The Final Report of:

The Web Soil Survey

By

Western Ag Research LLC
John Taberna Jr—Research Agronomist

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The Web Soil Survey CIG Project

Introduction

The USDA Natural Resource Conservation Service released soil survey data, called the Web Soil Survey (WSS), online at http://websoilsurvey.nrcs.usda.gov. The WSS provides soil data, such as soil texture and soil series name, which were collected in the National Cooperative Soil Survey. The website is a quick and easy way to find information on farmers' fields and examine soil variability. Soil surveys for all counties in Idaho are now accessible online and any field of interest, called the area of interest (AOI), can be obtained within minutes. This tool has powerful potential for use in precision agriculture by accelerating prescription map making for variable rate fertilization. The WSS provides information on different soil types in the field, so that soil sampling can be targeted to these different zones.

Western Ag Research LLC tested the viability of using the WSS for applying fertilizer in zones on 24 fields devoted to raising several different crops. We were able to successfully use the WSS to develop precision maps for fertilizer application. The soil delineations provided in the WSS were determined to be reliable and could be used for fertilizer application in zones.

The success of the WSS will be enhanced when field boundaries can be saved automatically as a shapefile, after the boundary is clipped from the AOI. This option is not yet currently available. This modification to the WSS would allow the field boundary to be incorporated into GIS software without having to physically drive around the field boundary using a vehicle with a mounted GPS.

Project Importance

Based on consultation with numerous farmers, Western Ag Research estimates that roughly 95% of all agricultural fields receive dry fertilizer at uniform rates. The application of fertilizers at an uniform rate is the fastest and easiest method for fertilizer and chemical companies to meet their customers' needs with as little time delay, as possible. While there are benefits for variable rate application of fertilizers, this method requires more time.

The advent of GPS technology allowed for fertilizers to be applied at different rates across a field. The use of this technology, however, is still minor when compared to the acreage devoted to applying fertilizers at uniform rates.

Fertilizer can be applied at variable rates across a field with two different methods. The first method is site-specific and includes soil sampling and fertilizer application using the grid system, with each grid representing two to four acres. Fertilizer rates can vary, as needed, from grid to grid throughout the field. The grid system is the most expensive, costing around $25 to $35 per acre depending on the size of the grid.

The other method is zonal application, with the fertilizer applied in zones based on the number of different soil types across the field. If there are three distinct and different soil types, then there are three zones that will receive three different fertilizer rates. This method utilizes aerial photographs and special software that color codes the fields into different zones based on the soil types detected by the aerial photography and special software. This method is cheaper and faster than grids and site-specific application, costing around $16 per acre for the mapping and soil sampling. The main problem with this method is the assumption that the color coordinates are correct across the entire field. That is, it is assumed, that within the field all yellows are the same soil type, all reds are the same soil type, all blues are the same soil type, and so forth. Verification of this would be more time consuming than grid sampling, therefore it is rarely, if ever done.

Our project proposed the use of the WSS system in a modified zonal fertilizer application. It uses soil survey data and does not rely on a color coded system that is not based on a soil survey, but based on aerial photos and its color codes from color reflectance measurements. We use color codes based on soil mapping units from soil survey data that are incorporated into a GIS database. The cost of doing the modified zonal fertilization, utilizing the WSS, is around $10 per acre.

While zonal fertilization is cheaper than applying fertilizer using grids and site-specific application, it still requires time for an airplane to take aerial photographs or for converting snapshots from other services such as Google Earth, FSA, or the USGS. When aerial photographs are used, ground truthing is an essential step to ensure that accurate information is used when making the zonal fertilizer map. The data in the WSS provide that ground truthing.

