

Spatial Distribution of Precision Farming Technologies in Tennessee

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INTRODUCTION

Precision farming practices have been around since farming began. However, new technologies in precision farming have become commercially available to Tennessee crop producers in recent years that could potentially increase farm profitability (National Research Council, 1997; Swinton and Lowenberg-DeBoer, 1998). Some of these new technologies can be used to gather crop-related information about a field and measure yield potential variability within the field. Other technologies aid in making decisions and recommendations about variable rate input application based on the information collected. Finally, some of these new technologies are used to apply inputs at variable rates across a field to match the recommendations (Roberts, English, and Mahajanashetti, 1998).

Precision farming includes a wide array of site-specific technologies from farmers using flags to partition a field into management zones to on-board computers interfacing with satellites to pinpoint precise coordinates within a field. Some of the more basic site-specific technologies include aerial photography and soil survey maps. These technologies provide a producer with site-specific information to aid in management decisions. Another more sophisticated technology includes optical sensors that allow on-the-go information to be collected and processed, and inputs to be dispensed according to computerized decision rules as a tractor moves through a field.

Global Positioning Systems (GPS) is a technology that allows site-specific information to be collected through interface with satellites. A GPS receiver can be attached to machinery such as tractors, combines, or all terrain vehicles. For example, GPS technology can be used with a

yield monitor on a combine to measure within-field yield variability. This information can then be converted from raw data into a yield map using precision farming computer applications. A database of yield variability over time can be used with other information, such as a topographical map of the field, to make crop management decisions for the specified field.

Grid soil sampling is based on GPS technology. Grid soil sampling involves partitioning a field into grids of a specified size and pulling soil samples from the grids. Grid soil sampling allows measurement of within-field variability of soil fertility. Another type of soil sampling involves taking samples from several management zones which are identified by characteristics such as soil type or topography. Information gathered from soil sampling, as well as other information such as soil electro-conductivity, may then be used to generate variable rate lime or fertilizer recommendations for different grids or management zones.

Variable rate application of crop-related inputs such as seed, lime, fertilizer, herbicide, and pesticide is another aspect of precision farming that uses GPS. Variable rate application involves applying crop inputs in a non-uniform manner based on varying needs throughout a field. Advantages of variable rate application may include higher average yields, lower farm input costs, and environmental benefits from applying fewer inputs (Snyder and Schroeder, 1996).

Specific information about precision farming technology adoption in Tennessee is needed to gain a better understanding of the ways farmers might benefit from its use. Some important questions to be asked are: What precision farming technologies are being adopted in Tennessee? Where are they being adopted? On what crops are producers using precision farming technologies? Answering these and other questions will improve our understanding of how

these new technologies will fit into farming systems throughout the state as they become more prevalent and accessible to crop producers. The objectives of this study were to: 1) identify the geographic distribution among counties of precision farming technologies currently (1999) used in Tennessee, 2) determine the crops on which precision farming technologies are used, and 3) determine current precision farming technology adoption trends among Tennessee producers.

METHODS

A telephone survey of County Agricultural Extension Agents was conducted in March 1999 to gather information about precision farming activity within 95 Tennessee counties. Two weeks prior to the telephone survey Extension Agents were informed by mail of the project and of the questions that would be asked. They were also informed of Extension Administration support for the project. The initial question required the Extension Agent to provide the number of crop producers using any kind of precision farming technology in their county. Precision farming technology was defined as any technology that would allow a farmer to: 1) gather information to identify variability in yield potential across a field, 2) make decisions about variable rate input application across a field, or 3) apply inputs at variable rates across a field. If the Extension Agent indicated that no producers were using precision farming technology, the survey was terminated. If the response was that one or more producers were using precision farming technology, the survey was completed.

The precision farming information collected from Extension Agents included the following: 1) the number of crop producers using precision farming technology in the county, 2) the precision farming technologies used, 3) the crops and acres on which producers used precision farming technology, 4) the increase in the number of producers using precision farming

regions were reported to have 98 producers using precision farming technology in 20 counties.

