

# PRECISION AGRICULTURE SERIES

# TIMELY INFORMATION

## Agriculture, Natural Resources & Forestry

March 2011

### Management Zones II – Basic Steps for Delineation

Management zones (MZ) support site-specific management (SSM) strategies. However, the benefits of a MZ approach are linked to natural field variability and the strategy used for zone delineation. Hence, MZ delineation is unique to each farm, each field, and approaches to MZ delineation vary. In addition, the process can evolve over time as additional data is collected.

Another approach to SSM, especially for fertilizer and lime applications, is to develop maps based on grid soil sampling rather than directed sampling using MZ. In fields exhibiting high variability, this strategy is best if it is conducted one-time as the basis for determining soil nutrient status, and subsequent management is conducted by zones. The grid soil sampling approach can result in a valid variable rate application map, however, it may not always be feasible because of the time and expense required. Therefore, a MZ approach is often a more economical method for developing variable rate application maps.

### Questions raised when considering Management Zones Delineation

The first consideration before one starts gathering data for MZ delineation is to identify the potential sources and/or field characteristics responsible for yield variability. The relation between yield and the sources of its variation (e.g., soil fertility, soil moisture, soil physical properties, pest and diseases) can be stable over time (e.g. intrinsic soil properties) or change from year to year (e.g. pests), and the identification of those relations can help you establish the most cost-effective strategies for SSM implementation.

The most frequent questions that arise when considering site-specific management are:

1. *Which input(s) should I apply through variable rate?*
2. *What information and data should be used for delineating management zones within a field?*
3. *How can information be processed into management zones?*
4. *How many management zones should be created?*

### ***Which input(s) should I apply through variable rate?***

We might have multiple answers to that question; however, before deciding to implement SSM, it is necessary to assess the degree of within-field variability. Once variability has been identified, the producer should focus on inputs that can provide the most economic benefit. Besides capitalizing on the inherent yield potential of an area, input costs play a significant role when varying the rate according to zone. High value inputs that maintain or increase yield should be considered first since they provide the quickest return.

### **What information and data should be used for delineating management zones within a field?**

Various sources of information can be used for MZ delineation. Examples range from farmer's knowledge to traditional soil surveys, high resolution aerial photographs or satellite images, elevation data, apparent soil electrical conductivity (Soil EC<sub>a</sub>, Figure 1a), and yield (single or multi-year, Figure 1b, 1c) data, among others. Typically, a combination of data layers characterizing several field properties and their spatial variability can provide a more accurate MZ map (Figure 1f) than using a single data layer (Figure 1d). For example, research has shown that MZ delineated from a combination of field topographic characteristics (e.g. elevation, slope) and/or soil properties (e.g., soil drainage class, surface textures, soil organic matter) can often depict yield variability due to differences in plant available water. The most common data layers used for MZ delineation are found in Table 1. Table 2 provides a list of inputs that could be managed differentially and type of data that can be used to delineate management zones.

Field characteristics used for MZ delineation can be described as:

1. *Quantitative-Stable* (e.g., elevation, (Figure 1a)),
2. *Quantitative-Dynamic* (e.g., yield data (Figure 1 b, 1c), soil moisture, soil EC<sub>a</sub>, plant N status)
3. *Qualitative-Stable* (e.g., soil color, soil survey maps)
4. *Intuitive/Historical* (e.g., grower knowledge of within-field variability, overall yield patterns (Figure 1 b, 1c), past crop rotations)

