

Precision Farming Services in Tennessee: Results of a 1999 Survey of Precision Farming Service Providers

Roland K. Roberts, Burton C. English and David E. Sleigh

Research Report 00-06
March 2000

Department of Agricultural Economics and Rural Sociology
Tennessee Agricultural Experiment Station
The University of Tennessee
Knoxville, Tennessee

Funding for this research was provided by Cotton Incorporated and the Tennessee Agricultural Experiment Station. The authors acknowledge Darrell Mundy, John Brooker, John Riley, Debbie Sharp, and Marty Danilchuk for their contributions to this work.

Precision Farming Services in Tennessee: Results of a 1999 Survey of Precision Farming Service Providers

INTRODUCTION

Precision farming is used to manage yield-potential variability within a field caused by variation in soil chemical and physical properties. It includes methods for 1) gathering information to identify management zones within a field, each of which is more homogeneous in yield potential than the field as a whole, 2) using the information to make decisions about optimal input application rates for each management zone, and 3) applying the inputs according to the decisions made (Mahajanashetti, English, and Roberts). The site-specific management methods used in the United States in earlier years were mostly lost to less costly, large-scale mechanization as field sizes expanded. With large-scale mechanization, farmers began treating fields as homogeneous units, applying inputs at uniform rates. In recent years, a set of new technologies has been developed to provide farmers with the potential benefits of site-specific management while still using relatively low-cost, large-scale machinery (Swinton and Lowenberg-DeBoer). Using these new technologies for precision farming could provide private economic gains and societal economic and environmental benefits (National Research Council).

Precision farming services have been available to farmers from off-farm providers for many years. Some common examples include soil mapping and aerial photography. More recently precision farming services using Global Positioning Systems (GPS), Geographic Information Systems (GIS), sensors, and variable rate input application technologies have become commercially available to producers through off-farm service providers (Lowenberg-DeBoer and Swinton; Swinton and Ahmad; Swinton and Lowenberg-DeBoer). Among others, these new precision farming services include grid soil sampling, processing and analyzing geo-referenced data, variable rate input application, and servicing precision farming equipment. To

date, the availability of precision farming services for Tennessee farmers has not been documented. Specific information about the available services would benefit Tennessee farmers and service providers alike by making the availability of these services more widely known and giving farmers more options in managing their fields. The objective of this study was to document the types, costs, and location of precision farming services available to Tennessee farmers from off-farm service providers.

METHODS

Information was gathered from a telephone survey of 51 farm service dealers, crop consultants, and custom applicators who were potential providers of precision farming services to Tennessee farmers. The 51 firms included potential providers located in Tennessee and potential out-of-state providers located within 60 miles of the state boundaries. Their names and telephone numbers were obtained from County Extension Agents, the Directory of the National Alliance of Independent Crop Consultants, soil testing laboratories, various sites on the Internet, and other scientists who were researching precision farming issues.

The telephone survey was conducted in April and May of 1999 using a questionnaire developed to query persons responsible for precision farming services at the identified firms. If the person was not contacted after two telephone calls, a message was left. The responsible person received a third telephone call after five business days if the call was not returned. If the responsible person was not contacted after the third attempt, no further attempts were made.

The first question was designed to eliminate those who did not provide precision farming services within Tennessee. Of the 51 potential respondents, 47 were contacted; 23 indicated that their firms provided precision farming services within Tennessee and all 23 provided

information about those services. The following information was collected from the 23 individuals who responded: 1) the counties in Tennessee where precision farming services were provided, 2) the precision farming services provided and the rates charged for those services, 3) the number of farmers by county using those services who had yield monitors with and without GPS, 4) the crops and acreages for which their precision farming services were provided, 5) the number of additional or fewer customers expected to be using each of their services in the following year (2000) and five years (2004) in the future, 6) the additional precision farming services they planned to provide in the future, and 7) the types of precision farming equipment and computer applications they used to provide their services (Appendix).