The WSS has the potential to speed up zonal fertilizer application and at the same time lower its overall cost. Use of the WSS is faster than aerial photography and cheaper than grid sampling for site-specific fertilizer application. Use of the WSS is also faster and cheaper than other zonal sampling methods, because the zones are already delineated in the WSS and the need for ground truthing is greatly reduced. With the WSS, ground truthing of soil variability (percent slope or the sand, silt, and clay content) is easily defined for the agronomist who will collect the soil samples. The agronomist knows to collect the soil samples in areas with the greatest variability within the WSS map. With other aerial photographs of a farmer's field, the pictures just show the field. The variability of soils shown on other photographs still has to be interpreted. This step is already done in the WSS, with its soil delineations of different soil mapping units.

This analysis of the WSS results in a more convenient and economical way of providing zonal soil sampling services to farmers for variable rate fertilizer application. With ground truthing and the zonal map making process proceeding at a cheaper and faster pace because of the use of the WSS, farmers' acceptance of applying fertilizer in zones will likely increase.

Project Objectives—Our main project goal was to promote producer adoption of applying fertilizer on a zonal basis, instead of uniformly, by using the WSS. The specific objectives were:

1. By fall 2008, six farmers in eastern Idaho will use the WSS for Zone Maps on 24 fields and 4 different crops (Wheat, Alfalfa, Corn, and Potatoes).

2. On the 24 fields, fertilizer prescription maps will be made based on soil texture and soil analysis from soil samples. In the fall, phosphorus, potassium, and sulfur will be applied based on the prescription maps. In the spring, nitrogen will be applied based on soil texture and soil N content.

3. By January 2009, we will demonstrate to 120+ farmers and 30+ crop consultants how to use WSS at our schools and our workshops. We will also do a short seminar for USDA personnel who have an interest in how we used the WSS for developing zone maps.

4. By May 2009, we will record a 'how to' power point presentation on the WSS. The power point will be 'stamped' so no edits can be made and will be available to any professional that wants one.

Project Accomplishments (What We Did)
The project objectives listed in our proposal were completed, with the exception of the short seminar for USDA personnel in Boise. We will do this seminar in 2010.

We made zonal maps using soil data in the WSS. We collected a few soil samples in each zone or different soil type and analyzed the nutrient levels. Then we prescribed fertilizer at different rates in those zones, within the same field boundary, based on the soil sample results. By using the WSS, we were able to make zonal fertilizer maps cheaper and faster compared to traditional methods. In 2010, Western Ag Research will promote and start selling the technology to farmers as a cheaper, faster, and accurate method for making maps and applying fertilizer in zones.

How the Funds Were Spent
Western Ag Research LLC was awarded $19,000 to investigate whether the WSS could be used in precision agriculture as a viable method for applying fertilizer in zones, instead of applying fertilizer using traditional methods at uniform rates across the field. We spent $11,233.50 of the $19,000 allotted for this project. This leaves $7,766.50 of unused funds, which we will not use. The monies spent went to:

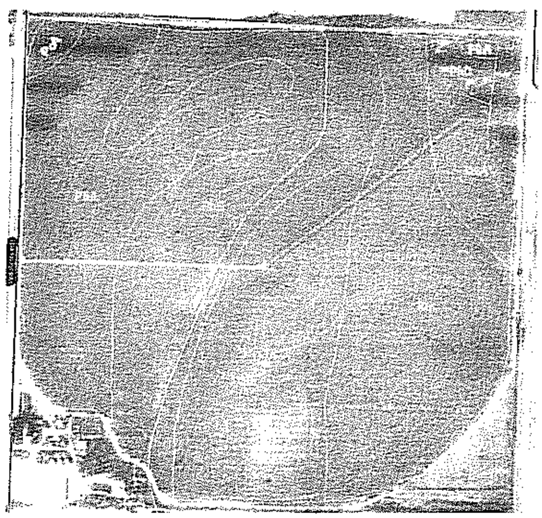
- $4,000 Research Agronomist fees—John Taberna Jr
- $7,233.50 Soil Testing fees—Western Laboratories

The cost share for this CIG project was no less than $20,000, which exceeds the 50% minimum requirement of the funds we received. The majority of the $20,000 match was from additional applicator fees paid for by the farmers. Fertilizer application fees are about $7.00 per acre for uniform application and about $11.00 per acre for variable rate application in zones. On this project, the extra $4.00 per acre amounted to $14,670 in additional applicator fees, which were paid by each participating farmer. In addition, vehicle mileage was donated to this project, as well as one part-time employee. The amount of time spent on the WSS by Western Ag Research's part-time employee was about $2,500. The additional funds were for fuel and vehicle use and were donated by Western Laboratories located in Parma, Idaho.

