Precision Agriculture

Lesson 3 Educator's Guide

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Lesson 3: Precision Agriculture: What do I do with the data.

Lesson Objectives

1. Learn the differences between traditional farming practices verses Precision Agriculture practices.
2. Learn the process of data collection and its sources.
3. Learn the process of Decision making using Precision Agriculture
4. Learn the concept of data layering to strengthen the quality of decisions.
5. Learn the probable and possible outcomes of implementing Precision Agriculture.

Vocabulary

NOTE: For the purpose of this lesson, definitions are geared toward Row crop farming even when animal and herd practices exist.

- Physical Observation – the gathering of data by one's own senses: sight, touch, smell, hearing, and taste.
- Subjective – Data observed is recorded based on the thoughts, opinions, moods, and feelings of the observer.
- Objective – Data observed is recorded based on the facts of the situation without consideration of the thoughts, opinions, moods, and feelings of the observer.
- Calibration – setting sensors and equipment to report the same reading based on a known sample.
- Field Boundary – a file that contains the GPS coordinates of a line that is drawn around a field
- Granularity - the scale or level of detail present in a set of data
- Zone – an area that has similar characteristics
- Data Layering
- Prescription

Compare/Contrast Traditional Farming Practices with Precision Agriculture

The primary difference across the differences between Traditional Farming Practices and Precision Agriculture can be classified in 3 categories:

1. How data is gathered
2. The detail of the data
3. How decisions are made and implemented from the data

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Data gathering

In all agriculture practices, data is gathered whether you realize it or not. In traditional farming practices, data is gathered primarily through **physical observation**. Physical Observation is the gathering of data by one's own senses: sight, touch, smell, hearing, and taste. For instance, an operator would visit and look across each field in the operation and notice a difference in plant color prompting a more detailed observation. The operator would then need to go to the specific sites and investigate more closely by looking at the plants to see what signs of stress are evident, feeling the plant leaves and the soil to find issues, listening for the sounds of insects or other pests that may cause harm and potentially smell in cases of dyeing plants that beginning to decompose. In general, only one thing can be observed at a single time in any detail. Also, the number of locations that can be observed each minute or hour is very few. In addition, the data taken can be **subjective**. Subjective means the data observed is recorded based on the thoughts, opinions, moods, and feelings of the observer. What one person perceive as a good condition, another person may perceive as fair or even poor for no other reason than his or her opinion or state of mind. Once the data has been gathered, decisions are made and those decisions are applied to a the rest of the field if not half the operation even though it is known that there is variation across each field and between each field.

This is an example of how seed depth, seed spacing and soil moisture is checked using physical observation.

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The green pin indicates how often data is taken for this field using physical observation.

With the use of Precision Agriculture practices, data is gathered with the use of sensors. Each sensor may gather a single piece of data or multiple. Sensors may also gather data at any frequency. Take the example of the data gathered at planting. With the use of a device like the SmartFirmer –

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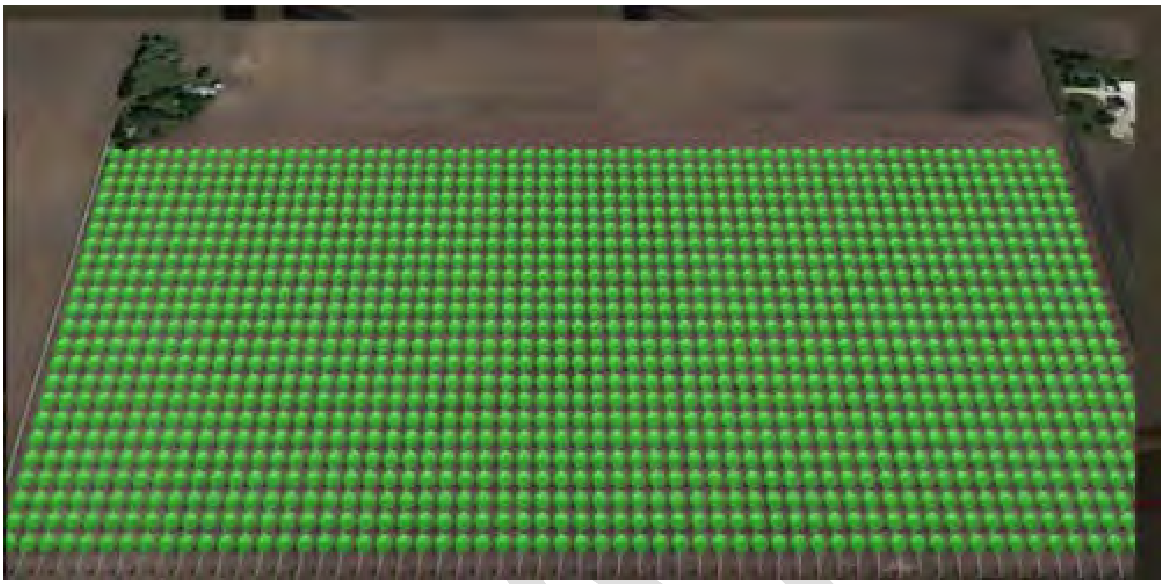
one can capture not only Soil Temperature, Soil Moisure, and seed spacing; but, can also gather the organic matter at each location. This data can be gathered not just once every day, hour, or minute, but up to 200 times per second, and combine that with a GPS receiver, the data can be mapped at each location recorded. Giving us a coverage map looking like this:



It would truly take an army to gather the data from this field and would take days to acquire that was gathered by a group of sensors as it moves across the field.

The data collected is merely the recorded data as it is taken. Because of this, it is **objective** data. Objective Data is recorded based on the facts of the situation without consideration of the thoughts, opinions, moods, and feelings of the observer. Objective data is recorded as it is found, no altered scale occurs between samples and no variance in criteria exists between sensors. Because of this, the data can be relied upon to be what was actually present at the source and therefore, treated in the same manner during analysis.

	Traditional Farming Practices	Precision Agriculture
How Data Is Gathered	One piece of data per location at one time. In order to gather multiple pieces of data, multiple observations are necessary. Takes time to perform necessary observations to gather the data correctly.	Several pieces of data may be collected at each observation per location. Data recorded instantaneously.

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	Number of sites observed are limited due to the amount of time required to gather data. Data accuracy is dependent upon diligence of recording and the viewpoint of the observer.	Significantly higher number of sites are observed and specifically recorded. Data is accurate to the level of equipment calibration. Each observation is based on that calibrated value.
The Detail of the Data	Detail is subject to the amount of time the observer has to record what is observed. Because fewer observations are made for a field, the data is less applicable as the distance increases from the point of observation.	Detail is exact as observations are taken and is recorded to the same level of accuracy. Because observations are taken constantly, the data is completely applicable to the entire operation.
How Decision are implemented	Decisions are applied to large broad areas of the operation, such as an entire field or section of a field based on the frequency of observation. All adjustments need to be made manually Resulting implemented management is applied to large areas based on very limited data.	Decisions are applied to much smaller areas because observations are being taken all the time. Many adjustments can be made automatically according to parameters set in the controls of the equipment depending on the observations of the sensors Resulting implemented management is applied precisely to the area based on that area's data.

Where does the data come from?

Data is everywhere. From the number of seeds planted per foot of row space, the rate fertilizer, insecticide or herbicide is applied, the location of the field, the location in the field, the date that an application was made, which equipment was used, the depth of the application, the soil type it went on… the list goes on and on. The trick is finding out how to collect the data in a manner that is easily managed so it can be used for better decision making. Today, there are sensors available to gather just about any data you want at any level of detail you want it. Some data points that can vary greatly from location to location such as soil moisture and fertility need to be known on a higher level of **granularity**. On the contrary, data points such as daily high temperature, low temperature, average temperature,

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and rainfall won't change substantially across a large area so a broader range method of gathering will suffice.

The act of data collection can occur in many ways and from many different sources. Atmospheric data, such as temperature and rainfall conditions, can come from a variety of web sources. A few include:

- https://www.usclimatedata.com/
- https://www.wunderground.com/
- https://www.climate.gov/
- https://www.ncdc.noaa.gov/
- https://www.agweb.com/weather/temperature-band/
- https://weatherspark.com/

Some sites take the historical weather data and analyze it to create a new data point. An example is Growing Degree Days or Heat Units for a variety of crops. A few include:

- http://www.nutrien-ekonomics.com/tools-to-calculate-fertilizer-needs/calculators/gdd/
- http://www.greencastonline.com/growing-degree-days/home

Some sites can supply Remote Sensing data that gives analyzed satellite images that can supply crop health images as of a given date. This data can be helpful within the growing season to identify crop health issues even before they are noticeable to the eye. This way this imagery is ordered, is that a Field Boundary is drawn around a field on a web tool that looks like Google Earth. A **field boundary** is a file that contains the GPS coordinates of a line that is drawn around a field. The field boundary is used to identify the Area Of Interest (AOI) that the user wants the service to gather data about. Without a field boundary, the amount of data would be substantially increased. More is not always better. At some point, each piece of data needs to be able to be related to each other. If the field boundary of one type of data does not match the field boundary of another type of data, that means not all the data can be used to it potential.

