Site-Specific Management Guidelines

H.R. Mount SSMG-35

Obtaining Soil Information Needed for Site-Specific Management Decisions

Summary

County soil surveys contain a compendium of information about soil and climatic conditions within a region. The soil surveys are available from local Natural Resources Conservation Service (NRCS) offices. Most are in the process of being digitized (http://www.ftw.nrcs.usda.gov/ssur.data.html). Boundaries of the different soils are usually drawn on an aerial photograph. Most soil surveys are Order 2, with scales of 1:12,000 to 1:31,680 and a minimum size delineation of 1.5 to 10 acres. Order 2 soil surveys were not developed for site-specific management, and research evaluating the ability to use them for site-specific management has been mixed. They can be personalized by developing a new map based on the Order 2 soil survey as well as experiences, visual observations, and measured values.

Interactions between soil and climatic conditions influence land productivity and weed, disease, and nutrient spatial and temporal variability. By understanding these interactions, our ability to manage risk, increase productivity, and protect the environment can be improved. We must recognize that there is no single strategy for incorporating soils information into the decision process. This guideline discusses different approaches for developing experience-modified soils maps which can be used for a variety of site-specific management decisions.

Introduction

Soil scientists have long recognized soil spatial and temporal variability. In many cases, soils maps show that there are 10 or more different soil delineations within a field. For example, in an 80-acre field in Clay County, Nebraska, six different soils are located in 12 different areas. Each area varies in size from 1 acre to 45 acres **(Figure 1**).

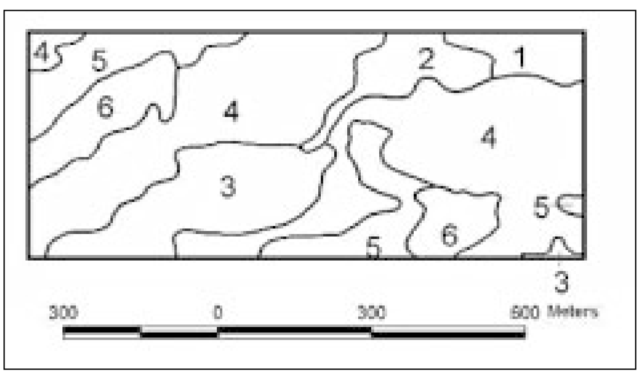

Figure 1. Soil survey map for a field in Clay County, Nebraska.

Soil surveys were developed by the NRCS to provide soil and climatic information to land managers. Soils information is available at several different scales. Published surveys, available at NRCS county offices, generally are Order 2. Many of the first attempts of site-specific farming involved research to evaluate the feasibility of using such surveys to identify nutrient management zones, but with only mixed results because:

- Nutrient concentrations have a temporal variability that soil surveys do not predict.
- Nutrient concentrations are influenced by prior management which soil surveys do not measure, i.e. old building sites, manure applications, how the field was cropped, etc.

An Order 1 soil survey has a finer resolution than an Order 2 and uses scales that are larger than 1:15,840. Steinwand et al. (1996) examined a 15-acre field in Iowa and found that the 1:15,840 and 1:3,350 scales were similar in terms of predicting crop yields. For precision nutrient management, previous management (location of homesteads and feed lots) must also be considered in the establishment of management boundaries. Old building sites can be identified on aerial images collected in the 1950s. Old aerial images may be available at NRCS and Farm Service Agency (FSA) county offices. For site-specific farming, techniques to integrate this information into existing published Order 2 soil surveys are needed. Each soil within this field may have different drainage, topography, parent material, and microclimate characteristics. Most scientists agree that management decisions can be improved by incorporating this information into the decision-making process (Steinwand et al., 1996).

The first step in developing effective site-specific soil management strategies is to obtain accurate and reliable data on the location of soil types. The next step is to

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match the soil management solution to the problem in a site-specific manner. Application equipment (variable-rate) has been developed that allows for different agro-chemical treatments and rates to be targeted to different areas of the field. Accurate soil nutrient variability information and equipment that matches the correct fertilization practice may result in lower fertilizer costs and increased net return.