Six Steps to Zonal Fertilizer Application Using the Web Soil Survey

Step 1: Clip the Field of Interest's Field Boundary in the AOI

The quickest way to find a field in the WSS is to type in the GPS coordinates of the field's location into the 'Quick Navigation' box in the WSS. After the GPS coordinates are entered, the WSS automatically zooms into the field of interest, called the area of interest (AOI) in the WSS. Once you see the field, the field boundary (the perimeter), is 'clipped' and then saved from the WSS as a jpeg file. You now have the field and its boundary saved.



The field of interest clipped in the AOI of the WSS.
The soil texture variability of the field is shown. This is useful information in that the areas are clearly delineated, so that the agronomist sampling the field knows where to collect samples from the different zones. The variability of this field is clearly shown. The WSS shows the soil series name, soil texture, map unit symbol, acres represented for each map unit symbol; and other soil characteristics such as soil reaction, hydraulic conductivity, and particle separates.

The field above is 139 acres in size and has four main soil types or map units, designated as PhA, PhB, DeA, and Km. The general soil characteristics are the following.

Map Unit Symbol	Soil Series	Map Unit Name	Acres in Field (AOI)
PhA	Pancheri	Pancheri Silt Loam, 0-2% Slopes	42.3
PhB	Pancheri	Pancheri Silt Loam, 2-4% Slopes	25.0
DeA	Declo	Declo Loam, 0-2% Slopes	43.7
Km	Kimama	Kimama Silt Loam	28.0

This field is definitely not uniform. Its variable characteristics of different soil types and mapping units are clearly seen. The work of aerial photograph interpretation and ground truthing has been greatly reduced by using the WSS. We can ground truth the same time as we collect the soil samples. All we need to do is verify the delineated zones as reliable when the soil samples are being pulled along with your GPS unit and the field map. From my experience, most of the delineated zones are reliable for use in zonal fertilizer application.

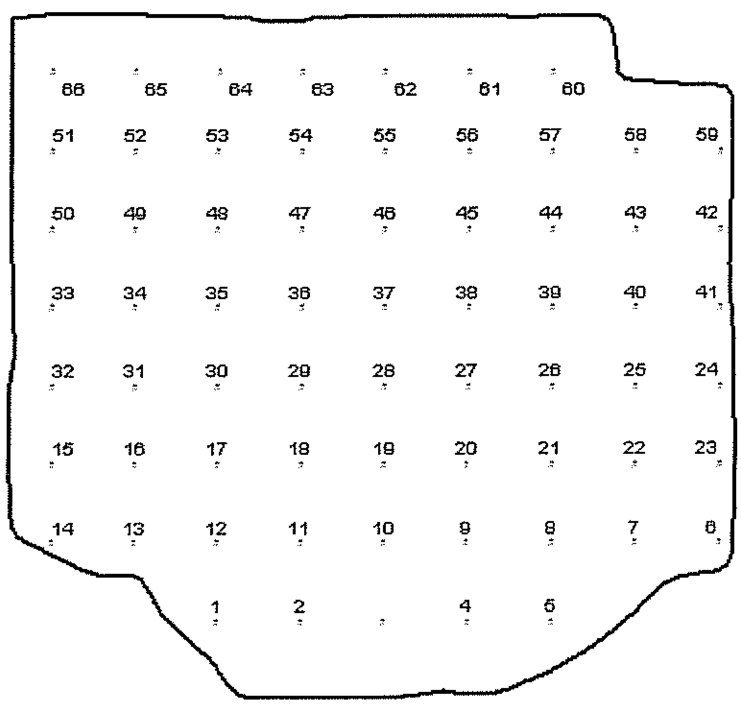
Step 2: Drive the Field Boundary using GPS and Lock-in the Boundary
The image of the field that was saved in step 1 is not geo-positioned; it is only a jpeg file. To do zonal fertilizer application, we must have the field geo-positioned using GPS and then saved as a file that can be used in zonal application, preferably a shapefile format.