Information related to variable rate input application was also collected. Respondents provided the following information: 1) the inputs for which they typically provided application maps, 2) whether they used single- or multiple-bin applicators for variable rate fertilizer application, and 3) the additional amount they would charge for variable rate versus uniform rate nitrogen application.

RESULTS AND DISCUSSION

Counties Where Services Were Provided (Question 2)

The results indicated that some form of precision farming service was provided to farmers in 27 Tennessee counties (Figure 1). Of those 27 counties, 52% (14 counties) were

located west of the Tennessee River. Other areas where firms provided precision farming services were the northcentral (five counties), southcentral (four counties), and southeastern

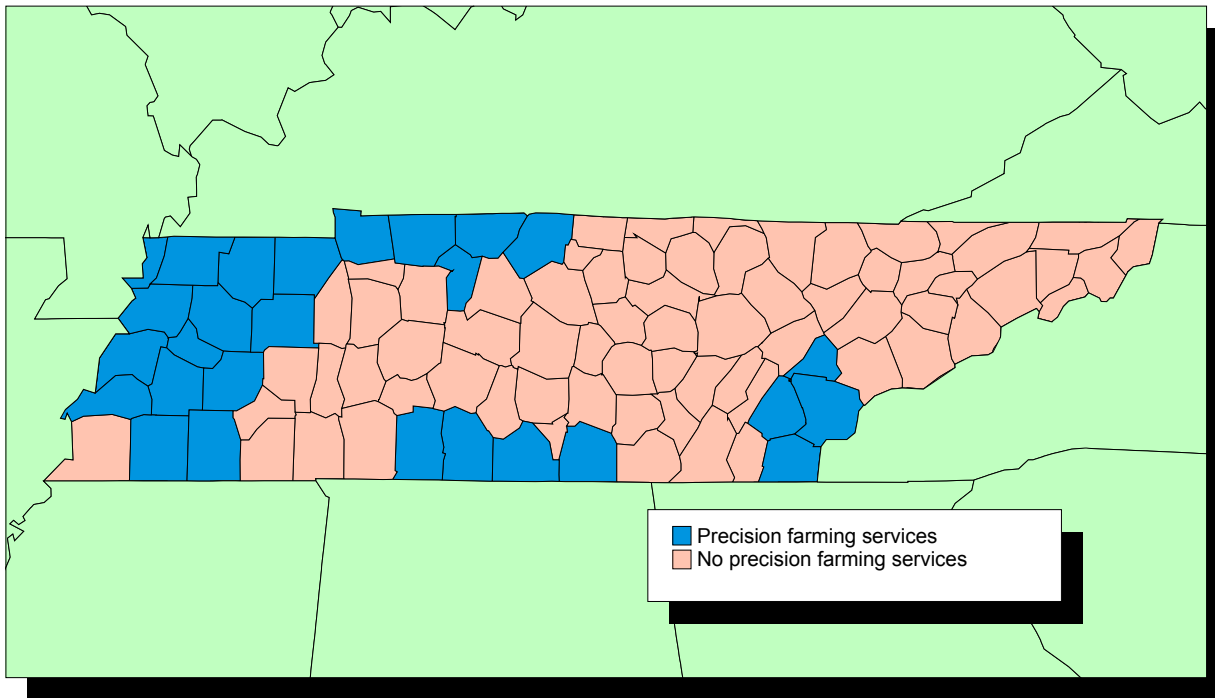


Figure 1. Counties with firms providing precision farming services (four counties) regions of the state. Of the 23 firms, 15 (65%) provided precision farming services to farmers in more than one Tennessee county. This result led to the clustering of counties with access to precision farming services. In fact, all counties with access to precision farming services were adjacent to at least one other county with access to precision farming services.

Precision Farming Services Provided and Rates Charged (Question 3a)

Precision farming services provided included precision soil sampling, processing and analyzing geo-referenced data, variable rate input application, and other services (Table 1).