Precision Farming Technologies Used by County

Yield monitors – Yield monitors were the most common precision farming technology used by Tennessee farmers (Figure 2), with 34 (36%) counties having farmers using this technology. Of the counties with yield monitors, 21 (62%) had farmers using yield monitors with GPS.

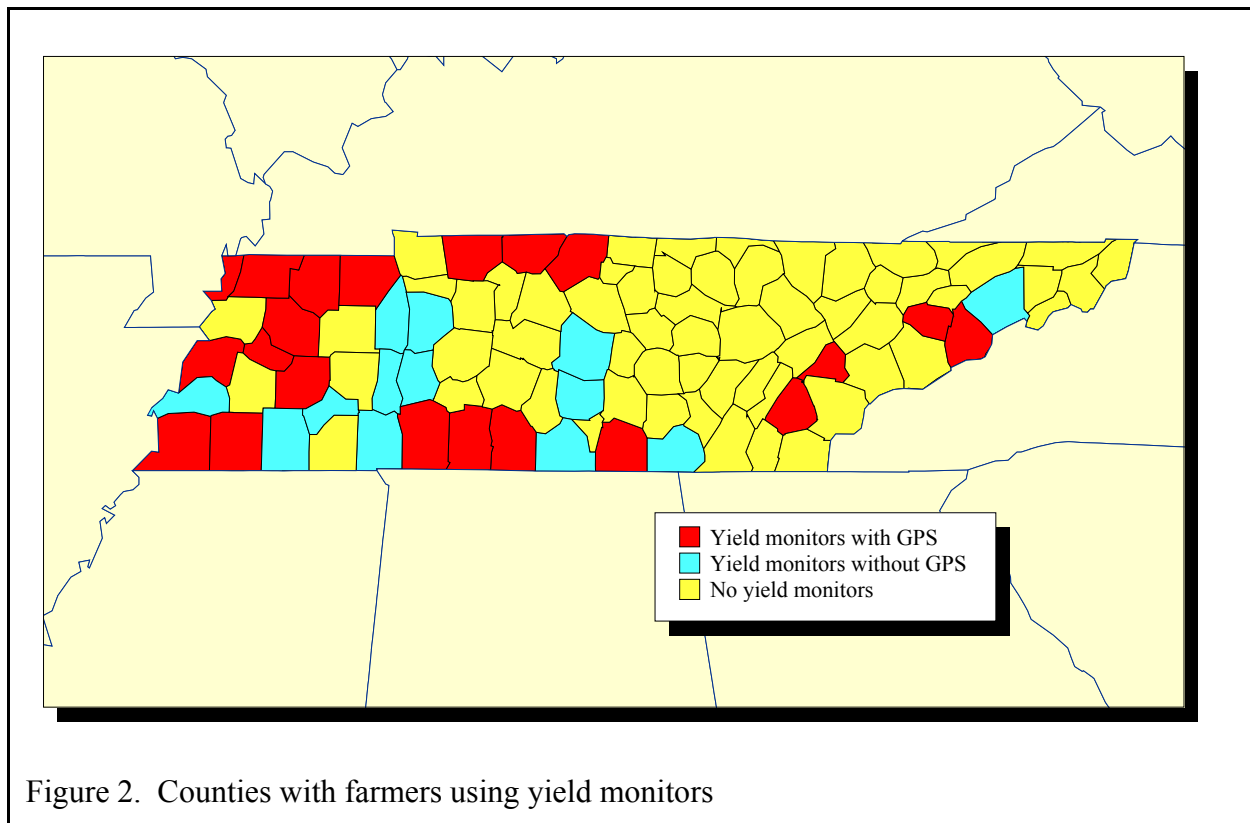


Figure 2. Counties with farmers using yield monitors

Yield monitor activity was most common in the western region of Tennessee, with 16 (76%) of 21 counties having farmers with yield monitors. Yield monitor activity with GPS was located mostly in that region (10 counties), with some in the northcentral (three counties), southcentral (four counties), and eastern (four counties) regions of the state (Figure 2). The

location of yield-monitor activity without GPS was somewhat different, with six counties in the western region, six counties in the central region, and one county in the eastern region.