To lock-in the field boundary, we drive a four-wheeler or truck around the edge of the field with a mounted GPS receiver. The field area is calculated by special GPS software. This method provides the most accurate acreage and identification of grid points that will reside in the different soil types.

After the field boundary is designated, most GPS data-collection software will request the desired grid size for a soil sampling plan and then automatically fix the geo-referenced positions for the grid points within the designated field boundary.

In site-specific fertilizer application, each grid point would be soil sampled separately and fertilizer rates ascribed accordingly to each grid point. Using the WSS and zonal mapping, we use the grid points to accurately geo-position each soil type and apply fertilizer based on the different soil test results within each soil type (zones).

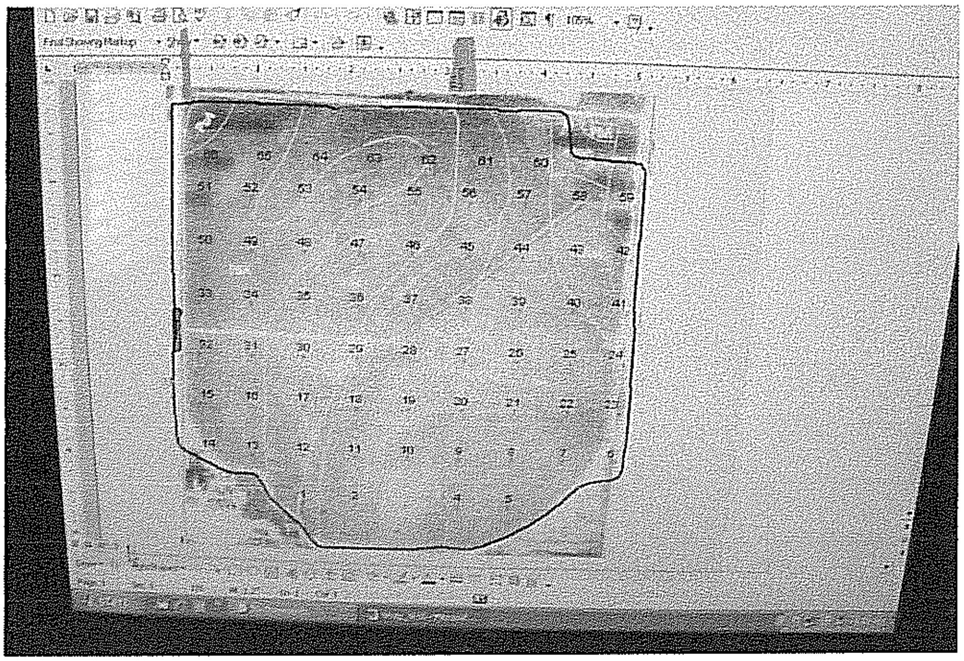
When this process is completed, we now have a very accurate geo-positioned field. Both its boundary and the grid points within the file boundary are accurately geo-positioned to within three to ten feet.



Step 3: Make a Transparency of Field Boundary with the Geo-Positioned Points
In step 3, a transparency of the field boundary and grid points from step 2 is made. The transparency is taped on the computer screen, which shows the field boundary that was

clipped from the AOI in step 1. Using this low technology method, the transparency with its field boundary is super-imposed on the field boundary that was clipped from the WSS.