With these concepts in mind, one can formulate detailed, step-by-step plans that work best for individual needs. Clearly, the most effective data collection strategy depends on matching data requirements to the problem.

Developing Experienced-Based Soil Maps

Method: After locating a soil survey map from the local USDA Ag Service Center Office or the Agricultural Experiment Station at a land grant university, use an ATV to quickly identify the location of varying soils by driving in a grid pattern or pseudo grid pattern across the field, stopping only at soil boundaries. Once a different soil is identified, determine the area it occupies by driving around its perimeter. Differences between the soil survey and your observations should be noted. If possible, record any visual limitations of each soil based on a predetermined set of criteria. For example, a yield limitation can be recorded as severe, moderate, or slight based on your knowledge of the soil's yield potential. Use a global positioning system (GPS) to provide accurate position information if possible. However, a rough estimate of location (either by counting rows or by using a measuring device) will do. The ground-truthed soil map can then be compared to yield maps and other available data for the field. This can be accomplished by comparing remotely sensed images (such as aerial photos), yield maps, soil electrical conductivity maps, or topography maps with a ground-truthed soil map. The attributes (drainage, organic matter, pH, etc) of each soil could be considered as an individual data layer. This information combined with long-term knowledge can be used to develop an experience-modified soil map. Information on electrical conductivity, yield, topography, and remote sensing is available in other guidelines (*Soil Electrical Conductivity Mapping*, SSMG 30; *Yield Monitor Accuracy*, SSMG 9; *Yield Monitors–Basic Steps to Ensure System Accuracy and Performance*, SSMG 31; *Selecting a DGPS for Topography Mapping*, SSMG 14; *Interpreting Remote Sensing Data*, SSMG 26; *Remote Sensing: Photographic vs. Non-Photographic Systems*, SSMG 16). In the process of developing an experience-based soil map, each individual piece of information will need to be assessed. When comparing and evaluating the different information layers, some factors will be given more weight than others. For example, soil drainage may be weighed heavier than soil pH. Lines should be hand drawn, based on the objective of the specific activity, on the soil survey. Different problems may result in different lines and, thus, different maps. Once the maps are developed, they can be scanned into the computer and incorporated into geographical information system (GIS) programs. In the GIS format, the information can be used by variable-rate equipment. It is important to point out that management boundaries may be influenced by climatic conditions.

Outcome: Data can be used to make a map that shows the location of individual soils as well as crop productivity maps. Some GIS software will also allow determination of percent field area occupied by each soil.

Advantages: The procedure is very quick and easy to implement, works best for soils that display visual variability.

Disadvantages: Soil differences may be difficult to identify, especially if sampling is done when soils are dry. You must be very clear as to what you mean when you classify a soil as severely, moderately, or slightly eroded.

Obtaining Site-Specific Information

Chemical and physical information reported for each soil within the soil survey represents average values. For site-specific management, average values may not be adequate, and actual chemical and physical measurements from a field may be needed. Three of the many approaches for obtaining this information are discussed here.

***Grid sampling*:** Data are collected on a uniformly spaced grid coordinate system (approximately 120 ft. spacing). At each grid point, the soil is examined and soil thickness, horizons, slope, organic matter, drainage class, degree of erosion, and texture class are either measured or estimated. Each measured parameter can be incorporated into GIS. Individual soil attributes can be used by GIS programs to identify different management zones.

***Experienced-based soil maps*:** At several locations in the experienced-based soil zones described above, the soil characteristics can be measured or estimated.

***Remote sensing*:** Multispectral remote sensing or black and white aerial photographs offer the potential to identify, categorize, and determine differences and similarities in crop and soil conditions over a wide geographic area. Images can be taken several times over years to give views of whole fields, farms, and watersheds. In many cases, interpreting a simple black and white aerial photograph will suffice in determining the variability of soils across a field **(Figure 2)**. Soil color may be related to organic matter content of the soils. Typically, light areas have lower organic matter content than dark areas. The amount of organic matter influences agro-chemical application rates, plant available water, and soil

Figure 2. Aerial black and white photo of a 160-acre field in Moody County, South Dakota.

quality. Black and white photographs are available for most fields from county NRCS or FSA offices.

