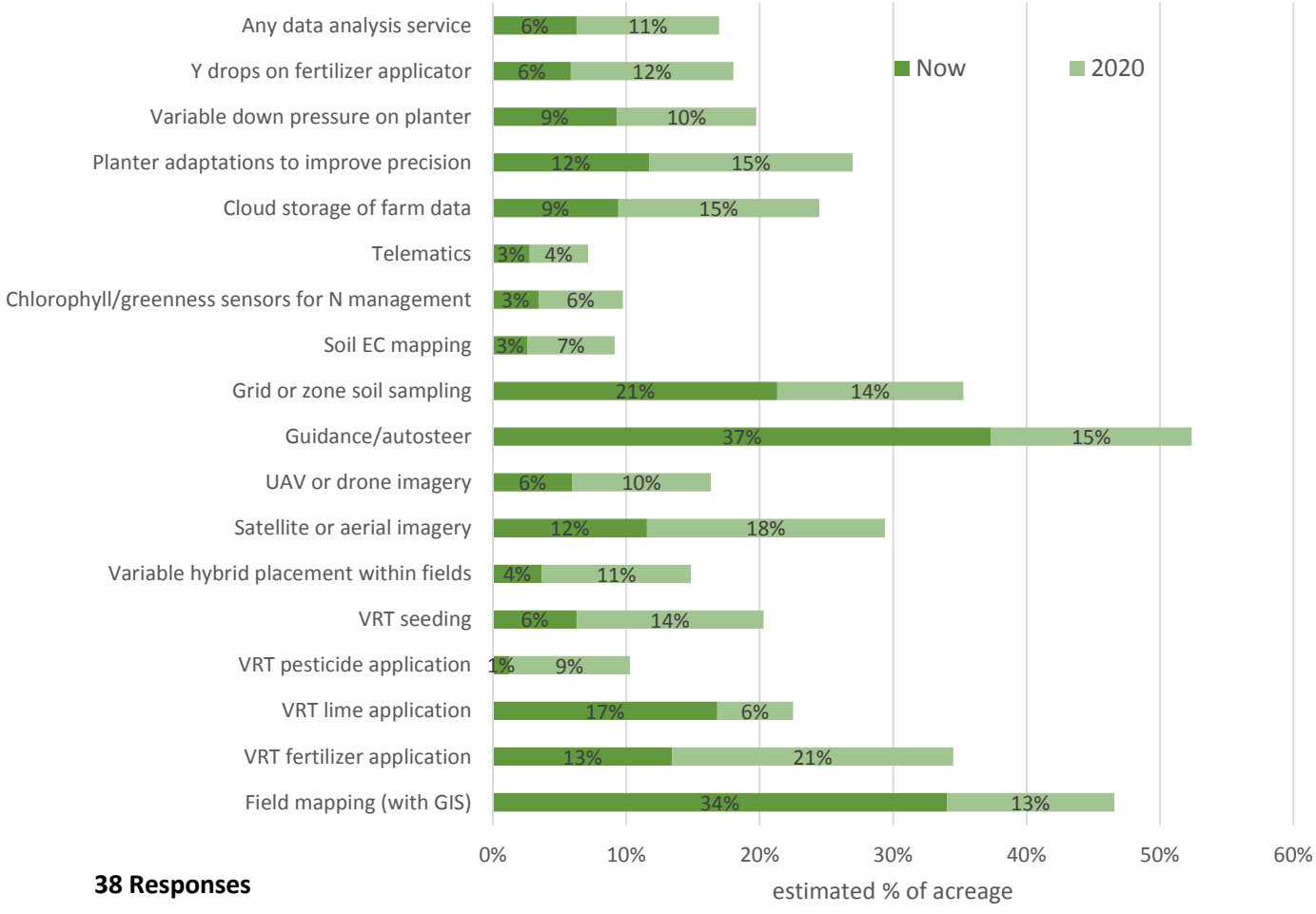


Figure 28. Producer Use of Precision Agricultural Technologies

The perceived levels of adoption of precision agricultural technologies are lower at the individual farmer level than for the agricultural input provider with the exception of field mapping using GIS. For example, approximately one-third of the farmers use GPS guidance systems (Figure 28) whereas over three-quarters of the service providers use autosteer (Figure 10). The largest relative difference in adoption rates between the farmer and input provider is for variable rate technologies. While variable rate is a common service provided by retailers, it is employed to apply fertilizer by approximately 15% of farmers themselves. Thus, the greater the level of investment required in the technology, the greater the relative difference in adoption rate between the individual farmer using in on her own field and the agricultural retailer using it on their customer's fields.