The field boundary embedded on the transparency is geo-positioned; the field boundary from the WSS is not. The field boundary in the WSS can be geo-positioned by aligning the field boundary that is on the transparency. This is done by using the zoom-in or zoom-out tool on the computer screen toolbar; thereby matching the two field boundaries as shown in the photo below.



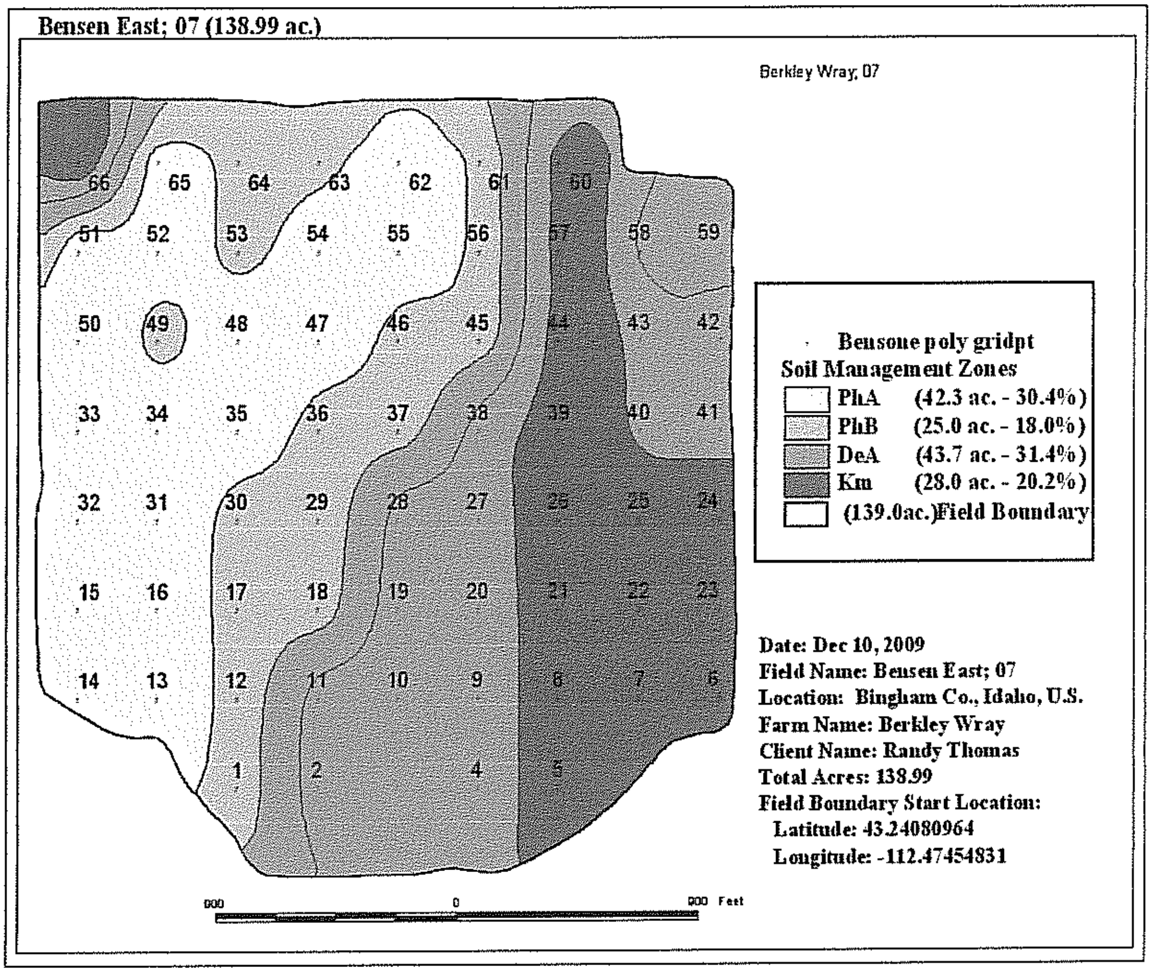
An astute student in GIS may determine that this method is low tech, archaic, and not necessary. A student proficient in GIS may want to align the WSS jpeg field boundary with the known geo-positioned field boundary by matching their projections in the GIS software program. That method can be used; however, use of the software program does take some level of expertise and care is needed to make sure the projections match and are accurate. If not, then an error of one hundred feet or more is possible.