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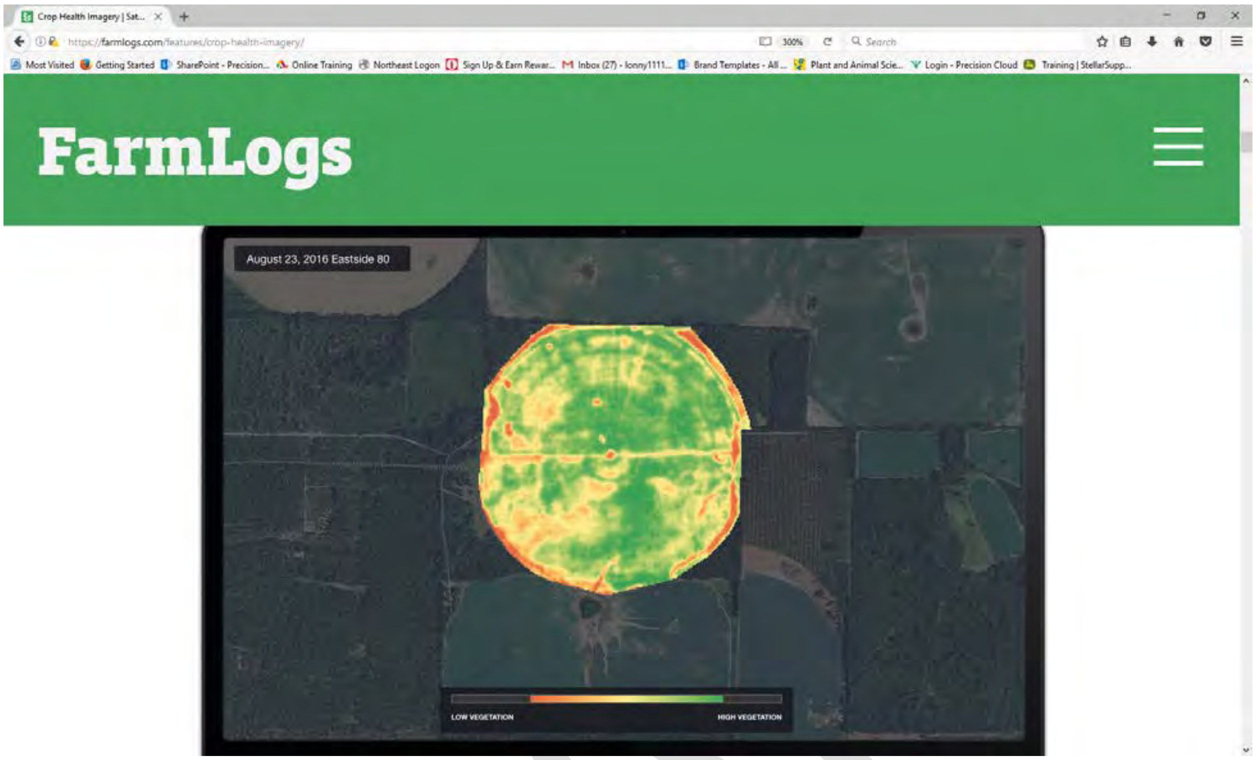
Example of imagery from FarmLogs.com



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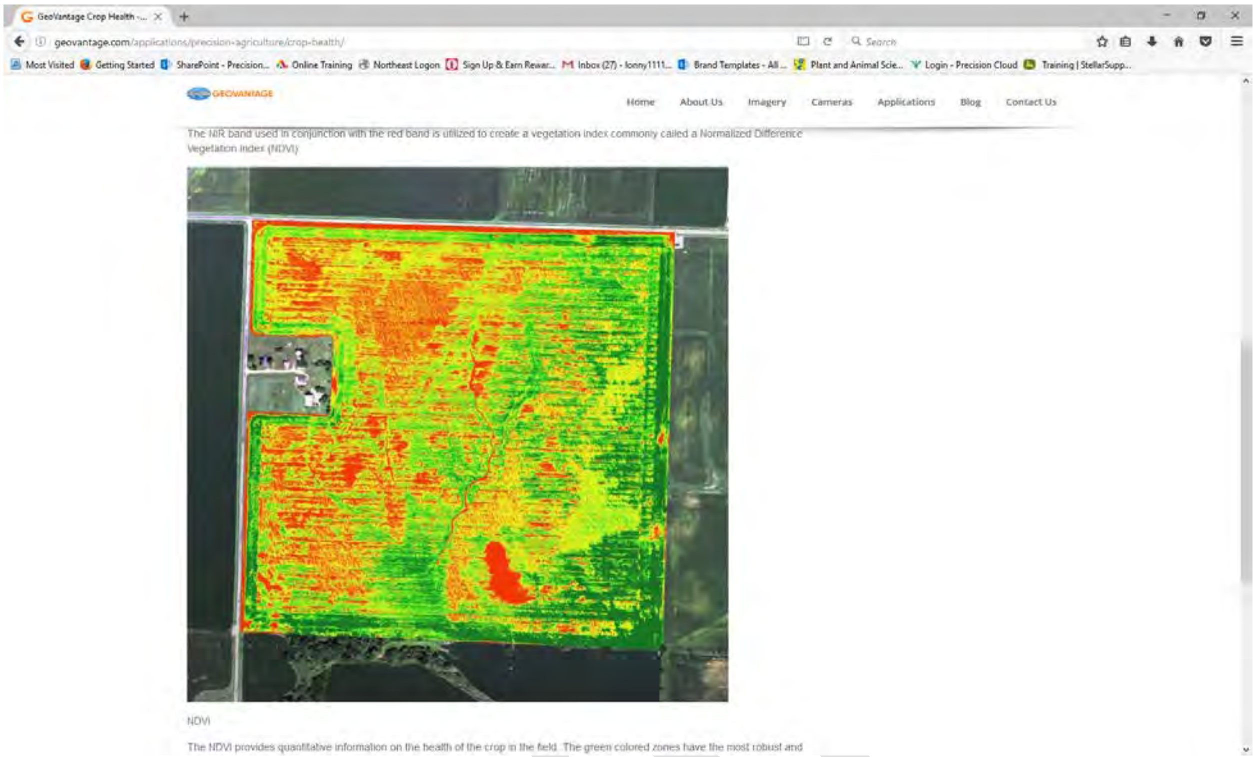
Example of imagery from geovantage.com



With the right software, similar imagery can be gathered with the use of UAVs (Unmanned Areal Vehicales) commonly referred to as drones. Some companies offer drone flown imagery gathering as part of their services.

Activity: Dray a field Boundary. Go to http://www.gmapgis.com/ and enter your zip code in the search window. Click on the Satellite option under the base maps on the left of the page. Drag and zoom to a field of interest. Once zoomed to the desired field, click the Rectangle tool at the top of the page. Now click at one corner of the field. Move the cursor to the opposite corner of the field and click again. This will draw a rectangle boundary around the field. Now click the eraser tool and click the field boundary you just drew. This will erase the boundary. Now click the Polygone tool. Then click along the edge of a field that you are interested in. then go around the field clicking at each spot there is a change that you want to follow. When the field has been completely outlined, double-click on the edge of the field. Here is an example of what can be done with field boundaries:

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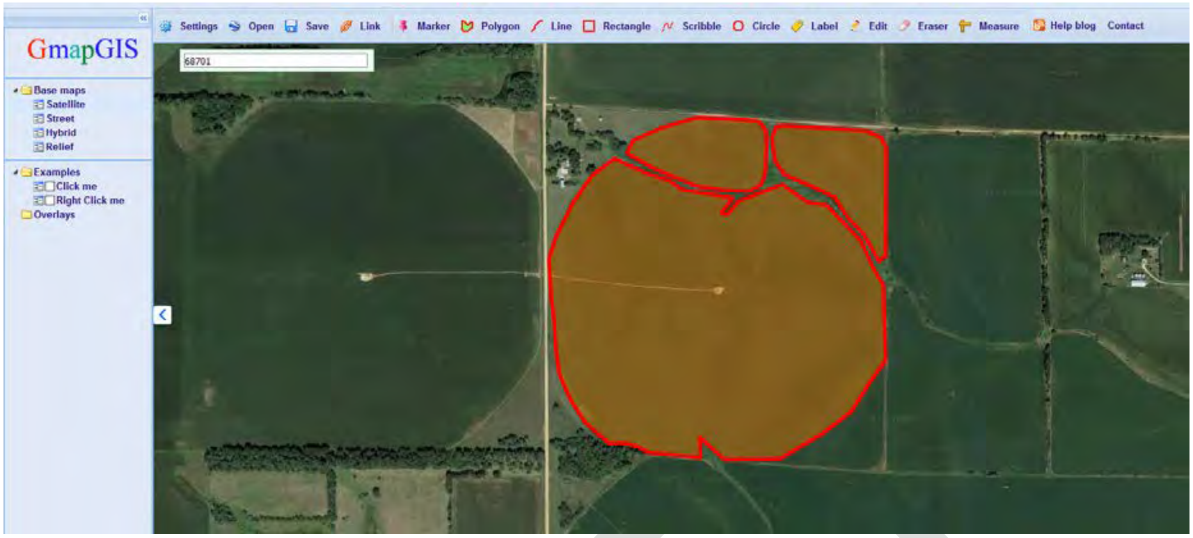
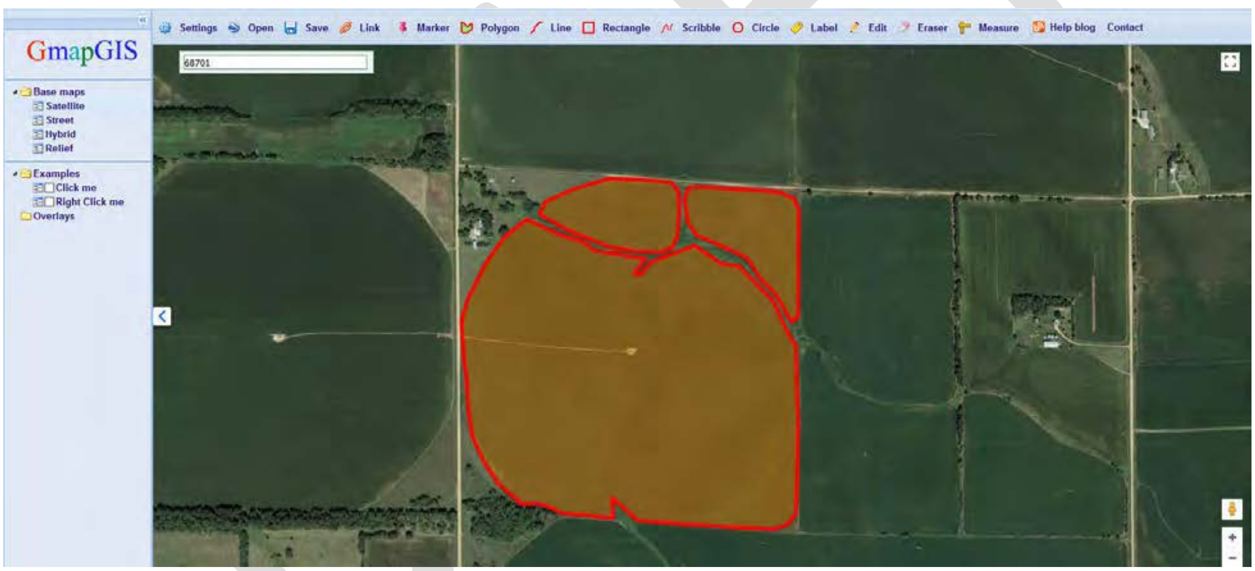


Now click the edit tool. And then click one of your field boundaries. You can now drag any of the points of the boundary to correct it. When done double-click the field boundary and your boundary will be edited.