The projected growth in adoption rates for VRT fertilizer application by the individual farmer is estimated by the respondents to nearly triple over the next several years (Figure 28). The adoption rates for the other precision agriculture technologies are projected to increase by approximately 15 percentage points, which represents a 40% increase for autosteer use and a 160% increase for cloud storage given the currently low adoption rate for the latter technology.

The barriers to precision agriculture technology's adoption or expanded use by farmers that the survey attempted to examine were: customers' concerns about privacy, lack of confidence in data based recommendations, data interpretation being too time consuming, soil profile limiting potential, topographical limitations, farm income limitations, and benefits of adoption not justifying costs of the technology.

Overall, responses reflected that customer privacy, the time-consuming nature of data analysis, soil profile, and topography were not perceived as being major impediments to customers' use of precision technologies either on their own, or through the dealership. Whether a lack of customer confidence in data-based recommendations was a major impediment was not decisive, as 37% of respondents agreed or somewhat agreed that it was, while 38% did not think that it was a major barrier to customers utilizing precision services. Farm incomes and technology costs not being justified by its related benefit were perceived decidedly more often as being barrier to adoption, with 11% and 26% more, respectively, agreeing rather than disagreeing with the related statements.

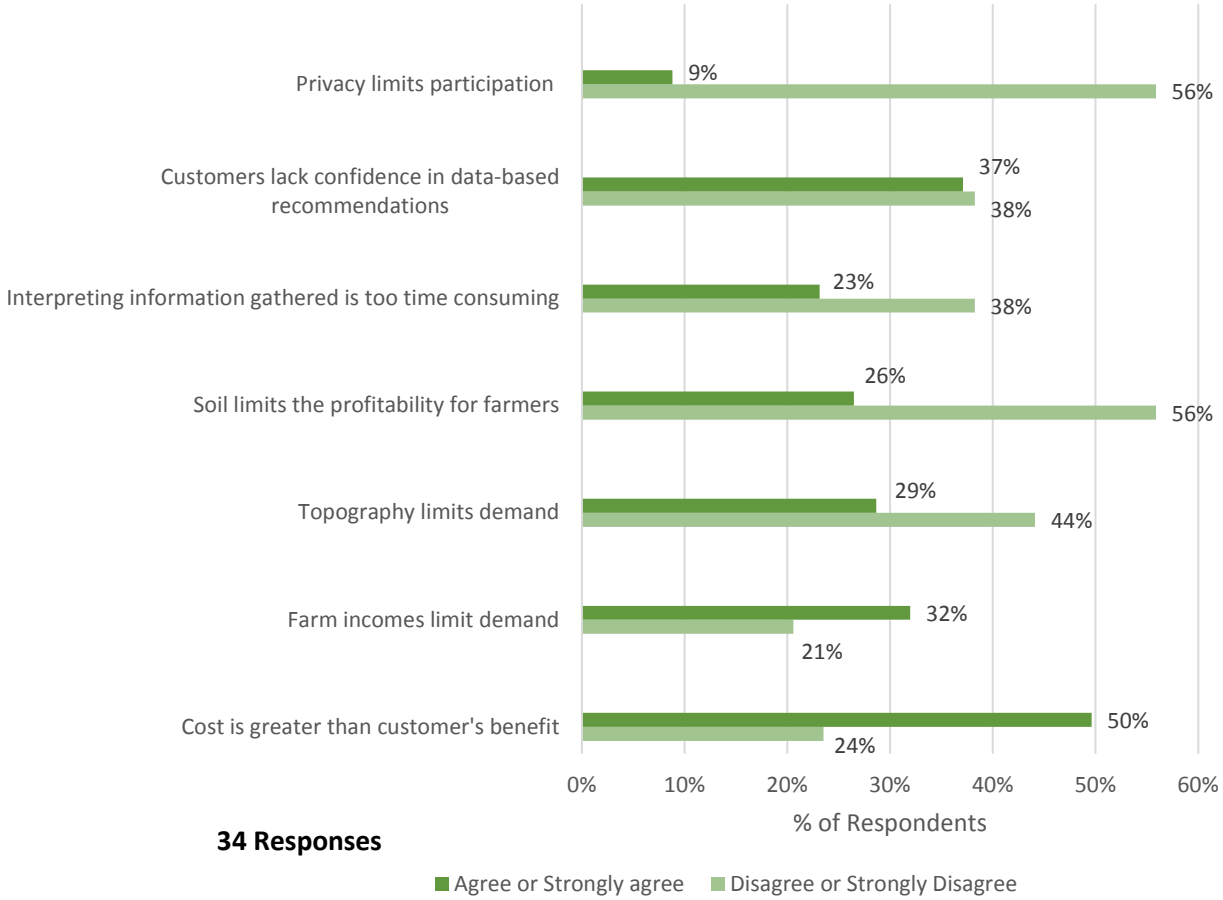


Figure 29. Dealer Identified Barriers to Farmers' Adoption of Precision Agriculture Technologies

7. Future Adoption of Precision Agriculture Technologies by Retailers

The previous section presented the adoption and projected adoption of precision agriculture technologies by individual farmers as perceived by the retailers. This section discusses how the surveyed retailers answered the same question but in terms of their own projected use in 2020 (see Figure 30). As with Figure 28, the projected use by 2020 represents an additional percentage of the total survey respondents, not the percentage increase from a base of the current use (now). The sum of both the "now" and "2020" groups will yield the total future use by producers.

