Yield mapping is one of the principle uses of precision agriculture technologies. Yield maps can be useful tools to aid in understanding why crops performed as they did in various areas of fields. Yield maps can also be used to estimate rental shares and to provide other important management information.

Combined with other information, such as fertility data, input rates (seed, fertilizer, crop protection chemicals, irrigation, etc.), machinery expenses, and labor costs, yield maps can also provide a means for determining variable net profits across fields.

By taking advantage of the many “layers” of information, producers can make more informed decisions for specific locations within fields concerning varieties best suited for various areas of fields, seeding rates, fertilization rates, weed management, conservation measures, etc. This fact sheet provides helpful tips toward obtaining accurate yield maps and avoiding problems from unreliable data.

Good yield maps do not magically appear on your computer screen. Getting good yield maps requires an understanding of how the yield monitor functions, that it be calibrated.
properly, and harvesting in a manner that can provide accurate information. For the purposes of this fact sheet, we will assume that the yield monitor is properly installed and calibrated.

The yield map in Figure 1 will be used to illustrate several points to keep in mind when examining your yield maps. This is a contoured yield map of a corn field with considerable yield variability during a dry year. Notice that there are several areas exceeding 125 bu/A, but also several areas yielding less than 75 bu/A. What is causing the low yields along the South of the field and running through the left center of the field? And, why are there “holes” in the data in several locations? Is this a correct representation of the yield? What can be done to correct any problems?

**Meaningful legends:** Establish a meaningful legend, or color coding scheme, to visually represent the varying yields for each crop. Use a color scheme that is meaningful to you, such as dark red for the lowest yields (losing money), through yellow for yields close to the breakeven point, to dark green for the highest yields (highest profits). Save the legend in your mapping software and use the same legend for all yield maps of that crop during the year. Avoid the temptation to use too many yield classifications, instead limiting the legend to about five to seven colors relating to various profit levels. Do not assume that the mapping software will automatically use your legend.

**Data quality:** Examine the yield map for potential data quality or accuracy problems. Study the map of yield points (Figure 2), looking for areas where the operator, harvester, or yield monitor system experienced difficulty or were not functioning normally. These areas include backing to clear plugs and to go around obstacles, operating in different directions to pick up downed crops and swaths that did not fill the header. By examining the map of yield points, it is possible to also identify areas where estimated yields are affected by point rows, changes in speed to cross ditches and terraces, etc.

Depending on the mapping or GIS software being used, it might be possible to filter out (delete or ignore) some of the questionable data, or to correct it in some cases. For instance, some software will permit adjusting swath width passes that did not fill the header if the combine operator failed to adjust it for that pass in the field.

**Correct moisture content:** Examine the crop moisture map, looking for patterns of variability
in a manner similar to the yield data. Fouling of the moisture sensor with crop residue can result in erroneous readings, and appears as consistent moisture readings across wide areas. Because the moisture content is used in estimating yield, this erroneous moisture readings result in incorrect yield estimates. If the moisture readings are found to be in error, it is possible to enter the average moisture content to improve the accuracy of the yield maps. Keep in mind that the accuracy of yield estimates will suffer for areas that are wetter or dryer when using a constant moisture content value.

**Correct acreages:** A properly calibrated yield monitor will accurately determine the yields for each yield point, but the estimated acreage for a field can be too high due to the extra distance covered while backing and pulling forward again, as well as the additional area covered by overlaps in point rows and turn rows. The yield monitor can report field acreages too low if areas are not harvested due to crop failure or poor field conditions.

It is strongly recommended that an accurate boundary file be generated each field. This provides accurate acreages that will be used by the yield monitor to calculate the field average yield. Boundary files can be obtained by driving along field boundaries with the GPS and yield monitor or other recording device, or by tracing field boundaries using GIS software and appropriate background images or data.

In the absence of a boundary file, manually enter the correct acreage that was measured with GPS, by using GIS and corrected aerial photographs, or other accurate surveying methods.

Using the correct acreage for a field will result in the field average yield and the average yield for the loads being adjusted so that the yields are reported on the correct acreage. The yields for the field and loads will be adjusted by the same proportions.