Table 1. Precision Farming Services Provided to Tennessee Producers and Average Rates Charged for Those Services, 1999

Precision Farming Service Provided	Average Cost	Range [†]	
		Min	Max
Precision soil sampling: (\$/acre)		
Grid soil sampling, lab analysis, and fertility recommendations, 2.5-acre grid	7.05	1.75	10.00
Grid soil sampling, lab analysis, and fertility recommendations, 5-acre grid	7.00		
Grid soil sampling, lab analysis, and fertility recommendations, 10-acre grid	7.00		
Grid soil sampling, lab analysis, and fertility recommendations, 15-acre grid	4.00		
Grid soil sampling only, 2.5-acre grid	2.00		
Soil sampling by soil-type contour and topography without GPS	3.25		
Processing and analyzing geo-referenced data:			
Fertility mapping, recommendations and application prescriptions	0.63	0.40	1.00
Yield mapping from yield monitor data	0.50	0.21	1.00
Geo-referenced field mapping and measurement	1.65	0.75	4.50
GPS data processing and analysis (\$/hour)	30.00		
Variable rate input application:			
Variable rate P and K application (spreading fee)	5.75	4.00	8.00
Variable rate lime application (spreading fee)	4.70	4.00	9.00
Other services:			
Service on yield monitor (\$/hour)	30.00		
Aerial input application using GPS, but not variable rate	—		

[†] Ranges are not reported when fewer than three firms reported providing the service.

Precision soil sampling services included grid soil sampling with and without lab analysis and fertility recommendations, and soil sampling by soil-type contour and topography. Processing and analyzing geo-referenced data included soil fertility mapping, fertility recommendations and application prescriptions; yield mapping from yield monitor data; geo-referenced field mapping and measurement; and GPS data processing and analysis services such as cross-referencing data, overlaying maps, and comparing yields to varieties. Variable rate input application included variable rate application of fertilizer and lime. Other services included yield monitor repairs and aerial application using GPS technology to apply seed, pesticide, and fertilizer, but not for variable rate application across fields.

Average rates charged for the reported services are shown in Table 1. Grid soil sampling was usually offered with a package of services including a lab analysis of soil samples and fertility recommendations based on sample results. Rates charged for 2.5-acre grid soil sampling ranged from \$1.75 to \$10/acre and averaged \$7.05/acre (14 firms). The most common rate charged was \$8.00/acre (five firms). The average rate would be \$7.46/acre if the low of \$1.75/acre were excluded from these calculations. The rates charged for grid soil sampling decreased only slightly for 5-acre (\$7.00/acre) and 10-acre (\$7.00/acre) grid sizes, although fewer firms offered those services. (The number of firms is not reported if fewer than five firms reported offering the service.) The average charge for grid soil sampling on a 15-acre grid decreased to \$4/acre. An average fee of \$2/acre was charged for 2.5-acre grid soil sampling without a lab soil analysis or fertility recommendations. Lastly, the average charge for soil sampling based on soil-type contour and topography was \$3.25/acre.

With regard to processing GPS-related data, charges for soil fertility mapping, fertility recommendations and application prescriptions averaged \$0.63/acre (range \$0.40 to \$1/acre). Yield mapping from yield monitor data was provided to farmers for an average of \$0.50/acre (range \$0.21 to \$1.00/acre). The rate for field mapping and measuring ranged from \$0.75 to \$4.5/acre and averaged \$1.65/acre (five firms). Finally, an average of \$30/hour was charged for processing and analyzing geo-referenced data.

Spreading charges for variable rate P and K application ranged from \$4 to \$8/acre and averaged \$5.75/acre (eight firms), while charges for variable rate lime application ranged from \$4 to \$9/acre and averaged \$4.70/acre (six firms). Responding firms offered uniform rate P and K application for an average charge of \$3.85/acre (range \$3.25 to \$4.5/acre) (not reported in Table 1), which is \$1.90/acre less than the average charge for variable rate P and K application. Also, firms reported spreading charges for uniform rate application of lime averaging \$3.75/acre (range \$1.75 to \$4.5/acre) (not reported in Table 1), which is \$0.95/acre less than the average charge for variable rate lime application. Lastly, the average charge for servicing yield monitors was \$30/hour.