Now click the Measure tool. Hover over one of the field boundaries. This will show you the area of that boundary.

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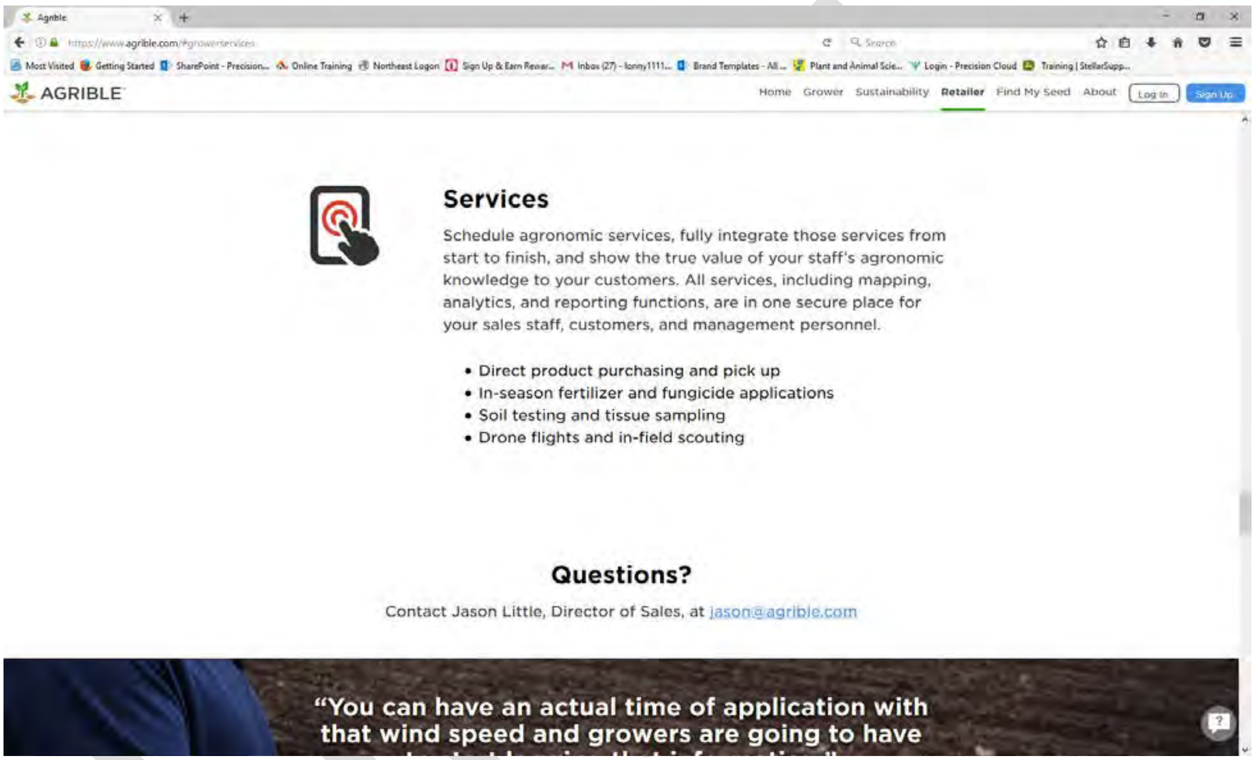
Another site that can be used is www.daftlogic.com

Here is an article showing the differences between drone and satellite imagery.
http://www.cropcopter.co/uav-imagery-vs-satellite/

Here is an example of a company that offers Drone flying services. www.agrible.com



Another source of data is archived soil maps and topographical maps that have been digitized so that they can be utilized in management software to aid in decision making. This type of data experienced extremely minimal change over the years without a substantial natural event, such as major flood or earthquake, or mechanical alteration such as with heavy machinery. Because of this, maps from 5, 10 or even 50 years ago are still valid and valuable today.

Another source of data is physical sampling. An example of this is soil sampling. Soil sampling is done to identify the PH, ability to hold and release water, fertility available in the soil and the fertility needs in the soil.

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Another source of data is equipment with sensors installed. This equipment can be mobile equipment like tractors, planters, combines and even 4-wheelers and others, or it can be stationary like soil moisture probes and weather stations. Weather stations are used to gather temperature, wind speed, wind direction, humidity, and rainfall.

Data gathered by sensors on mobile equipment can be collected either while doing other operations, such as soil Organic Matter while planting with the SmartFirmer, or as a specific activity like when flying a UAV over a field to gather imagery.

How is the data collected?

Web Sources:

Data collected from web sources can sometimes be downloaded in an electronic file that can then be used in the software the operator uses to aid in the decision making process. This allows the software to take the data provided from the web site and tie the location of each piece of data collected with other pieces of data already stored in the software. This allows the operator to compare the information about each location and see if there are any correlations of that data that helps to make better informed decisions.

Remote Sensing:

Data collected from remote sensing comes in the form of image files that have coordinates tied to it so it can be uploaded into the operator's software similar to files from web sources. The image files also have other pieces of information about different sections of the image that define the size of each sample and how that area varies from the rest of the areas of the field.

Digitized Historical Maps:

Digitized maps come in the form of image files that have coordinates tied to it so it can be uploaded into the operator's software similar to files from web sources. Digitized maps include maps such as soil types and land elevation maps (topographical maps). Some areas of the country have taken historical maps digitized them to be used with software to add information for decision making purposes. There are maps being re-generated utilizing remote sensing to replace maps that are 50-100 years old. Both have value as the total change over the years is minimal barring earthquake, severe flooding or human terrane alteration.

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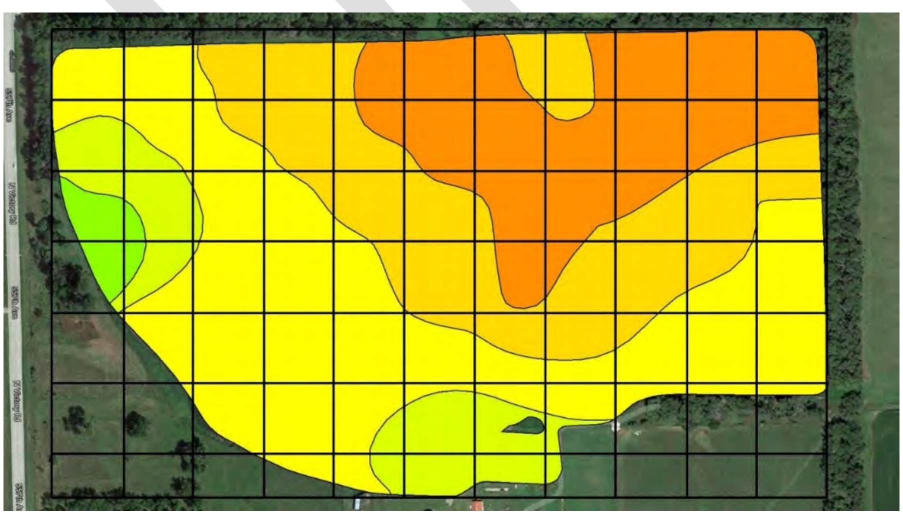
Physical Sampling:

For our example of physical sampling, we will use soil sampling. <u>(This may be a good exercise for the class to do at the school. Soil probes can be borrowed from area agronomists and one may even come in and do the sample for the class and send it in so they can see the results.)</u> The way soil samples are taken, is someone drives to each location in the field where a sample is desired and uses a soil probe to pull out a sample of the soil which is collected and sent off to a lab for analysis. Different depths are sampled depending on the need for the sample. Sometimes, samples are taken at different locations in a **<u>zone</u>** and the soil at the desired depth is mixed and send as a single sample to get an average across the zone. This limits the effect of high and low levels in a single area from skewing the results for the entire zone.

Soil Probe: miltona.com

Soil sampling can be done in 2 ways. The traditional way is to lay out a grid in a field and take a sample to analyze from each square in the grid. This would be what grid sampling would look like:



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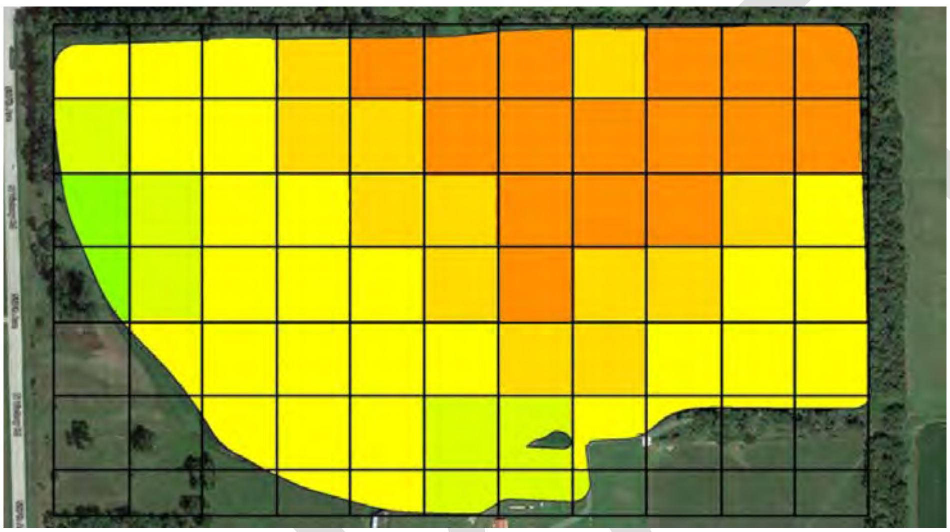
Inside each square of the grid, a sample would be taken and analyzed to get the details of the soil in that section of the grid. The benefit of this type of sampling is that there are a lot of data points because each square gets a sample so the expectation would be that you could capture the details of the variability of the field.