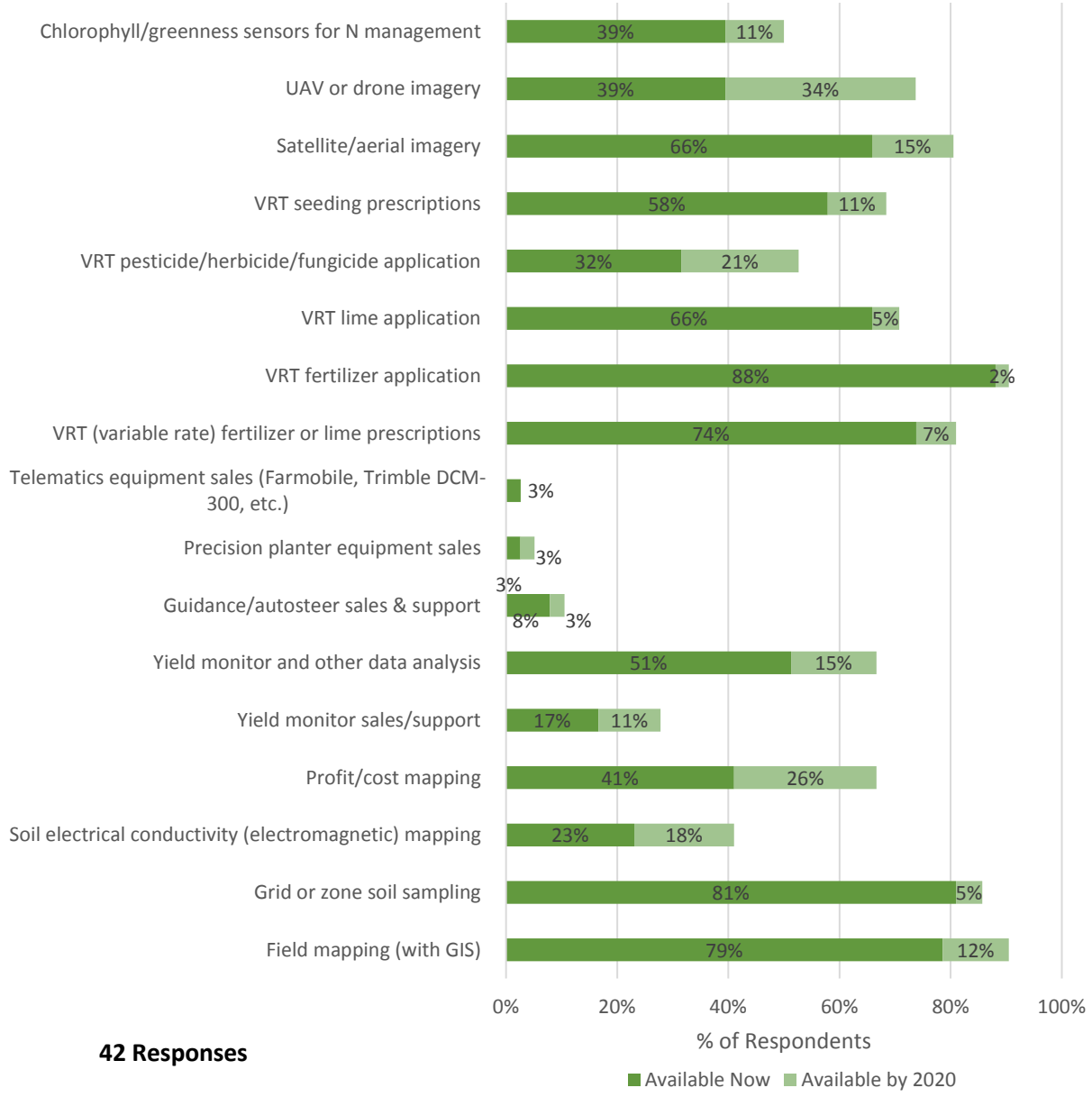
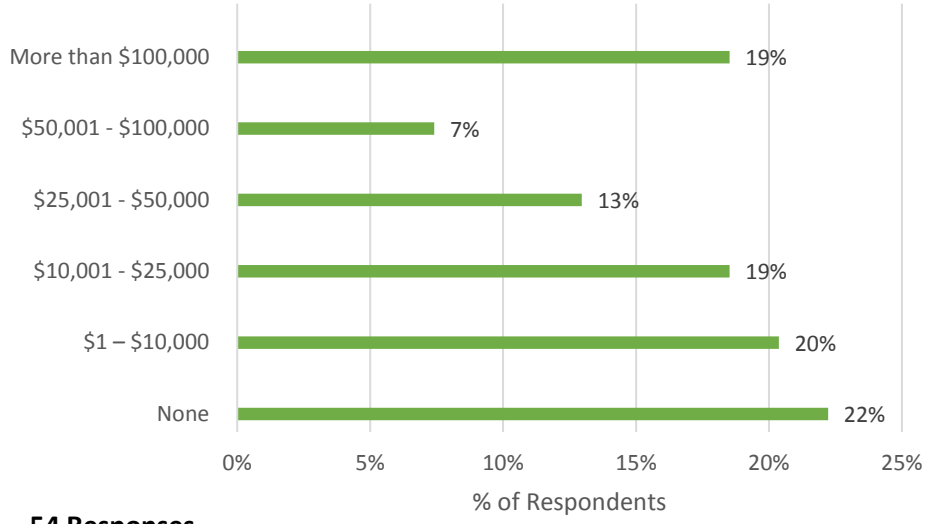


Figure 30. Projected Adoption of Precision Agriculture Technologies by Retailers by 2020

Field mapping with GIS will be offered by over 90% of the respondents by 2020. Other precision agriculture technologies that are currently widely used such as grid or zone soil sampling and VRT fertilizer application will continue to be adopted by more of the respondents but there is little scope for further increases. In contrast, more than half of the respondents will be using VRT for the application of pesticides by 2020 compared to the one-third that currently do so. Observational service technologies, such as electromagnetic mapping, UAV or drone imagery, and chlorophyll/greenness sensors for N management, are the ones with the greatest project growth potential.

How much an agri-business company invests in precision agriculture is directly related to the variety of services that they are able to offer to their customers. This investment is also a good indicator of the long-term financial sustainability of the company in question, and has a relationship with the services that recipients plan on offering in 2020 (Figure 30). Recipients were asked to identify approximately how much they intend to invest in precision agriculture in the next 12 months at their location. This does not take into account the size (i.e. revenue) of their company/location, but it does give insight regarding the value of the precision agriculture sector as a whole.