Counties with Farmers Using Precision Farming Services (Question 3b)

The surveyed firms provided services related to grid soil sampling to 170 Tennessee crop producers in 26 counties (Figure 2). Producers were located in the western (14 counties), northcentral (four counties), southcentral (four counties), and southeastern (four counties) regions of the state, with a majority of 124 producers (73%) located west of the Tennessee River. (Numbers of farmers are not given by county to avoid disclosure.) A total of 88 producers used variable rate

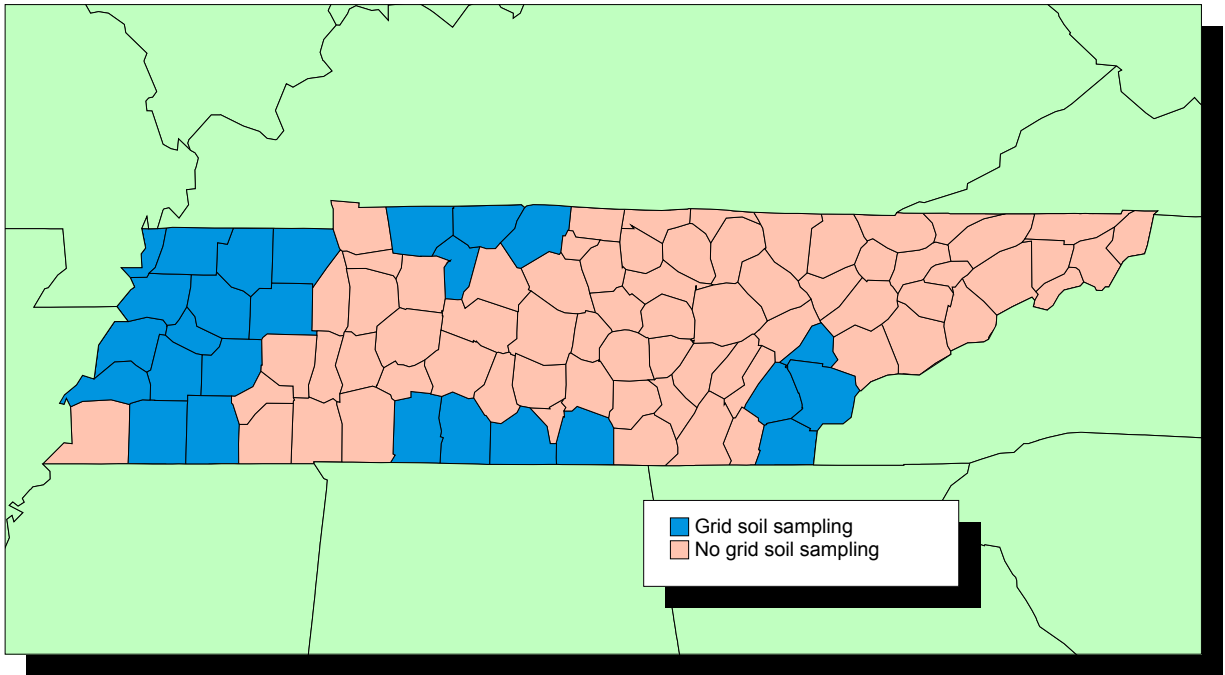


Figure 2. Counties with firms providing grid soil sampling services

fertilizer and/or lime application services in 18 counties (Figure 3) and most producers who used this service (53 producers) were located west of the Tennessee River. The percentage of farmers using variable rate application services compared to those using grid soil sampling services was 52%.