Grid soil sampling – A total of 28 (29%) counties had farmers using grid soil sampling, 16 (57%) of which were located in the western region of Tennessee (Figure 3). The central (eight counties) and eastern (four counties) regions of the Tennessee also had grid-soil-sampling activity. The overlap of grid soil sampling and yield monitoring was quite large. Of the 28 counties with grid-soil-sampling activity, 25 (89%) also had yield-monitor activity. Only Dyer and Carroll Counties in the western region and Monroe County in the eastern region of the state were reported to have farmers using grid soil sampling and no farmers using yield monitors.

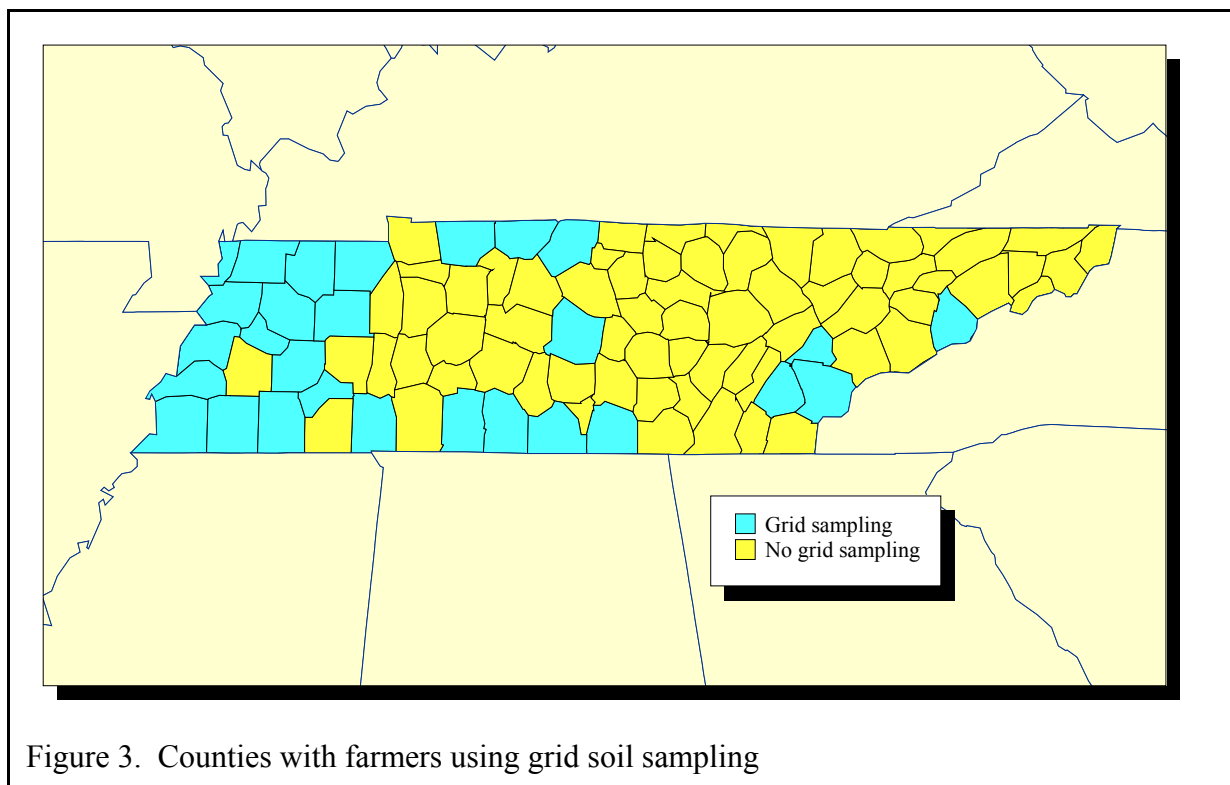


Figure 3. Counties with farmers using grid soil sampling

Variable rate input application – Use of variable rate input application technology was less

prevalent than both grid soil sampling and yield monitoring. Extension Agents reported 18 (19%) counties with farmers applying inputs at variable rates (Figure 4). All counties with farmers applying inputs at variable rates also had farmers who were grid soil sampling and yield monitoring. The western region of the state contained 11 (61%) of the 18 counties with variable-rate-application activity, while the central and eastern regions had five (28%) and two (11%) of the 18 counties, respectively.