Approximately three-quarters of the respondents plan to invest in precision agriculture technology this year while only 22% say that they will not be investing in these technologies (Figure 31). Of the 78% that will be investing in precision agriculture, 19% say that they be investing over $100,000, while approximately 40% will be investing less than $25 000.



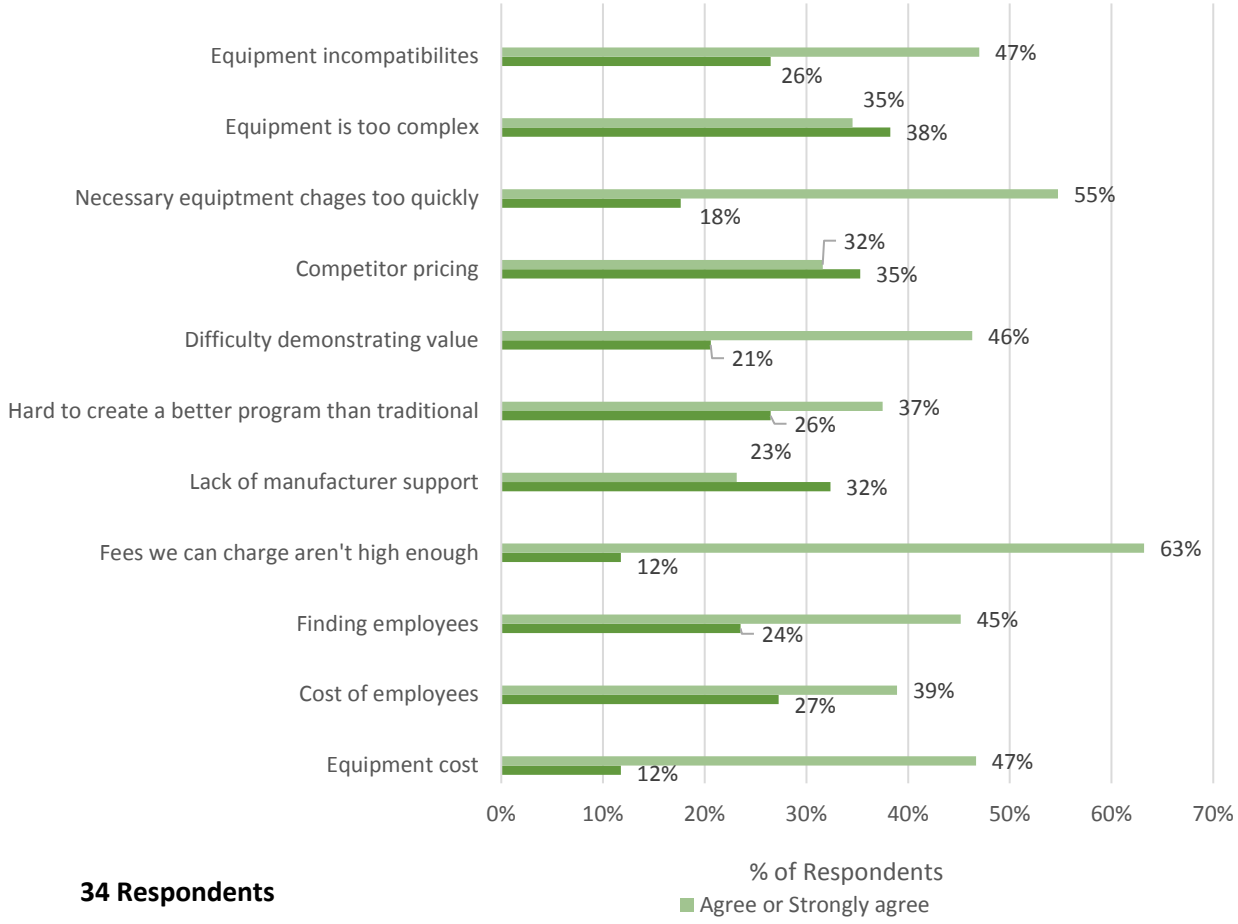
54 Responses

Figure 31. Current Annual Investment in Precision Agriculture Technologies

Based on the growth predicted by respondents, there seems to be sufficient demand for precision agriculture technology and services to counter barriers and obstacles that otherwise hinder adoption of precision agriculture technologies. These impediments do remain, and pose an obstacle for retailers in offering services to farmers, as there are still some dealers who

choose not to offer some precision agriculture services. The barriers that dealers identified in the survey are illustrated in the chart below (Figure 32).