Counties with Farmers Using Yield Monitors (Questions 3c-3d)

Only 41 producers in 12 counties who were clients of the responding firms used yield monitors. Of those 41 producers, 35 (85%) were in nine counties west of the Tennessee River (not reported in a figure). Furthermore, only 14 farmers in eight counties who used precision farming services from an off-farm provider were reported to have yield monitors equipped with GPS and all but two were located in seven counties in the western region of the state. The results indicate that most farmers who used the precision farming services of off-farm firms did not have yield monitors.

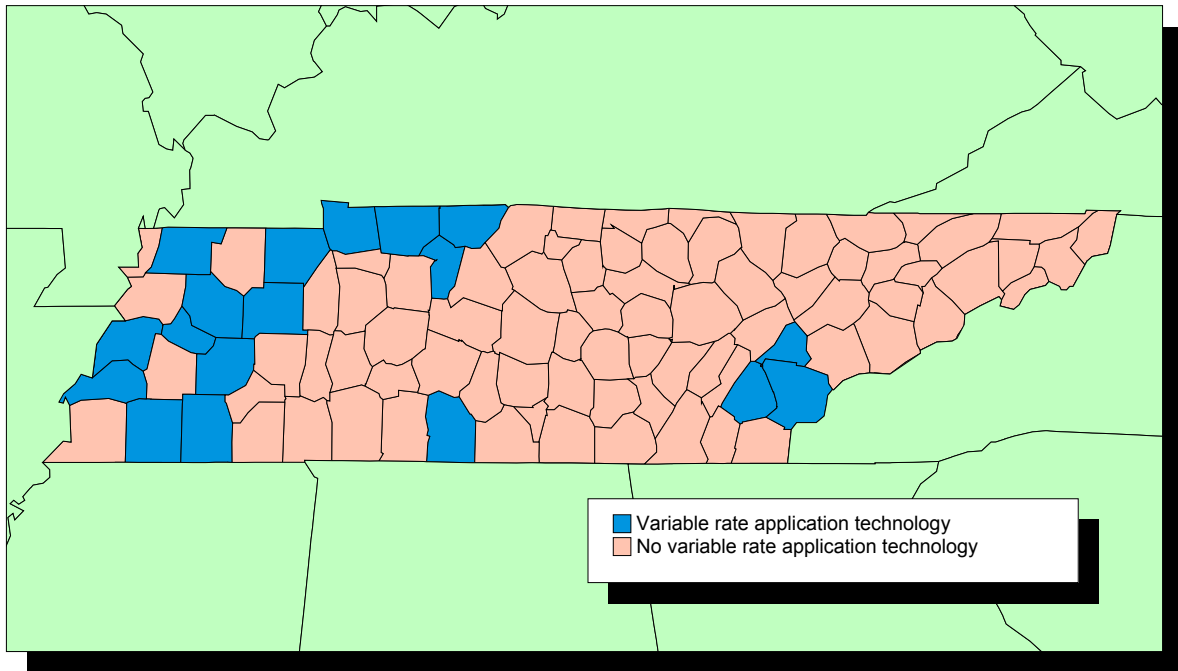


Figure 3. Counties with firms providing variable rate fertilizer and/or lime application services

Moreover, a companion survey of Agricultural Extension Agents (English, Roberts, and Sleigh) found that yield monitors were used by farmers in 34 counties and yield monitors with GPS were used in 21 counties. When these surveys are compared, the results suggest that most farmers who had yield monitors were not using the precision farming services of off-farm firms.

Crops for Which Services Were Provided (Question 3e)

The crops produced using precision farming services included corn, soybeans, wheat, cotton, sorghum, rice, hay, and pastureland (Table 2). Respondents reported a total of 110,525 acres using the grid-soil-sampling services of off-farm service providers. Crops produced with grid soil sampling

Table 2. Acreages of Crops Produced Using Grid Soil Sampling and Variable Rate Lime and/or Fertilizer Application and the Percentage of Grid Soil Sampled Acres Receiving Variable Rate Applications, 1999