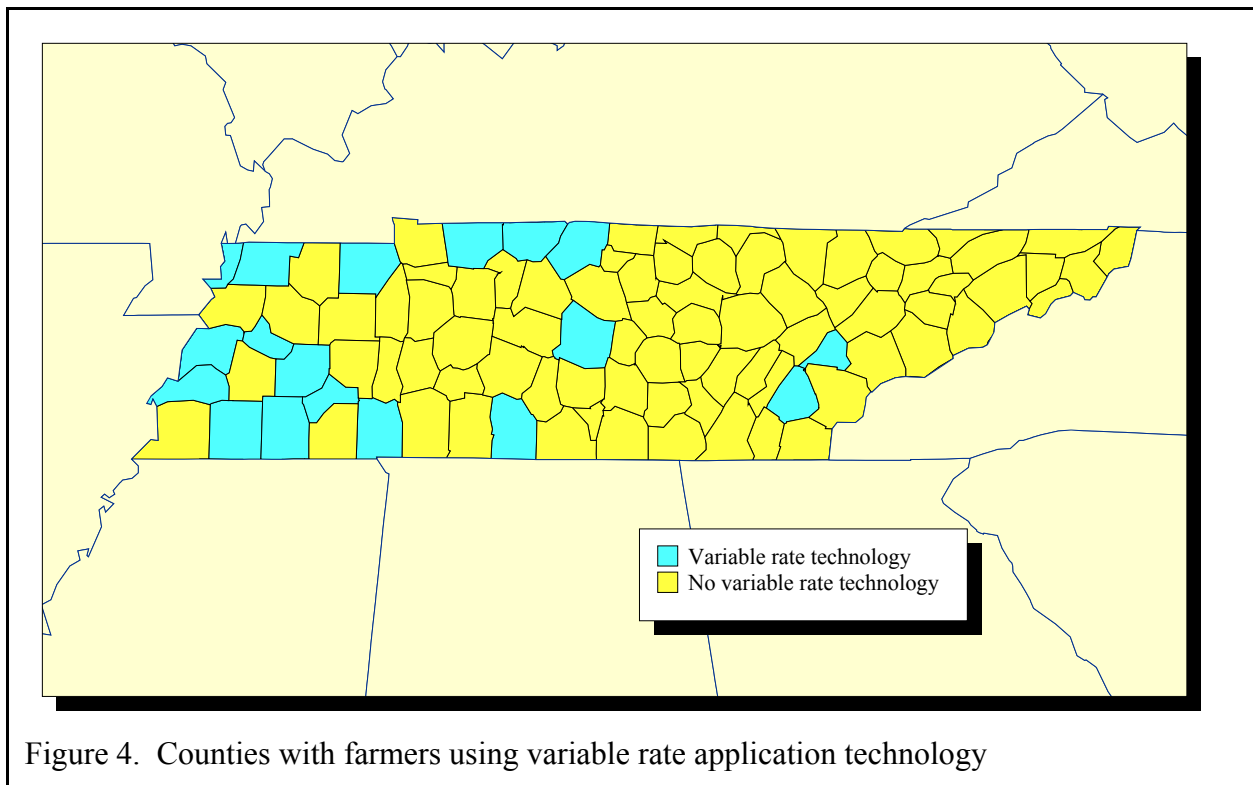


Figure 4. Counties with farmers using variable rate application technology

Crops Produced with Precision Farming Technology by County

Extension Agents reported that more than 149,180 acres of corn, soybeans, cotton, and wheat were produced with precision farming technology. Corn was the most common crop produced using precision farming technology, with more than 55,420 acres produced in 31 counties (Figure 5). Soybeans were produced with precision farming technology on more than

54,050 acres in 24 counties (Figure 6), while cotton and wheat were produced with precision