The down side of this type of sampling is you have different soil characteristics that could indicate a significant capacity of the soil inside many of the grids. Because of this that grid is not being represented in a manner that adequately represents the true variation of the soil. Let's say that this is a grid over a soil type map. If we assumed that each soil type was very similar in its analysis, and we took a sample at the center of each grid section, the resulting soil test map would look something like this:



Another way to do a soil test is to break up the field into Zones. A **zone** is an area that has similar characteristics. In our case of the soil type map, we can use the soil types as our primary zones. The positives are that we keep the information for the soil sample inside the same soil types, while adding the granularity was want, and yet we save money by having much fewer zones. The negatives are that we lose some of the detail of the samples in the larger zones, such as the yellow zone. To add some granularity to the data, we can beak the areas up into smaller sub-zones like this:

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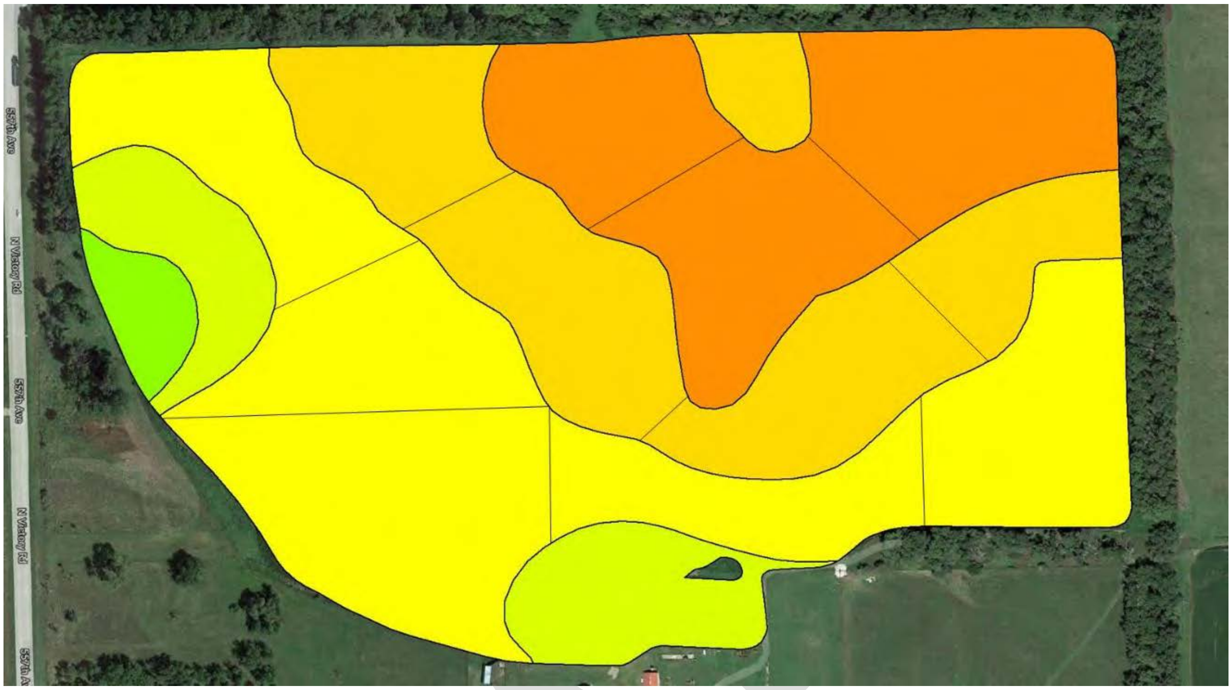

QUESTION: How many Samples are in the Grid sampling model? How many are in the Zone sampling model? If each sample costs $8 to analyze, how much will you save? The individual operator would need to decide if the savings to sample the field using zone sampling would be work the loss of added data gathered.

Sensors

With Precision Agriculture equipment, data is collected either passively, while another activity is being completed, or actively, the activity specifically intended to gather a specific type of data. For instance, data gathered with the SmartFirmer, like soil temperature, soil moisture, PH, and organic matter, is an example of passive data, but seed depth and seed spacing are examples of active data because those pieces of information are directly related to the planting function. While harvesting, a combine will gather Yield data and Moisture data using the installed sensors. This is another type of active data collection since both the yield data and moisture data are used to calculate dry yield.

There is also equipment that is designed to collect a single type of data such as weather stations and soil moisture probes. Soil moisture probes are place in strategic spots in a field and do nothing more than gather the amount of moisture in the soil at different depths.

Regardless of the type of data being collected, there has to me a manner for the data to be saved and transferred to the software capable of processing that data. When data is gathered, it is stored in a temporary memory module housed within the equipment. From there, one of 2 methods are available depending on the equipment. One method allows users to download the data to a mobile memory module like a PCMCIA card, USB drive, SD memory card, or micro SD memory card. These data transfer

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methods are listed in data of implementation. Original Precisions equipment had a slot for the PCMCIA flash memory card to be inserted for the recording of data. As time went on, technology changed and moved to the USB drive, SD card and finally the Micro SD card. Some equipment also allows for an iPad or other tablet to be connected to record or transfer the data.

Some equipment is fitted with a WIFI or cellular transmitter that sends the data to a location that can be accessed using internet cloud services so the user can access a secure website to download the data, or even be notified when a certain condition exists. Soil moisture probe technology for instance can allow users to log into a site via a smart phone and check on the site data recorded to be able to determine if irrigation needs to be turned on. There are some services that will also notify a user when a certain threshold is reached alerting the user about the current moisture.

Sample PCMCIA Flash Card

Sample USB Drive

Sample SD Memory Card

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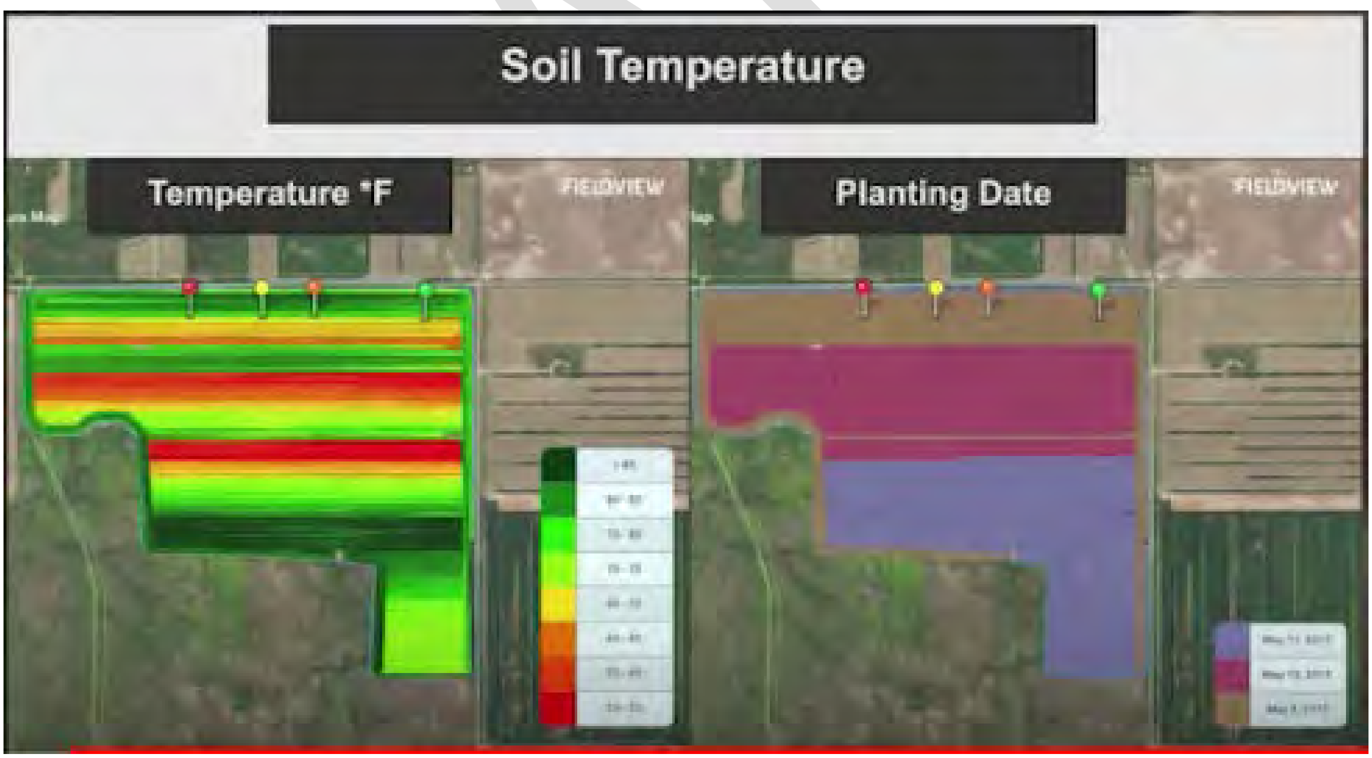
Sample Micro SD card with SD adapter