The major barriers to adoption surrounded profitability and adjustment costs. Over 60% felt they could not charge fees high enough to generate sufficient returns and around half felt the costs of the technologies were too expensive resulting 46% feeling it was difficult to demonstrate value of precision agriculture to the farmers. Another set of barriers were associated with the technology itself; either it is changing so quickly to make it obsolete in a short period of time or the compatibility issues with the equipment and/or data. Respondents indicated that technology complexity, competitor pricing, and lack of manufacturer support were not perceived as being major impediments to customers' use of precision technologies either on their own, or through the dealership.



34 Respondents

Figure 32. Dealer Self-Identified Barriers to Further Adoption

8. Summary

Agricultural service providers affiliated with the Ontario Agri Business Association (OABAO were surveyed on the extent to which their businesses use precision agricultural technologies for crop inputs purchased by farmers in Ontario. The responding retailers tended to be located in southwestern Ontario and were either cooperatives or independent dealerships. Over half of the retailers had more than $10 million in sales of agronomic products and services and approximately one-quarter had more than $20 million in sales. Approximately half of the fertilizers and pesticides sold by these companies are custom applied on land managed by the buyer of the inputs and nearly half of the respondents custom apply crop inputs on over 50,0000 acres. Thus, a significant portion of Ontario cropland on which precision agriculture technologies could be employed are directly serviced by the agricultural retailers surveyed.

An indication of the wide spread use of precision agriculture in some form for crop production is that only 4% of respondents report not using precision agriculture at all within their business. The most popular use of the technology within the businesses and in their custom application services are GPS autosteer systems and precision spraying technology to minimize overlap and to ensure complete coverage. Almost all reported using automatic steering for at least some of their custom application and 60% indicated using automatic steering for over 75% of their custom application. In addition to guidance systems, other geographic services widely used were the field mapping and soil sampling. Over 80% offer soil sampling, and while the traditional whole field soil sampling is the most common technique offer, 64% and 53% of respondents offered management zones and grid pattern sampling, respectively. Over three-quarters of respondents offer VRT fertilizer application. While only one-third custom apply pesticides using VRT, there is significant projected growth. Observational service technologies, such as electromagnetic mapping, UAV or drone imagery, and chlorophyll/greenness sensors for N management, are the other precision agricultural services with the greatest project growth potential.

Future adoption of precision agricultural services for crop production are limited by profitability issues either due to the limited value to the farmer and/or the insufficient returns to the input provider. Other barriers to adoption include technological obsolescence associated with the rapid progress in developing advances in the systems, incompatibility between systems gathering the data, assessing the data and applying the prescribed input, and privacy concerns. Despite these barriers, the results suggest continued investment in precision agriculture technologies for crop production in Ontario by both individual farmers and agricultural input providers.

Appendix I: Glossary

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.

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

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

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.

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

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.

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.

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.

Appendix II: Survey Instrument

Dear agricultural retailer,

Since 1981, CropLife America dealerships and Purdue University in Indiana have partnered to undertake a survey that chronicles the development and adoption of precision agriculture. By executing the survey in Ontario, the University of Guelph, along with our sponsor, OMAFRA, aspires to do the same through the Ontario Agri-Business Association (OABA). This will help academia, farmers, and yourself, better understand the development and adoption of precision agriculture techniques by dealers like you from across Ontario.

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 until 2020, at which point it will be destroyed, 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?

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

Q2 Which best describes your input supply business?

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

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

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

Q4 What were the total annual retail sales (in CAD) of agronomic products and services (fertilizer, chemicals, seed, services) at this location in 2016?