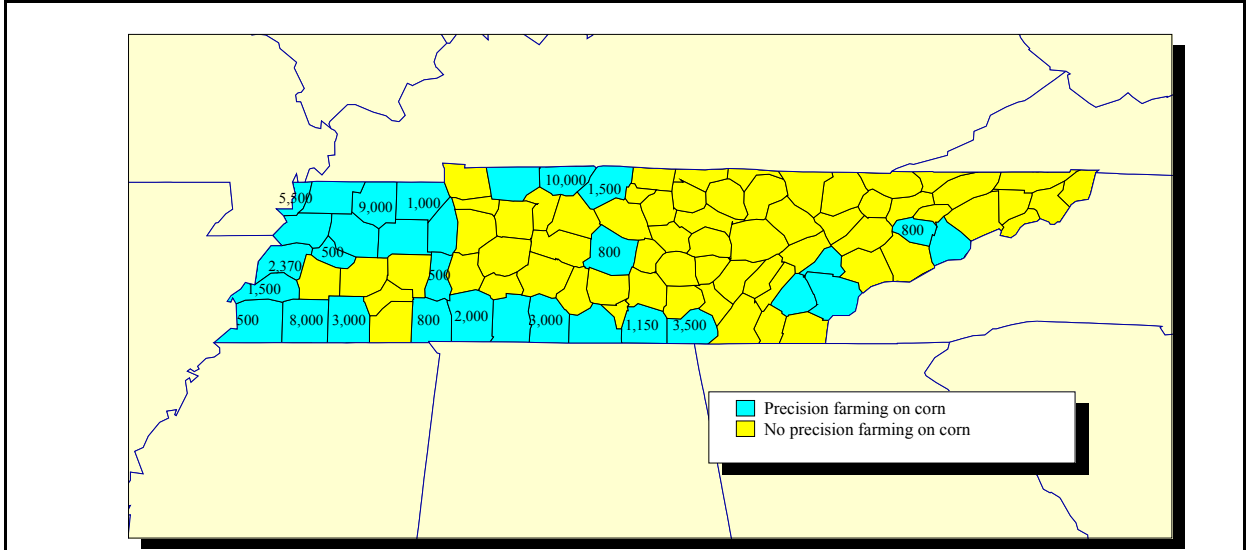


Figure 5. Counties with farmers using some type of precision farming technology on corn
 (If corn was reported in precision farming with no acres reported, the number of acres was left blank.)