Take this Soil Temperature map below:



This shows 2 pieces of data. On the right side, the planting date is identified in 3 zones by the Blue on May 11 2017, Purple on May 10 2017, and Brown on May 9 2017. On the left, it shows the soil temperatures as the field was planted. Dark green being warmest and dark red being coolest. Red being 50 – 55 degrees F, and going up by 5 degree increments until the dark green is 85 degrees. So what this

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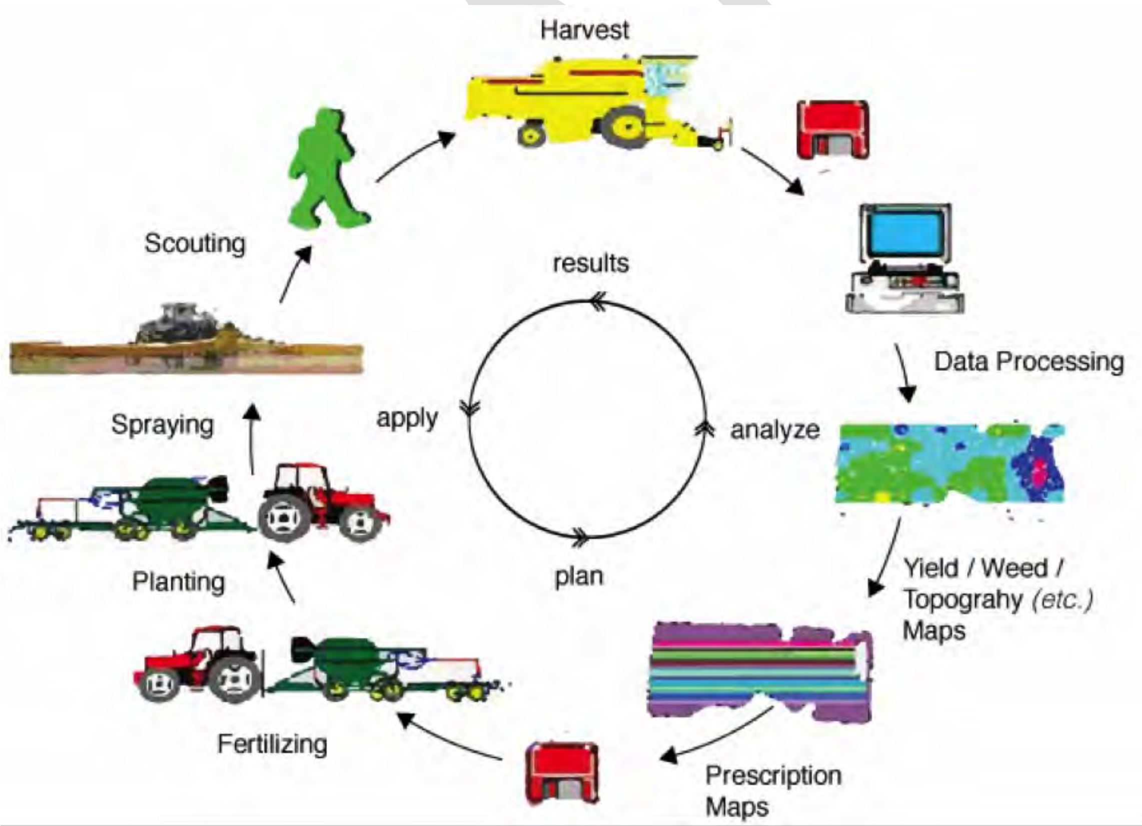
shows is at the top end of the field, they started planting at the warmest part of the day. As the day cooled down, the soil temperature cooled also until they stopped for the day. The next day they began in the early morning so the red line shows the soil being cool and as the day warmed up, so did the soil. Then when the day cooled down so did the soil. The best display of this was the third day.

Question for Students: Can anyone tell me about how big this field is? ANSWER: it is almost 1-mile-wide and 8/10ths of a mile tall. It's a big field, almost 2/3 of a section. This is why it took 3 days to plant.

Question for students: Why are the soil temperature bands so much thicker on day 3 than they were on day 2 and why were the bands on day 2 thicker than they were on day 1? ANSWER: because the width of the field became narrower as the planter completed the field, it took less time for the planter to go across the field, therefore more passes were able to be made resulting in wider bands of soil temperature. (this information is in the video listed below at 30:50 – 33:20 at https://www.youtube.com/watch?v=m9LP5IH7L44

The Process of Making Decisions Using Precision Agriculture Data



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Gathering Data

The decision making process always starts with gathering data. All the data collected can have some impact on the decisions that are made. For instance, let's say year 1 we plant when the soil temperature averages 65 degrees ranging from 50 – 80 degrees and we average 230 bushels per acre on a particular field. The next year the average soil temperature is 45 degrees with a range from 40 – 65 degrees and we have an average yield of 210 bushels per acre. Presuming all other conditions were that same from year to year, one would say that by planting in warmer soil, the germination was better and therefor the plant was set from the start to be healthier and yield more. That is one way that the data can influence the decisions.

This data can include Yield and Moisture and other sensor based data, Soil Sampling data, Crop Scouting data, and what did I do last year. Last year's decisions would include things like seed choices, planting practices, how or when or what rate of fertilizer was applied, what tillage was done, irrigation applications including frequency and amounts applied, weed management practices and issues, insect and disease management, planting dates, and harvest dates. These are all different sources of data that need to be considered.

Analyze/Compare the Data.

Once all the data is available, the data needs to be looked at to see if there are any correlations between a piece of data and the resulting yield and/or profitability. Correlations are relationships between something that is done that directly affects an outcome. An example would be if the operator planted 2 different seed hybrids on a field and one yielded better, then perhaps the hybrid that performed poorer should be replaced for something that may perform better. When analyzing data, we also look at trends. Trends are similar outcomes that seem to occur when an individual decision is made. In order to identify trends, there needs to be one imperative component. That is having multiple years of data for a particular field. Having multiple years of data allows the user to rule out other variables like rainfall, temperature, and other environmental issues as well as other decisions. Analyzing and comparing data allows the user to make better decisions giving better outcomes and profitability.

Layer the data

Data layering is taking multiple sources of data and using them together to identify how different combinations of decisions affected the overall outcome. This allows the user to see how decisions work together and find the best mix of those decisions to result in the most profitable option.

Here is an example of layered data. This is a Soil Type map that was obtained years ago by surveying by the USDA. It was obtained from the USDA website.

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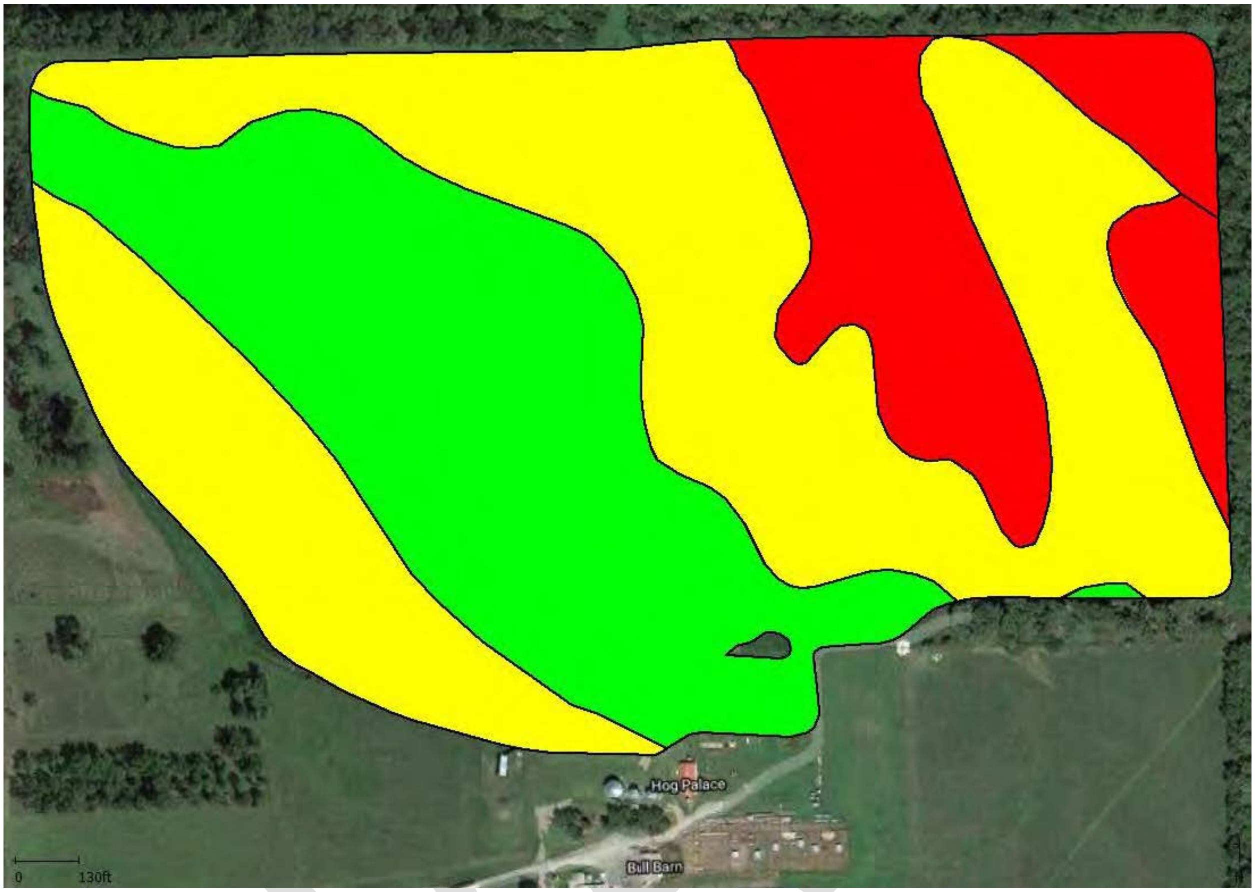

Here is a variable rate irrigation map that was applied to this field. This data was gathered using a specially equipped pivot irrigation that allows the pivot to vary the amount of water applied.