I have found that the transparency method is best. It is easier and faster to use the field boundary with known geo-positions and projections printed on the transparency and then to overlay the transparency onto the computer screen with the jpeg of the WSS field. When this is done, zonal areas within the field can be traced onto the transparency with a very high degree of accuracy on a geo-positioned scale. As the photo above shows, the boundary and grid-points are aligned using the zoom-in and zoom-out tool. The field boundary with the known GPS data and projections are matched with the field boundary clipped from the WSS with its unknown GPS data and projection.

Step 4: Color the Zones and Collect Soil Samples for Each Soil Type
The next step is to distinguish the different zones by assigning them different colors. For each grid point, we assign the appropriate map unit symbol (ie., PhA, PhB, DeA, and

Km). Then we make a color map that shows each soil type or soil zone more distinctively. The map unit symbols are entered into the GIS database along with the corresponding grid point. The resulting map is more easily read than the original soil survey map from the WSS generated in step 1.

This makes it easier to view the field variability. It also makes it easier to collect soil samples in each zone. It is obvious to see that this example field has four separate zones. Consequently, we will collect four separate sets of soil samples to represent each of the four zones.



Step 5: Build the Database

The next step is to build the database. The database in the GIS software is where all the information is housed. In the database shown, each grid point has its corresponding GPS longitude and latitude coordinates. For each set of coordinates, the database contains information that will be used to generate the zonal map. In this example, the mapping units for the four zones and the zonal application levels of phosphorus and potassium fertilizer are shown, along with soil test values (shown below). There are four zones and consequently four different fertilizer application rates for both phosphorus and potassium.

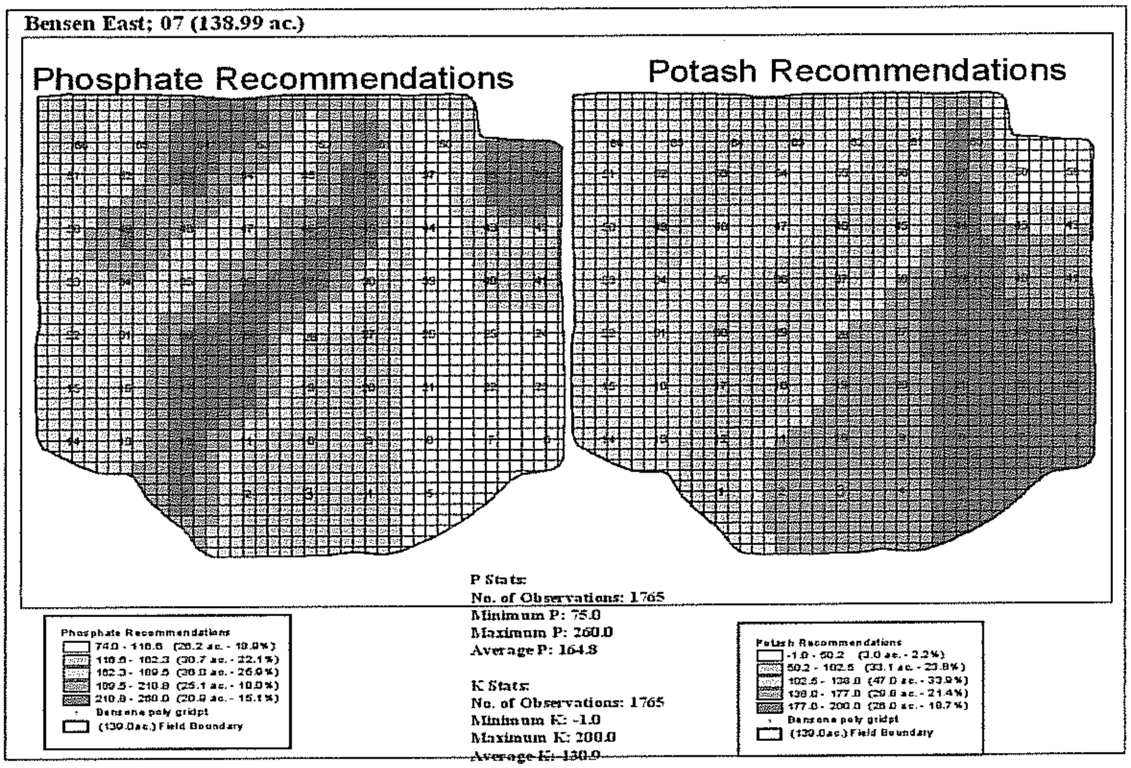
	Soil Test Data			Fertilizer Recommendations	
Soil Type	P ppm	K ppm		P_2O_5/acre	K_2O/acre
PhA	15	145		180	120
PhB	9	170		220	80
DeA	17	140		150	160
Km	21	125		80	200