Crop	Precision Farming Services		
	Grid soil sampling	Variable rate application of lime and/or fertilizer	Grid soil sampled acres receiving variable rate lime and/or fertilizer
	(acres)	(acres)	(percent)
Corn grain or silage	29,600	9,900	33
Soybeans [†]	20,875	5,765	28
Wheat [†]	13,900	4,765	34
Cotton	44,750	10,075	23
Sorghum	700	100	14
Rice	500	0	0
Pasture and hay	<u>200</u>	<u>200</u>	<u>100</u>
Total	110,525	30,805	28

[†] When soybean and wheat acres were reported as doublecropped, the number of acres was reported for both soybeans and wheat.

were cotton (40%), corn and corn silage (27%), soybeans (19%), wheat (13%), sorghum (less than 1%), rice (less than 1%), and hay and pasture (less than 1%).

Variable rate application from off-farm service providers totaled 30,805 acres, with cotton having the highest acreage of 10,075 acres. Although the acreage receiving variable rate application was highest for cotton, the percentage of acres that received variable rate application compared to the acreage receiving grid soil sampling (23%) was lower than for corn (33%), wheat (34%), soybeans (28%), and pasture and hay (100%).

Demand Expectations of Firms (Question 3f)

Table 3 shows the anticipated number of Tennessee producers in 2000 and 2004 using three precision farming services, along with percentage changes from 1999. For geo-referenced

Table 3. Number of Tennessee Farmers Using Specified Precision Farming Services Offered by Off-farm Service Providers in 1999 and Projected for 2000 and 2004

Precision Farming Service	Number of Farmers in 1999	Projected Number of Farmers in 2000 (Percent Change from 1999)	Projected Number of Farmers in 2004 (Percent Change from 1999)
Geo-referenced mapping & measurement	9	18 (100)	48 (433)
Grid soil sampling	170	210 (24)	371 (118)
Variable rate fertilizer and lime	88	139 (58)	332 (277)

field mapping and measurement, firms anticipate doubling the number of farmers using their services from nine in 1999 to 18 in 2000 and further increasing the provision of this service to 48 farmers in 2004. The surveyed firms anticipated increasing their provision of grid soil sampling from 170 farmers in 1999 to 210 (24% increase) in 2000. They expected the provision of this service to increase by 118% to 371 farmers in 2004. Variable rate fertilizer and lime application was expected to increase from 88 farmers in 1999 to 139 (58% increase) in 2000 and 332 (277% increase) in 2004. The anticipated percentage increase in variable rate application was greater than the anticipated percentage increase in grid soil sampling, suggesting that firms expect more of the farmers who use grid soil sampling to also use variable rate application of fertilizer and/or lime in the future. In fact, the anticipated percentage of farmers receiving variable rate input application services compared to

those receiving grid-soil-sampling services is 66% for 2000 and 89% for 2004, compared with 52% in 1999.

Anticipated New Services Provided in the Future (Question 3g)

Nine firms (39%) said they did not plan to offer additional services in the future beyond what they offered at the time of the survey, while 14 said they planned to offer at least one of the following additional services in the future: precision farming equipment sales; field mapping; yield mapping; 5-acre and 10-acre grid soil sampling; aerial photography with geo-referencing; variable rate input application, including seed, lime, fertilizer, herbicide, side-dressed nitrogen, and insecticide; geo-referenced crop scouting; experimental use of remote sensing; measurement of soil electro-conductivity; and a complete precision package, including decisions on inputs, varieties, and insect and weed control.

Precision Farming Equipment Used in Providing Services (Question 3h-3i)

Equipment used by firms to offer their services included GPS receivers, four-wheelers, personal computers, and variable rate trucks, control beds and applicators. Yield monitors used by farmers who were serviced by the responding firms were Greenstar and AgLeader. Computer software used for processing and analyzing geo-referenced data included the Rockwell Vision System, Instant Survey, Agris AgLink, and Agris FieldLink.