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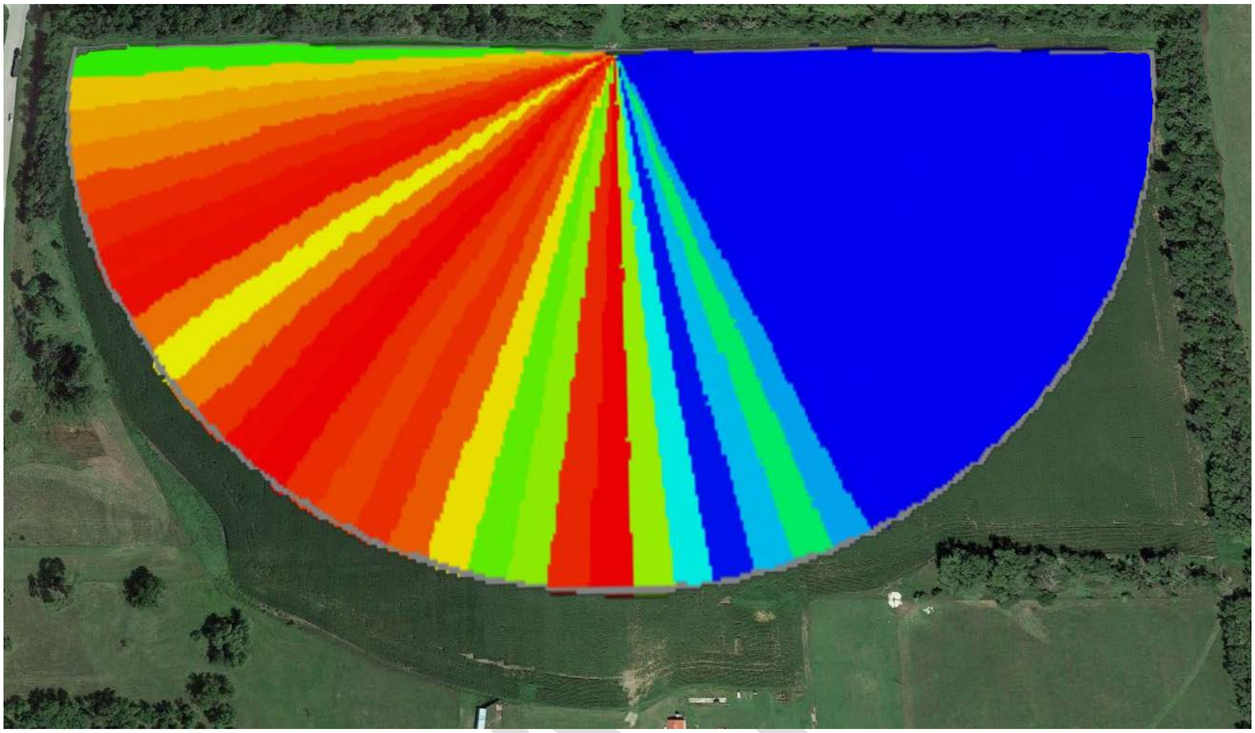
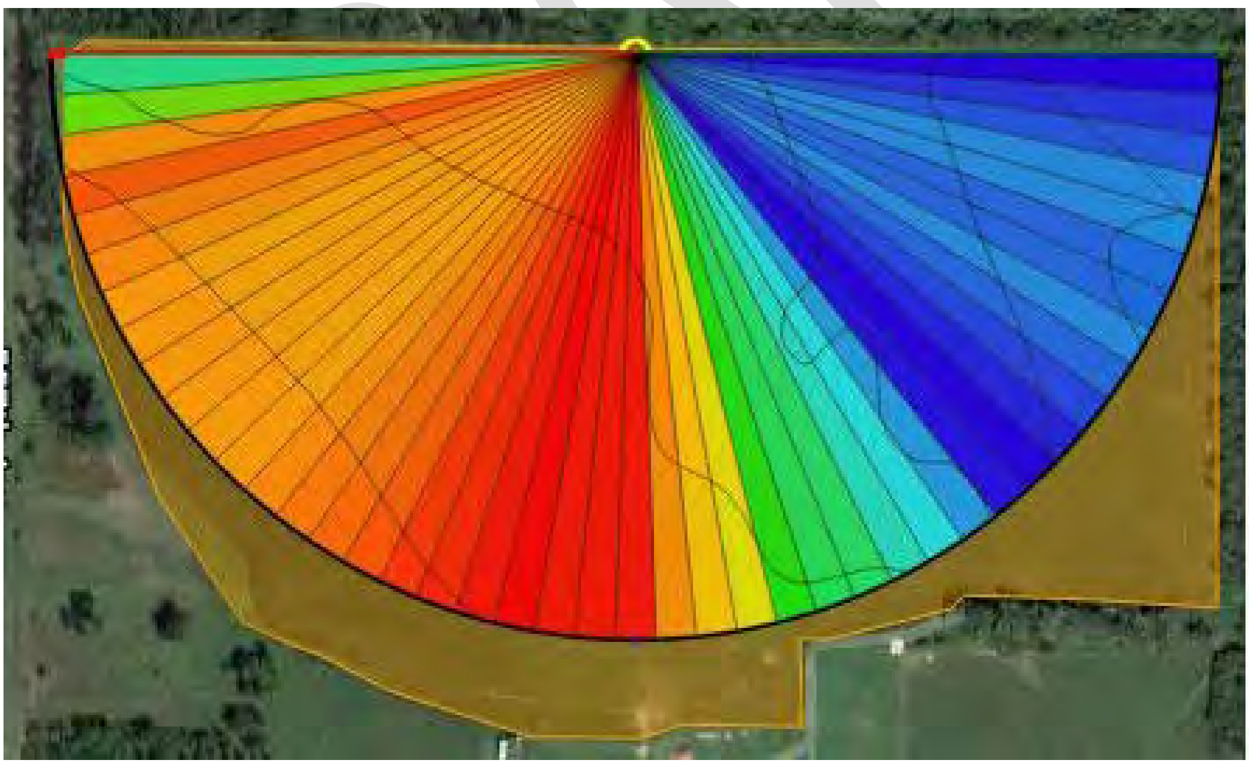


By layering these maps we can then see how much water was delivered to each soil type. Here is what that would look like.



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One thing to realize is that higher yield does not always result in higher profit. A producer may be able to bump the corn yield by 10 bushels per acre by adding an additional $40 of fertilizer and $10 of irrigation, but if corn sells for $3.50 per bushel, that would result in a loss of an additional $15 per acre, but if the corn price is like it was several years ago and it sold for $7.50 per bushel, that would result in an added $25 bushels per acre presuming the fertilizer price was the same.

Make decisions for the next year

Once the data has been thoroughly analyzed, it is time to make the decisions for the next year. These decisions will include what hybrids or varieties of seed will go in what places in each field, how much fertilizer and what type of fertilizer will go on each area of the field, what chemical applications will be needed to manage potential weed, pest and disease issues that were present last year, and what other observations will be need this year to increase profitability and quality of data for the next year. All of these decisions will work together to allow the operator to define a **prescription** to best use resources for each field. A prescription is a program or script that precision equipment can utilize to apply a specific amount of something to a specific place in the field. For instance, perhaps we use the soil type map above and decide that we are going to plant a certain hybrid on Green and Red soil types and another one on the Yellow and Orange soil types. We would use software to create a prescription that would tell a dual hybrid equipped planter to plant hybrid A in the Red and Green zones and hybrid B in the Yellow and Orange zones. Then we use this yield map from last year

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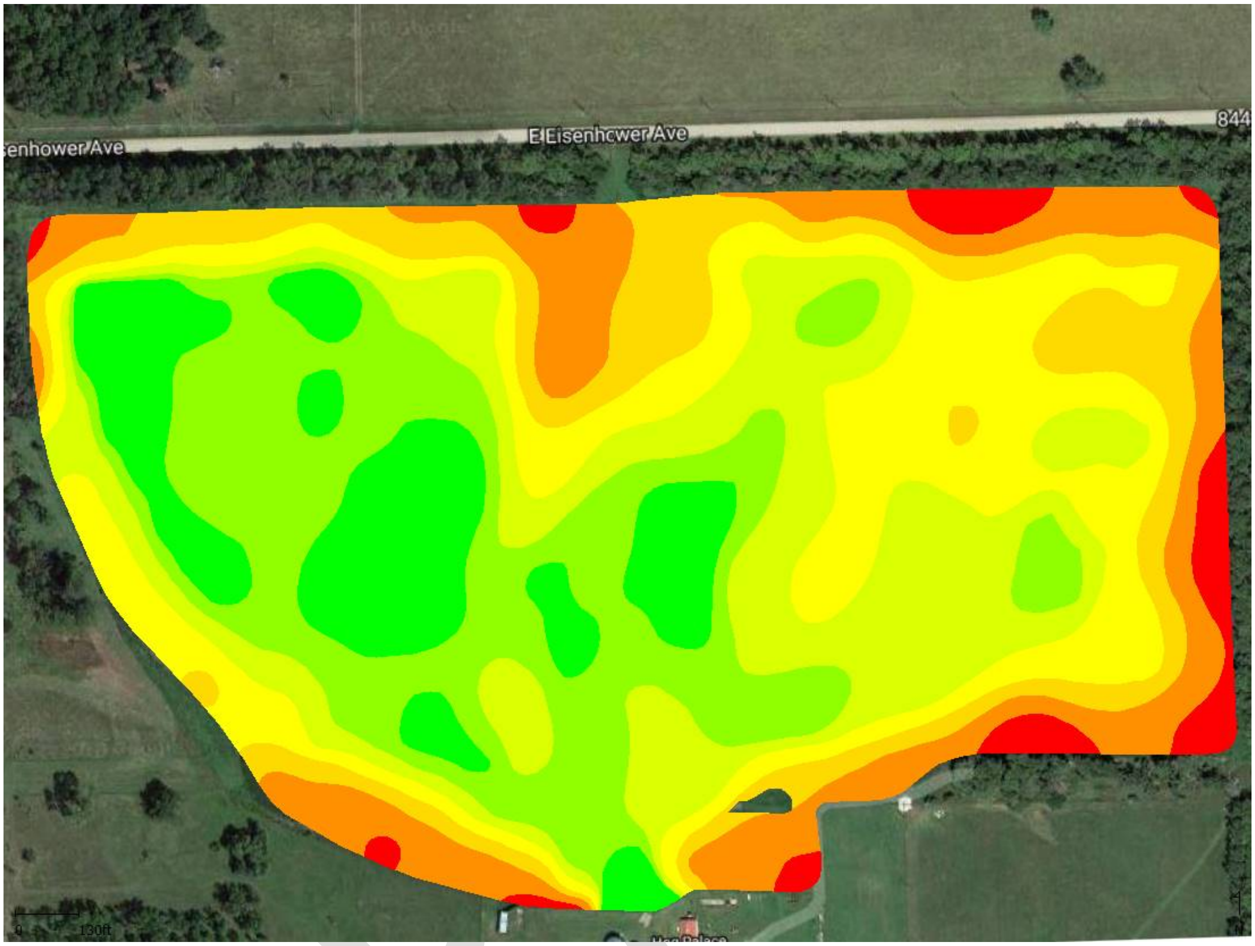