For example, if the yield monitor reports a total harvest of 20,000 bushels on an estimated area of 100 acres, the estimated field average would be 200 bushels per acre. If, however, the correct acreage is known to be 98 acres (entered manually or obtained from a boundary file), the yield monitor will adjust the field average yield to 204 bushels per acre. The average yields for all loads from that field will be adjusted by the same amount. The total volume harvested will remain unchanged. Estimated yields for the individual yield points will not be adjusted by changing the field area. The yield estimate for each point is based on the measurement of the mass, moisture content, and area covered for that particular location.

**Collecting reliable data:** This yield map provides examples of several situations that can result in misleading yield maps. Some can be corrected during harvest, while others can be corrected while analyzing the data.

We will begin analyzing the data by examining the point data that was recorded every second during the harvest (Figure 2). Notice that the layout of the field prevented long, straight rows extending from one end of the field to the other. There are ditches extending from the road to the North to the creek to the South of the field. There is also a considerable elevation difference from the North center of the field to the creek, and some old terraces that force the combine operator to slow considerably. These terrain features force the combine operator to change speeds and result in a significant area of the field being harvested as point rows.

Each time the combine enters the crop, several seconds are required for the grain to travel through the combine and reach the flow sensor. During this lag time, the yield monitor can record a very low, or even zero, yield for a few seconds. To correct this situation, measure the time required for the crop to reach the mass flow sensor and enter this time into the yield monitor and/or yield mapping software.

**Maintaining a steady speed** and making more gradual speed changes can result in more consistent yield estimates. When the combine suddenly changes speeds, yields can be greatly over- or under-estimated during the few seconds it takes grain to pass through the combine. For example, if the combine has been recording 200 bushels per acre while traveling at 4 miles per hour, suddenly slowing to 2 miles per hour would cause the yield at that instant to appear closer to 400 bushels per acre (the exact yield recorded depends on the suddenness of the speed change and several
factors for the harvester). A similar underestimation of yield occurs when the combine accelerates.

Correct swath widths: It is important that the correct swath width be entered during setup of the yield monitor, and that it be adjusted as necessary during harvest. Yields at each point in the field are determined based on the volume of grain harvested (mass and moisture content) and the area covered (swath width and distance traveled). Three of the factors are measured by the yield monitor from the various sensors, but the swath width is entered by the operator. Failure to use the correct swath width results in inaccurate yield estimates.

The effect of point rows is an under-estimation of the yields because the yield is estimated for the full width of the header, while it is actually harvesting a smaller area. A combine with a 12-row header that is harvesting only 6 rows of 150 bu/A corn will record a yield of only 75 bu/A.

The point data map contains one long pass indicating a very low yield near the East end of the field. This was a pass with only 3 rows entering a 12-row header, so the estimated yield was only 1/4 of the actual yield.

If the point rows are very short, you may not want to take the effort to adjust the swath width each pass. However, in the case of the long pass mentioned above, the operator can adjust the swath width to 3 rows to obtain accurate results.

Remember to raise the header or to stop recording data. You might also notice a few places where the combine made turns or loops with the header not raised high enough to stop the collection of data. This is a common occurrence with a couple of solutions. The best solution is to make sure the header is raised above the height programmed as the cutoff height. The cutoff height can be programmed at any header height, but be careful that the cutoff height is not so low that data is not recording while crossing terraces.
**GPS accuracy:** There are a couple of passes where the combine appears to have wandered off course or the track disappears altogether. These are times when the US Coast Guard beacon differential correction signal for the GPS was “lost.” The GPS receiver was using a Coast Guard beacon from a tower located approximately 100 miles away. Although the signal to noise ratio (SNR) was greater than 20 when the receiver was tested in the area, there are times when the correction signal (a low frequency AM signal in the 280 - 325 kHz range) can be lost due to interference, terrain or atmospheric conditions. You can expect to lose the correction signal in depressions, especially near timber. High tension power lines and other sources of radio interference, such as your own 2-way radio equipment, can also cause problems. A satellite DGPS correction source (such as WAAS, OmniStar, StarFire, or others) can reduce the occurrences of lost DGPS signals.

Although the GPS system is very reliable, there will occasionally be times when the satellite orbits do not provide the necessary “view” of four satellites in positions that allow good positioning. In addition, GPS positioning may be difficult along the edge of the woods, bluffs, or other objects that block reception of the GPS signals. These problems cannot be entirely eliminated, it may be possible to plan demonstration and research projects in areas that provide the best view of the sky.