Input Application Maps Provided with Soil Sampling Service (Question 4)

Sixteen firms that provided grid soil sampling services also offered input application maps. Application maps for phosphorus, potassium, lime, and nitrogen were typically provided with grid soil sampling services. In addition, a number of firms offered application maps for other elements including sulfur, sodium, boron, zinc, copper, aluminum, and magnesium. Three respondents

specifically stated that they did not offer application maps for nitrogen and one firm did not offer application maps for lime.

Variable Rate Lime and Fertilizer Application Equipment (Question 5)

Variable rate lime and/or fertilizer application was provided by 12 firms using single-bin applicators. One of those firms also had a single micronutrient bin. Three respondents with single-bin applicators used them for lime application only. Another of those respondents used both single-bin and two-bin applicators. One respondent used a three-bin applicator that also had two micronutrient bins.

The typical method of variable rate P and K application with a single-bin applicator was to mix P and K according to the average needs of the field and then variable rate apply the mixture according to the requirements of the most limiting nutrient. This method over-applies the least limiting nutrient in some parts of the field and under-applies it in other parts of the field. Variability in this year's least limiting nutrient can be corrected by variable rate application of a P and K mixture according to that nutrient's requirements in the following year. However, true variable rate N, P, and K application requires either a three-bin applicator or three trips across the field with a single-bin applicator. Similarly, variable rate application of micronutrients requires multiple micronutrient bins or several trips across the field.

Cost Differences in Variable and Uniform Rate Nitrogen Application (Question 6)

Variable rate nitrogen application was not typically a service provided by the 23 firms surveyed; however, 10 respondents provided satisfactory information about the difference they would charge for variable rate nitrogen application versus uniform rate application if they were to provide it. The difference in cost ranged from a low of \$1.50/acre to a high of \$5.50/acre and averaged

\$3.08/acre. Extra charges for variable rate compared to uniform rate application included creation of a nitrogen application map and variable rate application of the nitrogen.

CONCLUSIONS

The numbers of Tennessee producers reported to be using grid soil sampling (170 producers) and variable rate fertilizer and/or lime application (88 producers) are less than 0.5% of the total number of farms harvesting crop acreage in Tennessee (56,016 farms) and less than 1% of the number of farms with sales over \$10,000 (21,288 farms) (U.S. Department of Agriculture, 1999). Furthermore, acreages of corn (29,600 acres), soybeans (20,875 acres), cotton (44,750 acres), and wheat (13,900 acres) produced with precision farming services from off-farm firms are 4%, 2%, 9%, and 5% of the total acreages of corn (575,878 acres for grain), soybeans (1,156,282 acres for beans), cotton (472,165 acres), and wheat (305,175 acres for grain) harvested in Tennessee, respectively (U.S. Department of Agriculture, 1999). Even with anticipated growth rates between 1999 and 2004 of 118% for grid soil sampling and 277% for variable rate fertilizer and/or lime application, the anticipated increase in demand for these services would not dominate Tennessee agriculture; however, these new precision farming technologies are more complex than traditional technologies that treated fields as uniform entities. Compared to traditional technologies, mastering and keeping up with these complex precision farming technologies is difficult and may become even more difficult in the future. Hiring qualified personnel who can understand and effectively utilize these rapidly developing technologies is imperative if firms are to instill in farmers the confidence necessary to demand their services. The resources of firms that provide precision farming services to farmers are being challenged and may be even more challenged in the future as they attempt to hire qualified personnel to effectively provide these services to farmers.

To meet the current and future needs of farmers and the firms that provide precision farming services to them, the authors suggest that the University of Tennessee Institute of Agriculture (UTIA) develop effective precision farming extension programs to train farmers and others with a basic understanding of these technologies and their use. One of many possible programs would be to provide web-based soil survey maps and training on how to download and overlay these maps on field maps. Another contribution within the mission of UTIA would be to modify student instructional programs to produce highly qualified employees for firms that provide precision farming services to farmers and to train future farmers in the use of these technologies. Finally, UTIA should continue its research efforts to assess the production efficiency and the economic and environmental benefits of existing precision farming technologies developed by industry and to develop new technologies that will yield greater returns than traditional technologies while preserving the environment.