For this example, the Km soil type was assigned the fertilizer rates of 80 lb P_2O_5 and 200 lb K_2O per acre in the table below. The PhA soil type was assigned 180 lb P_2O_5 and 120 lb K_2O lb per acre. The other two zones, PhB and DeA, were assigned the fertilizer rates of 220 lb P_2O_5 and 80 lb K_2O and 150 lb P_2O_5 and 160 lb K_2O, respectively.

Shape	*Sampleid*	*Longitude*	*Latitude*	*Soil*	*Text*	*ES_r*	*P*	*K*
Point	1	-112.47173613	43.23451107	PhB	2	300	220	80
Point	2	-112.47061162	43.23451107	DeA	4	225	150	160
Point	3	-112.46948747	43.23451107	DeA	4	225	150	160
Point	4	-112.46836296	43.23451107	DeA	4	225	150	160
Point	5	-112.46723880	43.23451107	Km	5	200	80	200
Point	6	-112.46499014	43.23533021	Km	5	200	80	200
Point	7	-112.46611429	43.23533021	Km	5	200	80	200
Point	8	-112.46723862	43.23533021	Km	5	200	80	200
Point	9	-112.46836296	43.23533021	DeA	4	225	150	160
Point	10	-112.46948729	43.23533021	DeA	4	225	150	160
Point	11	-112.47061162	43.23533021	DeA	4	225	150	160
Point	12	-112.47173595	43.23533021	PhB	2	300	220	80
Point	13	-112.47286029	43.23533021	PhA	1	400	180	120
Point	14	-112.47398462	43.23533021	PhA	1	400	180	120
Point	15	-112.47398462	43.23614946	PhA	1	400	180	120
Point	16	-112.47286029	43.23614946	PhA	1	400	180	120
Point	17	-112.47173577	43.23614946	PhB	2	300	220	80
Point	18	-112.47061162	43.23614946	PhB	2	300	220	80
Point	19	-112.46948711	43.23614946	DeA	4	225	150	160
Point	20	-112.46836296	43.23614946	DeA	4	225	150	160
Point	21	-112.46723844	43.23614946	Km	5	200	80	200
Point	22	-112.46611429	43.23614946	Km	5	200	80	200
Point	23	-112.46498978	43.23614946	Km	5	200	80	200
Point	24	-112.46498978	43.23696857	Km	5	200	80	200
Point	25	-112.46611393	43.23696857	Km	5	200	80	200
Point	26	-112.46723844	43.23696857	Km	5	200	80	200
Point	27	-112.46836260	43.23696857	DeA	4	225	150	160
Point	28	-112.46948711	43.23696857	DeA	4	225	150	160
Point	29	-112.47061144	43.23696857	PhB	2	300	220	80
Point	30	-112.47173577	43.23696857	PhB	2	300	220	80
Point	31	-112.47286029	43.23696857	PhA	1	400	180	120
Point	32	-112.47398444	43.23696857	PhA	1	400	180	120
Point	33	-112.47398444	43.23778768	PhA	1	400	180	120
Point	34	-112.47286011	43.23778768	PhA	1	400	180	120
Point	35	-112.47173577	43.23778768	PhA	1	400	180	120
Point	36	-112.47061126	43.23778768	PhB	2	300	220	80
Point	37	-112.46948711	43.23778768	PhB	2	300	220	80
Point	38	-112.46836260	43.23778768	DeA	4	225	150	160
Point	39	-112.46723808	43.23778768	Km	5	200	80	200
Point	40	-112.46611393	43.23778768	DeA	4	225	150	160
Point	41	-112.46498942	43.23778768	DeA	4	225	150	160
Point	42	-112.46498942	43.23860676	DeA	4	225	150	160
Point	43	-112.46611357	43.23860676	DeA	4	225	150	160