- O Under $1,000,000 (1)
- O $1,000,001 - $5,000,000 (2)

O $5,000,001 - $10,000,000 (3)

O $10,000,001 - $15,000,000 (4)

O $15,000,001 - 20,000,000 (5)

O More than $20,000,000 (6)

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

O 0 (1)

O 1 (2)

O 2-5 (3)

O 6-15 (4)

O More than 15 (5)

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

___ 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 How much will your location be investing in precision/site-specific technology during 2017?

O None (1)

O $1 – $10,000 (2)

O $10,001 - $25,000 (3)

O $25,001 - $50,000 (4)

O $50,001 - $100,000 (5)

O More than $100,000 (6)

Q8 In a typical year, how many total acres does you location custom apply (fertilizer, chemicals, seeding – total acres including multiple applications)?

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

Q10 In 2016, approximately what percentage of the sales for each product were custom applied?

Fertilizer (1)	
Herbicide/pesticide (2)	

Q11 Which of the following soil sampling services do you offer? (Select all that apply)

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

Display This Question:

If Which of the following soil sampling services do you offer? (Select all that apply) Grid pattern Is Selected

Q12 What grid size is most commonly used when doing grid pattern soil sampling?

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

Display This Question:

If Which of the following soil sampling services do you offer? (Select all that apply) Management zones Is Selected

Q13 By what factor are management zones determined?

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

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

- ☐ 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 to develop fertilizer prescriptions (8)

☐ UAV or drone to develop seeding prescriptions (17)

☐ UAV or drone to develop fungicide prescriptions (18)

☐ 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 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 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)

Q15 What type of GPS correction do you use for your guidance applications?

O Utilize WAAS (Wide Area Augmentation System) (1)

O Purchase satellite correction (i.e., OmniSTAR XP or HP, StarFire 2) (2)

O Personal RTK base station (fixed or portable) (3)

O Purchase correction from RTK array/cluster (i.e., Deere, Trimble) (4)

O Purchase RTN (Real Time Network) connection (i.e., Trimble ARS Now, Leica iMAX) (5)

O Other (6) _____

Q16 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)	O	O	O	O
VRT (variable rate) fertilizer or lime prescriptions (2)	O	O	O	O
VRT fertilizer application (3)	O	O	O	O
VRT lime application (4)	O	O	O	O
VRT pesticide/herbicide/fungicide application (5)	O	O	O	O
VRT seeding prescriptions (6)	O	O	O	O
Yield monitor sales/support (7)	O	O	O	O
Yield monitor and other data analysis (8)	O	O	O	O
Satellite/aerial imagery (9)	O	O	O	O
UAV or drone imagery (10)	O	O	O	O
Guidance/autosteer sales & support (11)	O	O	O	O
Grid or zone soil sampling (12)	O	O	O	O
Soil electrical conductivity (electromagnetic) mapping (13)	O	O	O	O

Chlorophyll/greenness sensors for N management (14)	O	O	O	O
Precision planter equipment sales (15)	O	O	O	O
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.) (16)	O	O	O	O
Profit/cost mapping (17)	O	O	O	O

Q17 In 2016, approximately what percentage of your total custom application (total acres, all products) used:

GPS guidance systems with manual control (light bar) (1)	
GPS guidance systems with automatic control (autosteer) (2)	
Auto sprayer boom section or nozzle control (3)	
VRT fertilizer/lime prescriptions (4)	
VRT pesticide/herbicide/fungicide application (6)	
Prescriptions from Satellite/aerial imagery (9)	
Prescriptions from UAV or drone imagery (10)	
Prescriptions from Chlorophyll/greenness sensors (11)	
Prescriptions from Soil electrical conductivity (electromagnetic) mapping (12)	