Outcome: Generally, costs increase exponentially with decreasing grid sizes**.** Optimal grid spacing is unknown and depends on several factors. One can decide on a grid spacing that maximizes both cost and labor efficiencies (i.e. I only have time to sample 100 points across a field). This has shown to be an effective method for soil sampling, where soil properties change gradually across a field and usually occur as larger polygons. Because soils are highly aggregated, this method may result in an entire soil delineation being missed because the size of the soil delineation is smaller than the grid spacing. One alternative would be to use a predefined grid system which allows the scout to deviate from the grid if soils are noted but otherwise missed. The allowable degree of deviation off the grid is dependent on time and cost considerations.

With soil-based sampling, the variation within a soil delineation is ignored. In some cases ignoring this variation may be a critical flaw. The value of the information is directly related to the accuracy and precision associated with all the estimated and measured values. Accuracy and precision of estimated values can be improved by using reference samples. For example, if texture is estimated by feel, then reference sample with a known texture can be used to calibrate your fingers.

For remote sensing, the ability to see individual features is related to the resolution. Different sources of remote sensing have different resolutions. For example, multispectral information available from AVHRR satellite sensors has a resolution of 1000 m; SPOT satellite data resolution is 20 m; Landsat 7's imagery resolution is 30 m; IKONOS satellite imagery resolution is 4 m. Resolution and aerial images collected from an airplane usually have resolutions of less than 1 m. A 1 m^2 pixel (cell) resolution will integrate reflectance to give one value for an area about the size of a tabletop. A pixel resolution of 30 m^2 integrates the reflectance in the area of six school buses parked together. Soil delineations that are apparent on a 30 m resolution image will most likely not be apparent on a 1000 m resolution image.

***Advantages*:** Obtaining site-specific information for the different soils or grid points within a field can improve your ability to manage your resource. This information can also provide base level values from which temporal changes in productivity can be assessed. For remotes sensing, aerial imagery allows you to modify a sampling strategy by having access to soil information on a field scale in a timely fashion.

Disadvantages: If the information is not collected using a consistent approach, the information may have limited value. This problem can be avoided by using reference samples. For remote sensing, this method requires post-processing of the images that may need to be completed by trained professionals. Therefore, there may be considerable time elapsed between data collection date and image availability

Processing Soil Information

For agricultural purposes, individual attributes may be more important than soil type. Under these conditions, all soils that are poorly drained with high organic matter may be grouped together, and all soils that are well drained with low organic matter can be placed in a different group. Using this approach, it may be possible to reduce the number of soil delineations from 10 to five. If the soil attribute data are a GIS information layer, then GIS can be used to classify these different zones. A variety of classification approaches can be tried. Classification schemes that work best for one problem may not work best for a different problem. For example, if plant diseases are a problem, then classification based on drainage may provide important information. However, if pesticides need to be applied, then classification based on texture and organic matter may provide important information for delineating different management zones.

Outcome: Interpolation techniques can be used to build a map showing the location, size, and inherent productivity potential of soil delineation across a field. If GIS is used, other information collected at the time of sampling (soil drainage) can be integrated into this map**.** The maps can be used to develop site-specific management strategies.

Advantages: The maps are needed to convert information from a variety of different sources into decisions.

Disadvantages: The maps most likely will not be perfect. Remember, the goal of integrating soil information into the decision process is to improve, not perfect, the decision process, and as more information is collected, the maps can be modified.

Conclusions

County soil surveys provide valuable information about the soil's physical, chemical and biological properties. Interactions of these properties and climatic conditions impact prevalence of diseases, nutrient spatial variability, and pest distributions. Understanding these interactions can improve the effectiveness of individual management decisions. Developing experience-based soil maps can help integrate this information into everyday decisions. ■

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