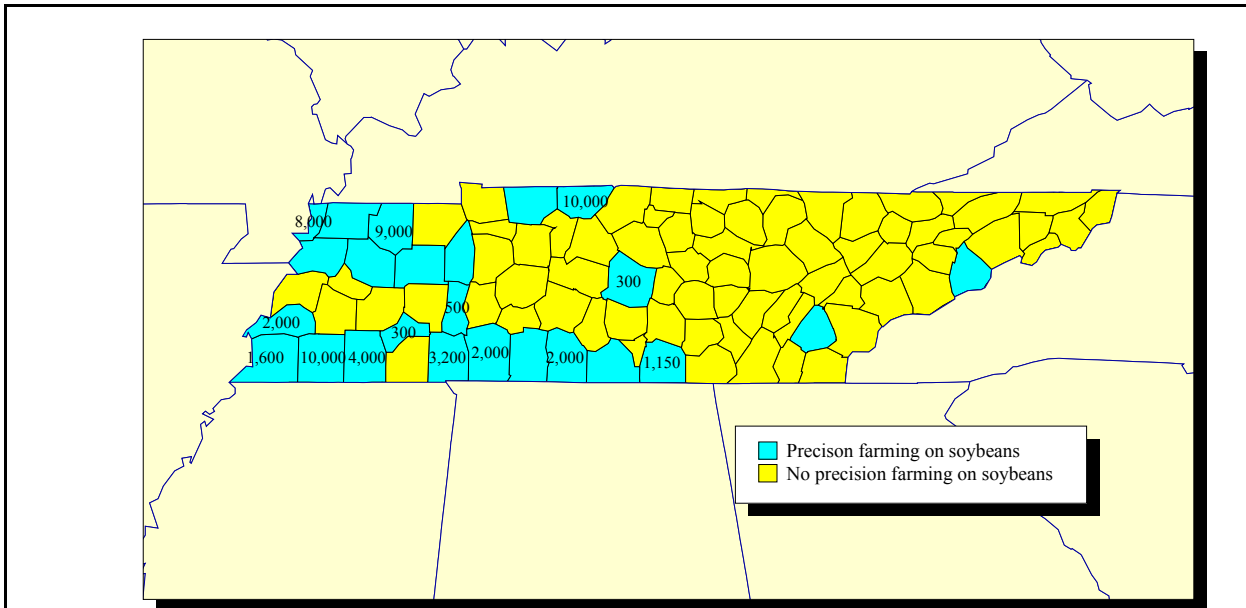


Figure 6. Counties with farmers using some type of precision farming technology on soybeans
 (If soybeans were reported in precision farming with no acres reported, the number of acres was left blank.)