Q18 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)	O	O	O	O	O
VRT (variable rate) fertilizer or lime prescriptions (2)	O	O	O	O	O
VRT fertilizer application (3)	O	O	O	O	O
VRT lime application (4)	O	O	O	O	O
VRT pesticide application (5)	O	O	O	O	O
VRT seeding prescriptions (6)	O	O	O	O	O
Yield monitor sales/support (7)	O	O	O	O	O
Yield monitor and other data analysis (8)	O	O	O	O	O
Satellite/aerial imagery (9)	O	O	O	O	O
UAV or drone imagery (10)	O	O	O	O	O
Guidance/autosteer sales & support (11)	O	O	O	O	O
Grid or zone soil sampling (12)	O	O	O	O	O
Soil EC mapping (13)	O	O	O	O	O
Chlorophyll/greenness sensors (14)	O	O	O	O	O

Precision planter equipment sales (15)	O	O	O	O	O
Telematics equipment sales (Farmobile, Trimble DCM-300, etc.) (16)	O	O	O	O	O
Profit/cost mapping (17)	O	O	O	O	O

Q19 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)

Q20 Does your company have a customer data privacy statement and/or data terms & conditions agreement?

- O Yes (1)
- O No (2)
- O Unsure (3)

Q21 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)	O	O	O
P and K decisions (2)	O	O	O
Liming decisions (3)	O	O	O
Overall hybrid or variety selection (4)	O	O	O
Variable hybrid or variety placement in field (5)	O	O	O
Overall crop planting rates (6)	O	O	O
Variable seeding rate prescriptions (7)	O	O	O
Pesticide selection (herbicides, insecticides, or fungicides) (8)	O	O	O
Cropping sequence/rotation decisions (9)	O	O	O
Irrigation decisions (10)	O	O	O
Other (11)	O	O	O

Q22 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?

Q23 What is the postal code of your business?

Q24 *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? What percent will be using each one in three years?

	Current (1)	Three years from now (2)
Field mapping (with GIS) (1)		
VRT fertilizer application (2)		
VRT lime application (3)		
VRT pesticide application (4)		
VRT seeding (5)		
Variable hybrid placement within fields (6)		
Satellite or aerial imagery (7)		
UAV or drone imagery (8)		
Guidance/autosteer (9)		

Grid or zone soil sampling (10)		
Soil EC mapping (11)		
Chlorophyll/greenness sensors for N management (12)		
Telematics (13)		
Cloud storage of farm data (14)		
Planter adaptations to improve precision (15)		
Variable down pressure on planter (16)		
Y drops on fertilizer applicator (17)		
Any data analysis service (Encirca, FieldView, FBN, FarmServer, etc.) (18)		

Q25 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)	O	O	O	O	O
My farmers are interested in precision services, but pressure on farm income in my area limits their use (2)	O	O	O	O	O
The topography (i.e., rolling ground, etc.) in my area limits use of precision services by farmers (3)	O	O	O	O	O
Soil types in my area limit the profitability of precision agricultural practices for my customers (4)	O	O	O	O	O
Interpreting and making decisions with precision agricultural information takes too much of my customer's time (5)	O	O	O	O	O

Customers lack confidence in the agronomic recommendations made based on site-specific data (e.g., yield maps, GPS soil sampling, remote sensing) (6)	O	O	O	O	O
Customer concerns with data privacy limit their participation (7)	O	O	O	O	O
The cost of the equipment required to provide precision services limits our precision offerings (8)	O	O	O	O	O
The cost of the employees who can provide precision services is too high for precision ag to be profitable (9)	O	O	O	O	O
It is difficult to find employees who can deliver precision agricultural services (10)	O	O	O	O	O
The fees we can charge for precision services are not high enough to make precision services profitable (11)	O	O	O	O	O

Lack of manufacturer support for precision services limits our ability to provide such services (12)	O	O	O	O	O
Creating a precision program that adds significantly more value for the grower than a traditional agronomic program is difficult for us (13)	O	O	O	O	O
Demonstrating the value of precision services to our growers is a challenge (14)	O	O	O	O	O
Our competitors price precision agricultural services at levels that are not profitable for us (15)	O	O	O	O	O
The equipment needed to provide precision services changes quickly, increasing my costs (16)	O	O	O	O	O
The equipment required to deliver precision services is too complex for many of my employees to use (17)	O	O	O	O	O

Incompatibilities across types of precision equipment and technology (different data formats, inability to share information) limit my ability to offer precision services (18)	O	O	O	O	O