REFERENCES

- English, B.C., R.K. Roberts, and D.E. Sleight. "Spatial Distribution of Precision Farming Technologies in Tennessee." Tennessee Agricultural Experiment Station, Department of Agricultural Economics and Rural Sociology, Research Report 00-05, 2000.
- Lowenberg-DeBoer, J., and S.M. Swinton. "Economics of Site-Specific Management in Agronomic Crops." Purdue University, Department of Agricultural Economics, Staff Paper 95-14, 1995.
- Mahajanashetti, S.B., B.C. English, and R.K. Roberts. "Spatial Break-Even Variability for Custom Hired Variable Rate Technology Adoption." Paper presented at the Annual Meeting of the American Agricultural Economics Association, Nashville, TN, August 8-11, 1999.
- National Research Council. *Precision Agriculture in the 21st Century: Geospatial and Information Technologies in Crop Production*. Washington, D.C.: National Academy Press, 1997.
- Swinton, S.M., and M. Ahmad. "Returns to Farmer Investments in Precision Agriculture Equipment and Services." pp. 1009-1018. In (eds. P.C. Robert, R.H. Rust, and W.E. Larson) *Proceedings of the Third International Conference on Precision Agriculture*. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, WI, 1996.
- Swinton, S.M., and J. Lowenberg-DeBoer. "Evaluating the Profitability of Site-Specific Farming." *Journal of Production Agriculture* 11(1998):439-446.
- Tennessee Department of Agriculture. *Tennessee Agriculture, 1999*. Tennessee Agricultural Statistics Service, Nashville, TN, 1999.
- U.S. Department of Agriculture. *1997 Census of Agriculture: Tennessee State and County Data*. Vol. 1, Geographic Area Series, Part 42. National Agricultural Statistics Service, Washington, D.C., 1999.

**APPENDIX:
SURVEY OF PRECISION FARMING SERVICE PROVIDERS, APRIL-MAY 1999**

May I please speak with a representative in charge of precision farming services?

My name is _____ from the Department of Agricultural Economics at the University of Tennessee. I am surveying farm dealers and crop consultants to develop a better understanding of the scope and cost of the precision farming services that are available to Tennessee producers.

The information you provide to us will be used for research purposes and no reference will be made in oral or written reports which could link participants to the study. Your participation in this study implies consent. Do you have a few minutes to answer some questions?

1. Do you currently provide precision farming services to crop producers in Tennessee? If no, stop.
2. To which counties in Tennessee do you provide your precision farming services?
3. The following questions deal with the precision farming services you provide related to **collecting site-specific, crop-related information, making decisions using the information collected, and variable rate applying inputs based on those decisions.**
 - a. What precision farming services do you provide in Tennessee? What are the rates you charge for each of these services and for uniform rate application?
 - b. By county, how many Tennessee farmers use each of these precision farming services?
 - c. By county, how many of these farmers have yield monitors with GPS?
 - d. By county, how many of these farmers have yield monitors without GPS?
 - e. For what crops do you apply each of these precision farming services in Tennessee? What is the acreage of the crops for which you apply each of these services?
 - f. How many additional customers or how many fewer customers do you expect to be using each of these precision farming services next year? Five years from now?
 - g. What additional precision farming services do you plan to provide in the future?
 - h. What types of precision farming equipment do you use (if any) to provide these precision farming services?
 - i. What precision farming computer application(s) do you use (if any) to provide these precision farming services?

4. If you grid soil sample, for which attributes including lime do you typically provide application maps?
5. If you provide variable rate fertilizer application service, do you use single-bin or multiple-bin applicators? Please describe your method of variable rate application.
6. If a farmer asked you to provide variable rate nitrogen application, what would be the difference you would charge for variable rate nitrogen application versus uniform rate application? What additional cost would be associated with variable rate nitrogen application versus uniform rate application?