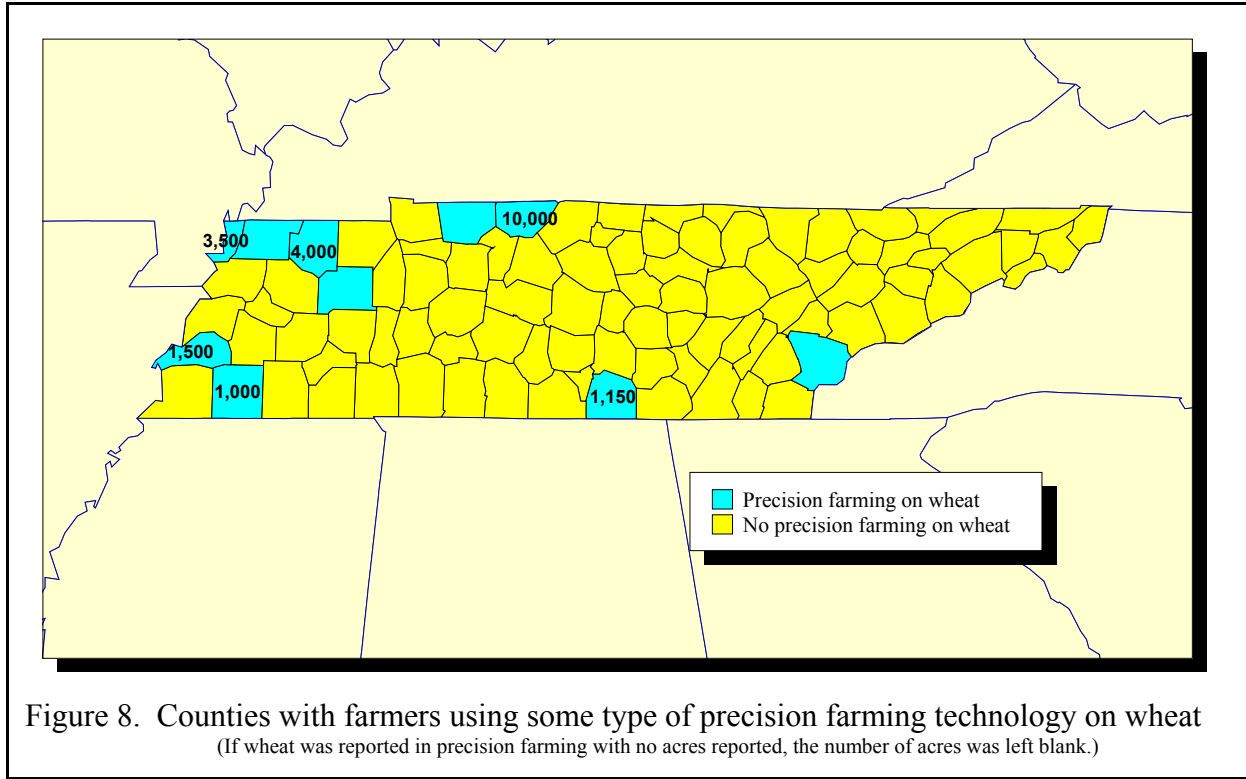
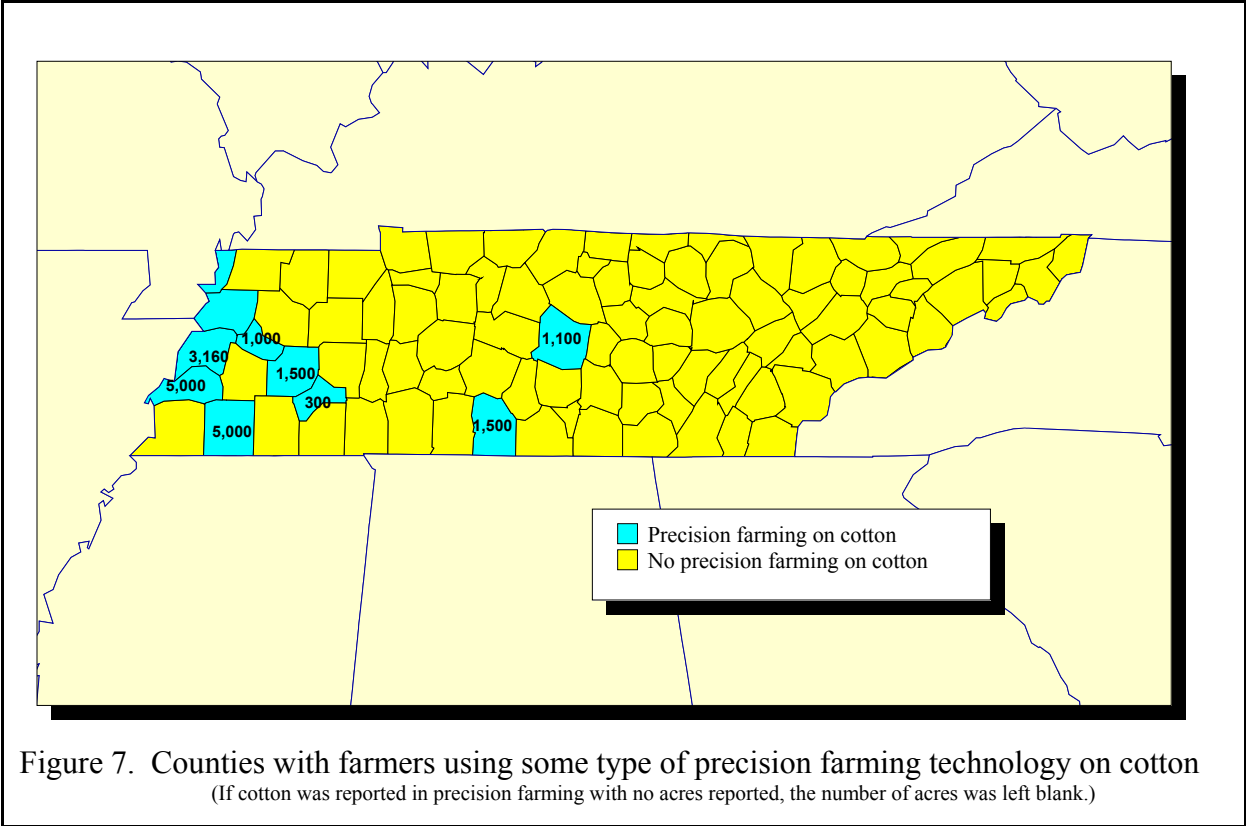
farming technology on more than 18,560 acres in 10 counties (Figure 7) and more than 21,150 acres in 10 counties (Figure 8), respectively.

Increased Use of Precision Farming Technology

Of the 38 Extension Agents who indicated precision farming activity in their county, 24 provided adequate information about the increase in the number of farmers using precision farming technology over the past year (Appendix, Question 4). Of those 24 Extension Agents, five indicated that the number of farmers in their counties using precision farming technology had not increased over the past year (not reported in a figure). The remaining Extension Agents reported that 85 farmers in 19 counties started using some type of precision farming technology during the year before the survey was taken (between March 1998 and March 1999). Thus, 30% of the 284 producers using precision farming technology at the time of the survey had started using it during the previous year. This result suggests that about 199 (284-85) farmers were using precision farming technology in March 1998 and that the growth rate in precision farming technology use during the previous year was about 43% ($100 \times 85 / 199$).