and determine that the Green areas can support 34,000 plants per acre, the light green areas can support 30000 seeds per acre, the lightest green and yellow can support 27,000 plants per acre and the orange zones can handle 24,000 plants per acre and the red zones can handle 20,000 plants per acre. By putting all that information into the prescription, they planter would then change the hybrid based on the soil type map as prescribed and change the planting population based on the zones of the old yield map. Once the prescription is made, the operator would have to configure the equipment to know that hybrid A comes from bin 1 on the planter and hybrid b comes from bin 2 on the planter. This is how Precision Agriculture management practices can put an input like seed in a location that will allow that resource to perform at the highest profitability possible.

Remember when we talked about the field boundaries of the data? Notice that the field boundary of all the images shown here are very similar in shape and the area of which each one covers. This shows why the field boundary is so important when it comes to relating data from map to map.

Apply prescriptions and determined management

Once all the decision making is done, the next step is to carry out the plans. This is where the rubber meets the road so to say. The results of the plans that were made is only a good at the way those plans were carried out. Let's use the seed prescription we discussed earlier. Let's say we load our planter with the 2 different hybrids, but we accidentally configure the planter to take hybrid A from bin 2 but we

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put hybrid A in bin 1. That would mean we didn't follow our plan and we put the hybrids on the wrong areas of the field because hybrid a would be where hybrid b was supposed to go and vice versa. This is where precision has to be part of management as well as the equipment. Because no matter how precise the plans and prescriptions are, if they are not followed with precision, some level of potential profitability would be lost.

Make Observations

Once all the applications of seed, chemical and fertilizer have been made, it is time to observe and take note of what happens throughout the year. It is important during this time, proper records are kept so that information gathered about different areas of the field can be taken into consideration during the next year. The last observation made during the year is the harvest data and the price the crop was sold. Now all the information of how much it cost for seed, equipment, fertilizer, chemicals, and labor, and how much money was earned, we then know if our decisions were good or if they could have been better.

Repeat For Next Year

Now we repeat the cycle and use what we learned from another year to make even better decisions and thereby become even more profitable.

ASSIGNMENT: Web searches and/or interviews with implement dealers, find 3 pieces of equipment used in Precision Agriculture. Explain what the equipment can do and how using the equipment aids its owner to have better decision making and/or profitability. This can be either an oral report using powerpoint presentations, story boards, or a written report handed in.

http://cropmetrics.com/wp-content/uploads/Staying-Ahead-of-the-Technological-Curve-The-PDS-Difference.png

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Additional Resources

Innovator walks through history of precision agriculture – Fam Industry News
http://www.farmindustrynews.com/technology/innovator-walks-through-history-precision-agriculture

The Unlikely History of the Origins of Modern Maps - SmithsonianMag.org
Read more: https://www.smithsonianmag.com/history/unlikely-history-origins-modern-maps-180951617/#bzzDxHE6aK6Jzt1H.99

Global Positioning System History – NASA
https://www.nasa.gov/directorates/heo/scan/communications/policy/GPS_History.html

What happens when Garming Goes High-Tech: National Geographic:
https://www.youtube.com/watch?v=tbkTi3zNN9s

Becs Hulti-Row Width, Multi-Hybrid Planter:
https://www.youtube.com/watch?v=bb7QZ9SsHTw

JohnDeere ExactEmerge Virtual Tour:
https://www.youtube.com/watch?v=XebeXoHOI_0

Precision Farming Key technologies and concepts: http://cema-agri.org/page/precision-farming-key-technologies-concepts

Precision Seeding: Higher yields with less seeds: http://cema-agri.org/page/2-precision-seeding

A brief history of GPS – PCWorld https://www.pcworld.com/article/2000276/a-brief-history-of-gps.html

www.GPS.gov

How GPS Works Video https://www.youtube.com/watch?v=IoRQiNFzT0k

https://www.youtube.com/watch?v=04VK5XscxB4

Precision Agriculture for livestock: Precision Livestock Farming (PLF): http://cema-agri.org/page/5-precision-livestock-farming

Very good publication from Virginia Cooperative Extension:
https://pubs.ext.vt.edu/content/dam/pubs_ext_vt_edu/442/442-500/442-500_pdf.pdf

Precision Planting video on using physical observation verses using sensor technology to check for Seed depth, soil moisture and seed spacing. Begin at 18:20 and play through 23:03. If time is limited, you can play at 125% speed to reduce total time of the video. Another good segment is starting at 27:02 -

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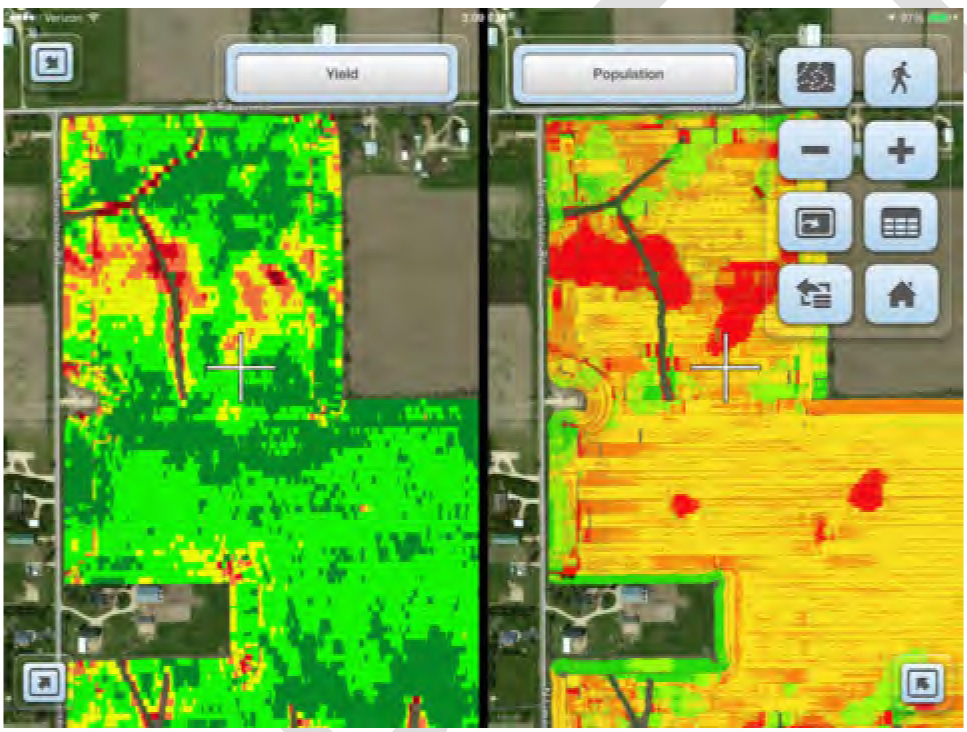
28:31. A third good segment is from 36:20- 40:00 regarding sensors indicating that something is wrong but is related to a mechanical issue with the planter rather than an environmental or sensor issue. https://www.youtube.com/watch?v=m9LP5IH7L44

Precision Ag Profitability study: http://www.precisionag.com/institute/precision-agriculture-higher-profit-lower-cost/

Modern farming vs. Traditional Farming video: https://www.youtube.com/watch?v=0MUya4sg-10

Simulation of Spray control. http://www.dailymotion.com/video/x2cf80s

John Deere Farm Forward video: https://www.youtube.com/watch?v=t08nOEkrX-I



Farmers Mutual Hail Insurance claim requirements using traditional vs. Precision practices. https://www.fmh.com/about/news/2017/09/29/precision-solutions-traditional-claim-vs.-precision-

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claim September 29, 2017

	TRADITIONAL CLAIM	PRECISION CLAIM
REQUIRED DOCUMENTS	• Settlement Sheets • Bin Measurements • Feed Records • Load Log	• Seeding Map (pixelated) • Harvest Wet-Weight Map (pixelated) • Calibration Report
TIME TO COMPLETE CLAIM	With multiple records, documentation, and the adjuster's bin measurements, validating a claim could **take hours to multiple days** to complete.	With fewer documents and more accurate data, the time required to validate a claim is reduced to a **fraction of the time** of a traditional claim.
DATA ORGANIZATION	Multiple, manually-maintained documents leave **room for human error** or missing information.	No need to keep track of multiple record sources, **eliminating simple errors** that often happen when using traditional methods.
ACCURACY	Manual records and maps might include non-farmland acres such as ditches and waterways, potentially **reducing the farmer's APH** which can affect a field's coverage level, per-acre guarantee, and loss payment.	Precision farming systems document the exact area that is planted and harvested within a field using GPS. This provides **more accurate, consistent, and complete data** – which results in the most fair loss payment.
3 YEAR AUDITS	A three-year review requires digging up years of paperwork, settlement sheets, and bin measurements. Not only can storage be challenging, it can be **time-consuming** to assemble for an audit.	A three-year review can be done **more efficiently and take much less time** using a precision planting map, harvest map, and calibration report.