Step 6: Make a Zonal Fertilizer Map

When the database is completed in the GIS software, an agronomist can begin encoding the maps where different fertilizer rates will be applied in zones. The fertilizer rates are also entered into the GIS database shown in step 5. In step 6, the fertilizer rates are made into a color map, often called a surface creation map. The surface creation map is where the fertilizer application rates are exported into the applicator's software that recognizes the variable fertilizer application recommendation files. The two surface creation maps shown are for phosphorus and potassium fertilizer. The different colored regions are different fertilizer rates for both nutrients.



Using the WSS, the field above had an average application rate of 165 lb P_2O_5 and 130 lb K_20 per acre. If this field had been fertilized using the standard uniform application method, it most likely would have received 220 lb P_2O_5 and 160 lb K_2O per acre. By using the WSS and the modified zonal application method, the farmer saved on average $32 per acre. That amount may seem trivial considering that it costs about $2,200 per acre to raise potatoes, but it still represents a savings. The strongest selling point of the WSS system is that the fertilizer is applied in zones at the rates that are required, thus saving money. This should also be beneficial to the crops that are grown.

The Future of Using the Web Soil Survey for Fertilizer Application

It is my opinion that the use of the WSS for zonal fertilizer application will increase. It is easy to incorporate, inexpensive, and fast. My goal for Western Ag Research is to complete maps for more than 80 fields using the WSS by October 31, 2010.

Other agronomists will likely adopt this process of using the WSS in zonal map making because it is fairly easy to learn and the initial setup is not extensive. As an example, let's assume that an agronomist on average has a customer base with a total of 250 fields that are rotated with potatoes, grains, corn, and alfalfa. Let's assume these 250 fields are on ten farms. First, not all 250 fields will have the soil type variability to justify splitting the field into zones and using the WSS for map making. From my experience as an agronomist for 25 years and through this project, I estimate that 35% of all fields in eastern Idaho have enough variability where the WSS zone mapping system could benefit the farmer.

Therefore, 35% of 250 fields or 88 fields could benefit from the zonal application of fertilizer using the WSS. Since I can drive the field boundaries using GPS in a nine hour period for at least 15 fields, only one week would be needed to generate the field boundaries and the geo-referenced grid points for all 88 fields. With another week, the agronomist could spend time clipping the fields and saving them in the jpeg format in the WSS.

Once the field boundary is designated and the files are saved from the WSS, it does not need to be repeated in future years for additional crops. This step would only need to be repeated if the farmer modified the field boundary.

I expect this practice of zonal fertilizer application will grow extensively in 2010, resulting in less fertilizer use and expense for Idaho's farmers.