Decreased Use of Precision Farming Technology

Twenty-five Extension Agents provided information about farmers who had stopped using precision farming technology (Appendix, Question 5). All but two indicated that they knew of no one who had stopped using precision farming technology. The remaining two Extension Agents indicated that some farmers had stopped using grid soil sampling because benefits from its use had not been demonstrated on their farms.



SUMMARY AND CONCLUSIONS

A telephone survey of Agricultural Extension Agents in 95 Tennessee counties conducted in March 1999 found that 284 farmers in 38 counties used precision farming technology of some kind. About 65% of those producers were located in 18 of the 21 counties lying west of the Tennessee River. Yield monitors were used in 34 counties and 21 of those counties had farmers using GPS with their yield monitors. Grid soil sampling was a technology used in 28 counties, while variable rate fertilizer and/or lime application was practiced in 18 counties. All counties that had farmers using variable rate input application technology also had farmers using grid soil sampling and yield monitoring technologies. Extension Agents reported more than 149,180 acres of crop land in corn (55,420 acres), soybeans (54,050 acres), cotton (18,560 acres), and wheat (21,150 acres) being produced with some type of precision farming technology. Between March 1998 and March 1999, use of precision farming technology by Tennessee farmers grew at a rate of 43% from 199 farmers to 284 farmers. Only two Extension Agents knew of individuals who had stopped using precision farming technology. In those cases, grid soil sampling was discontinued by farmers because the economic benefits had not been adequately demonstrated on their farms.

The number of Tennessee producers reported to be using some form of precision farming technology (284 producers) is less than 0.5% of the total number of farms harvesting crop acreage in Tennessee (56,016 farms) and slightly more than 1% of the number of farms with sales over \$10,000 (21,288 farms) (U.S. Department of Agriculture, 1999). If the 43% annual growth rate between March 1998 and March 1999 calculated in this report were extended five years into the future to 2004, the anticipated number of farmers using precision farming

technologies (1,698 farmers) would be about 3% and 8% of total crop farms and farms with sales over \$10,000, respectively.

The percentages of crop land farmed with precision farming technologies compared to harvested acreage in Tennessee are larger than the percentages in the preceding paragraph, suggesting that farmers with larger than average acreages are the current adopters of precision farming technologies. Acreages of corn (55,420 acres), soybeans (54,050 acres), cotton (18,560 acres), and wheat (21,150 acres) produced with precision farming technologies are 10%, 5%, 4%, and 7% 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). The annual growth rates for precision farming technology adoption on these crops could be less than 43% because farmers with smaller land holding than those currently using precision farming technologies will be among future adopters. If the annual rate of increase in crop acreage produced with precision farming technologies were only 20%, crop acreages produced with precision farming technologies in 2004 for corn (137,903 acres), soybeans (134,494 acres), cotton (46,183 acres), and wheat (52,628 acres) would be 24%, 12%, 10%, and 17% of the aforementioned total acreages reported in the 1997 Agricultural Census, respectively (U.S. Department of Agriculture, 1999).

Although the number of producers and the acreages produced with precision farming technologies do not currently dominate Tennessee agriculture and would not likely dominate it in 2004, these new technologies are challenging the agricultural industry because they 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 for crop producers and may become even more difficult in the future. Furthermore, 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 in the use of these technologies. One of many possible programs would be to provide web-based soil survey maps and training for farmers on how to download and overlay these maps on maps of their fields. 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 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.

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APPENDIX

Tennessee Adult Agriculture Extension Agent Questionnaire, March 1999

The following questions relate to precision farming technology. We are defining precision farming technology as a set of technologies used to measure within-field variability, prescribe application rates for site-specific inputs, and/or apply farm inputs as prescribed.

- 1) How many crop producers in your county use precision farming technology?
- 2) What types of precision farming technology are used by producers in your county?
- 3) On what crops are producers in your county using precision farming technology?
What is the acreage of those crops using precision farming technology?
- 4) How many more producers are using precision farming technology this year compared to last year?
- 5) Do you know of any farmers in your county who have adopted and decided to stop using precision farming technology?