There are occasionally short periods (a few minutes) when there are not enough satellites available for positioning, or their positions relative to the GPS receiver do not provide highly accurate positioning. This is due to locations of the satellites in their six orbits and the rare occasions that a satellite is out of service. You can plan ahead by checking the Trimble web site (www.trimble.com) to determine satellite availability and expected dilution of precision (DOP) for your harvest times. If the collection of highly accurate data is important, do not harvest when the DOP is expected to be greater than 8.

**Analyzing and cleaning up data**

Anything that leads to the collection of reliable harvest data will yield benefits during data analysis. It is easier to collect good data than to identify and correct problems at the office. However, a few things can be done after the harvest to improve the reliability of your yield maps.

Each data point includes a record of the mass of crop harvested, and the total mass is necessary for determining the field average and load average yields. However, some data points may result in incorrect representations of the yield as the data is processed into gridded, smoothed, and contoured yield maps. Some editing of the data may be necessary in order to obtain accurate map products.

**Deleting unrealistic yields points:** Check the data for points with zero or near zero yields that do not accurately reflect the crop conditions. Delete any that are the result of entering the crop, point rows, forgetting to raise the header, etc. These data points will artificially lower the yield representations when gridding, smoothing and contouring the data.

Likewise, delete data points that indicate unrealistically high yields. These are most likely places where the machine suddenly slowed or stopped.

Yield mapping and agricultural GIS software normally permits “filtering” yield data to exclude points with yields above or below set limits.

**Correct swath widths:** Correct or delete any passes that were a partial swath for which the swath width was not adjusted in the cab. The yield mapping or agricultural GIS software should allow correction of swath widths for selected passes.

**Correcting passes:** Loss of the differential GPS correction signal can result in the appearance that the harvester is wandering about the field. Some yield mapping and agricultural GIS software permit “straightening” selected passes. This may not be as easy as desired, and an easier alternative is to simply delete the data taken without differential correction.

**Dealing with turn rows and point rows:** Data from the turn rows is valid if not “thrown off” during processing by the data from point rows. Consider discarding the data from the point row areas, as it is the most unreliable data anyway, giving low yield estimates.

A common question is, "If I delete these data
points, won’t I mess up my yield estimates?” The answer should be "No" with yield mapping software such as that from AgLeader SMS Basic and John Deere JDMap. Yield data for generating reports will still reside in the yield data files, and deleting points from the map will not modify that data. However, if yields are estimated from the modified data, then discrepancies will occur.

Making a more useful product
The point data should be the first map reviewed, because it reveals the manner in which the data was collected. Potential sources of error can be identified by the spacing of the yield points, such as changes in the speed and course taken by the harvester.

It is necessary to generate maps of the average yields for each “cell” of the field to provide a more usable picture of the yield. Consult the yield mapping or GIS software for procedures to follow for generating a grid map of the yield.

Specify the grid size for the processed yield maps based on the field unit size that can be realistically managed. Avoid the temptation to use grid sizes that are too small, because it will take longer to generate the maps and not be as useful as you want it to be. You might consider setting your grid size to match a multiple of your planting or fertilizer application equipment swath width. For example, specifying a cell size of 60 feet might be reasonable when planting and harvesting equipment covers 30 foot swaths and the fertilizer application equipment covers 60 foot swaths. Smaller cell sizes can be used, but would not result in more useful fertilizer application prescriptions.

Finally, contour the data to create a yield map that is similar to a USGS topographical map. This makes it easier to visualize yield variations and patterns within a field.

Now what?
After developing a realistic yield representation, it is possible to develop a profit/loss map for the field. While the crop yield data is important, it is economic yield (profits) that is the ultimate goal.

By adding other layers of data, various data analyses can be performed to determine the effects of field conditions and management decisions on yields and profits. Among the additional data that can be added are:

- soil types
- soil fertility data
- topography (slope and aspect)
- other data: digital orthophoto quarter quadrangle images (DOQQ), satellite imagery, weather data
- input costs: seed, chemicals, nutrients, irrigation
- machinery costs: site prep, application equipment, planting, tillage, harvest, transportation, storage

By evaluating each area or “management zone” it is possible to develop strategies for more profitable management of those zones in future years. These decisions may include most appropriate crop selections, nutrient management, irrigation management, implementation of conservation measures, etc.