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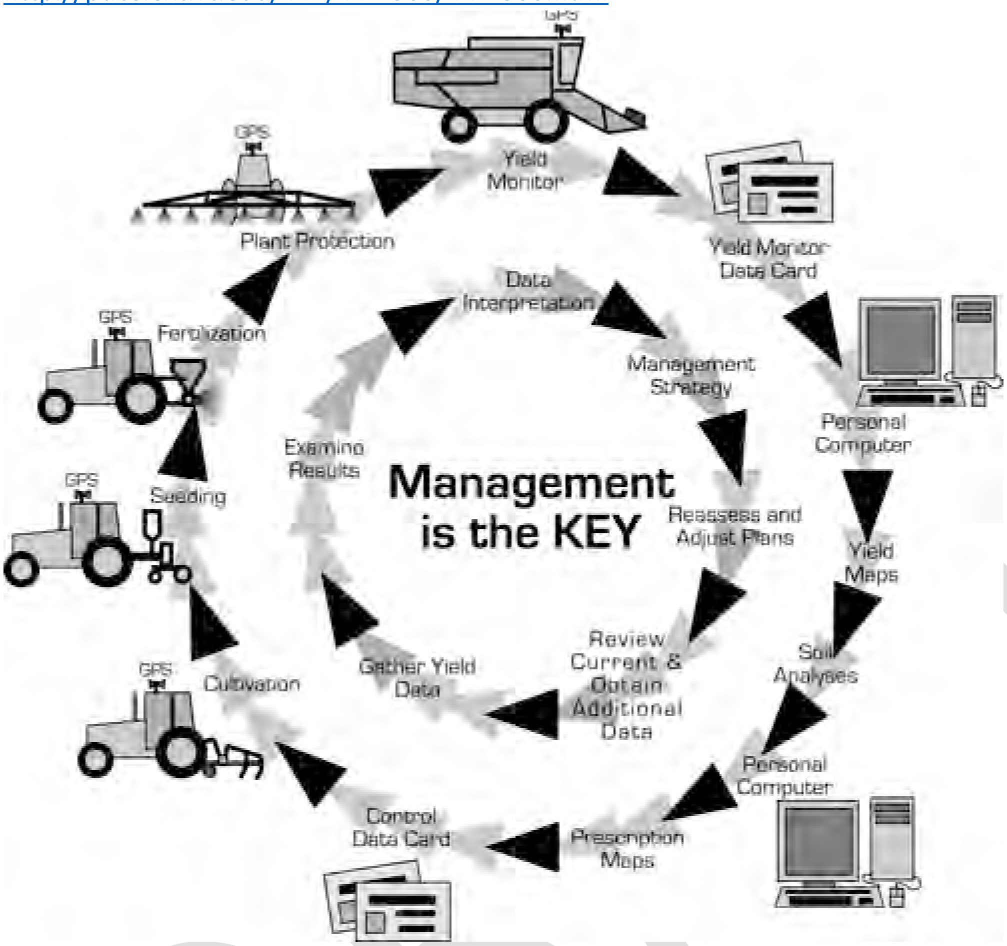
http://pubs.ext.vt.edu/442/442-500/442-500.html



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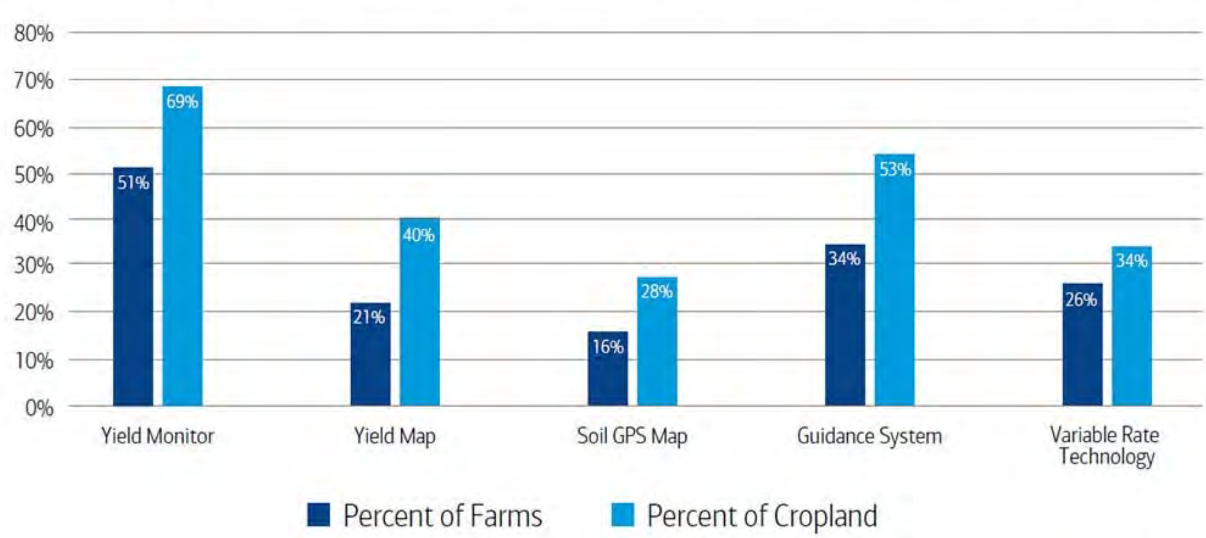
USDA Economic Research Service and National Agricultural Statistics Service, 2012 Agricultural Resource Management Survey https://www.ustrust.com/articles/future-of-technology-in-agriculture.html

Adoption of precision agriculture technologies on soybean farms in the U.S., 2012



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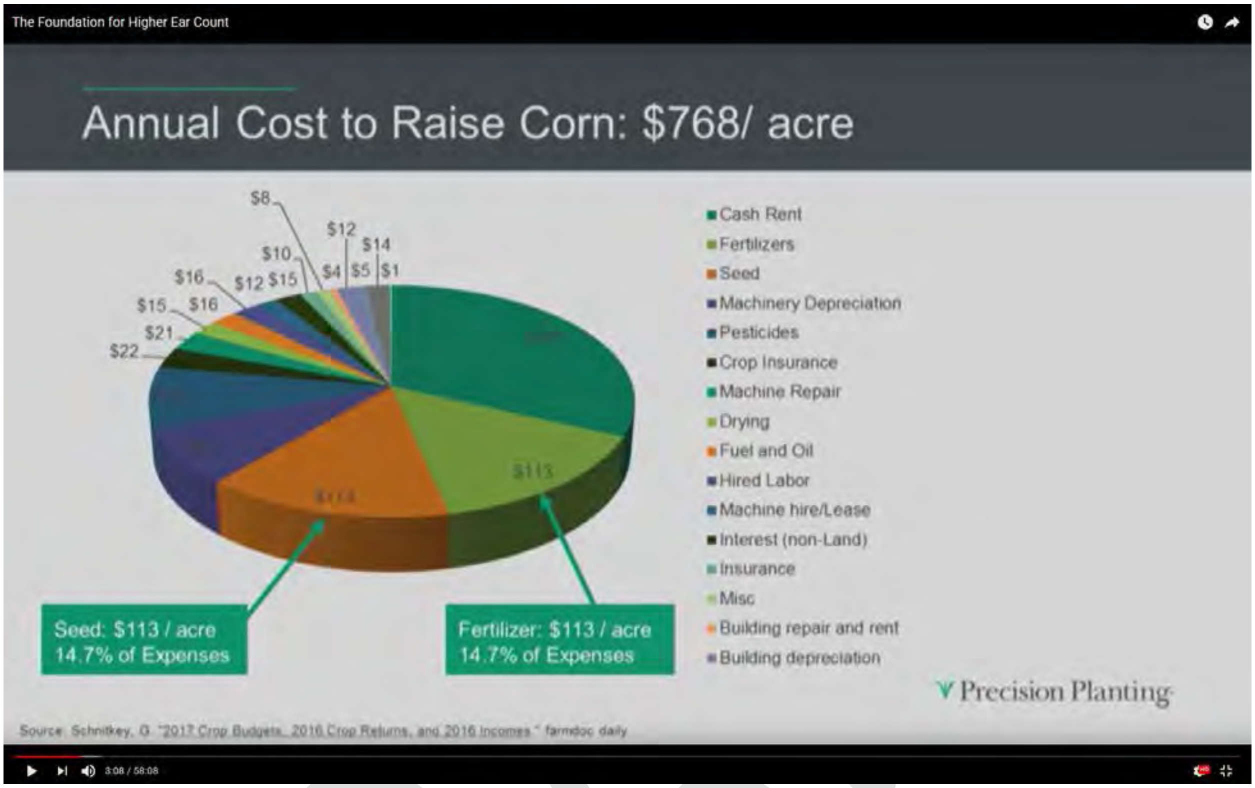
Annual Cost to Raise Corn: Precision Planting slide based on source data from Schnitkey. G “2017 Crop



Budgents, 2016 Crop Returns, and 2016 Incomes. Farmdoc daily. Taken from Precision Planting presentation, “The Foundation for Higher Ear Count” https://www.youtube.com/watch?v=nruVal-oK9E

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