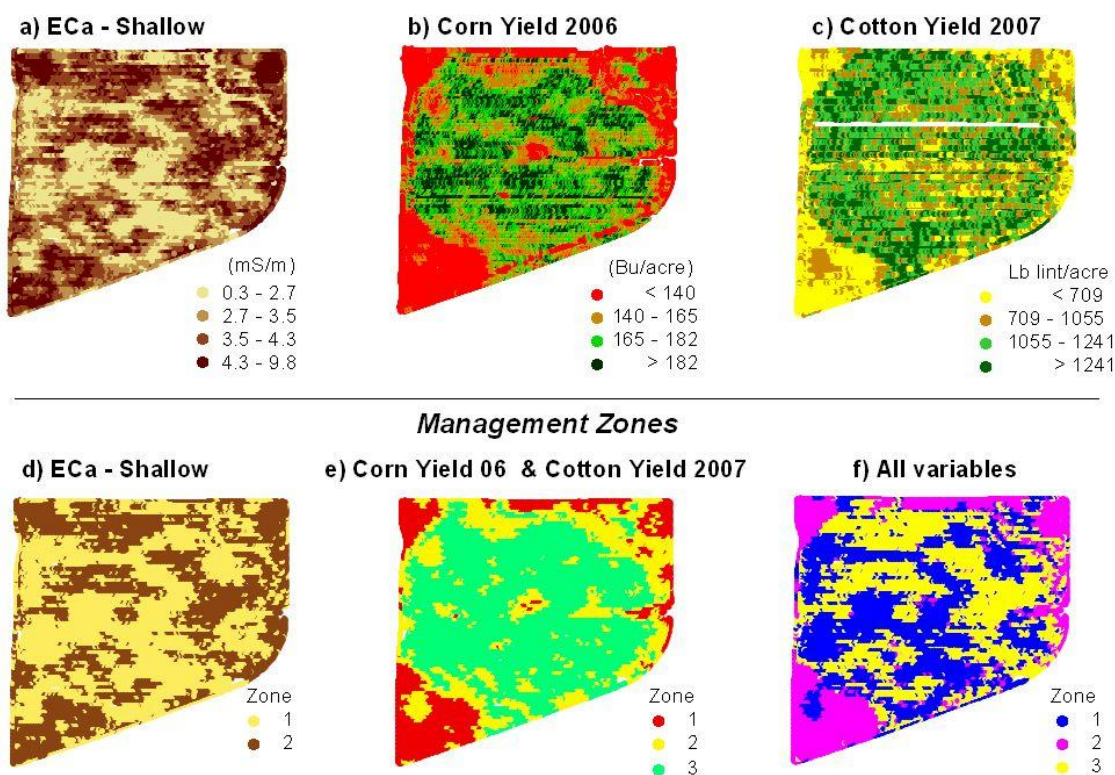


Figure 1. Examples of management zones delineated from a single soil data layer (d, generated from a), combination of two years of yield data (e, generated from b and c), combination of soil and multiple years of yield data (f, generated from a, b, and c).

Table 1. List of the most common data layers used for management zone delineation.

Data Layer	Description	Method of data collection
Apparent Soil Electrical Conductivity (Soil EC <sub>a</sub> )	Soil EC <sub>a</sub> is used as proxy for inferring soil properties such as soil texture, soil water content, soil organic matter, soil depth and cation exchange capacity (CEC).	Commercial sensors available to collect Soil EC <sub>a</sub> are 1) VERIS 3100 (direct soil contact sensor) and 2) EM38 (indirect soil contact sensor).
Soil Organic Matter (Soil OM)	Soil OM is positively related to soil fertility.	Regularly spaced grid soil sampling allows the generation of maps depicting the spatial variability of soil OM and soil nutrients. Soil EC <sub>a</sub> data allows an indirect assessment of within-field soil OM variability.
Bare soil imagery	Light reflected from the soil could be related to soil properties such as organic matter content or soil texture.	Aerial photography, satellite imagery, or on-the-go sensors such as GreenSeeker or Crop Circle can measure differences in bare soil spectral reflectance.
Soil survey	Order 1 soil surveys have a higher resolution than Order 2 surveys (produced by NRCS), but are not readily available. Soil surveys separate soil units on landscapes, which can become the basis for management zones.	Digital soil surveys (Order 2) are available through Natural Resources Conservation Service (NRCS). <a href="http://www.aces.edu/waterquality/gis_data/table_all_ssurgo.php3">http://www.aces.edu/waterquality/gis_data/table_all_ssurgo.php3</a> <a href="http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm">http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm</a>
Terrain elevation	Elevation changes are related to soil variability and water movement across landscapes, which can result in crop yield differences.	Elevation data can be collected with RTK-GPS systems used for tractor guidance. Digital Elevation Models (DEMs) available through the USGS can be also used to generate elevation maps.

Table 1 continued. List of the most common data layers used for management zone delineation.

<b>Data Layer</b>	<b>Description</b>	<b>Method of data collection</b>
Terrain slope	Terrain slope, usually derived from elevation data, is related to soil water movement (runoff), soil moisture, erosion, and crop yield	Slope is derived from elevation maps, so any method that collects elevation data can be used for slope map development.
Crop imagery	Remote sensors can detect and quantify differences in plant characteristics based on the amount of reflected light. The evaluation of crop growth is possible by collecting and comparing images at different times.	Multispectral or hyper-spectral sensors mounted on airplanes, satellites or agricultural equipment (e.g., GreenSeeker, Crop Circle) can collect crop spectral reflectance.
Crop Yield	Yield data is a direct measurement of crop productivity. Yield maps are the result of many potential sources of yield variability such as soil fertility, soil physical properties, soil moisture, pest and diseases. The evaluation of multiple years of yield maps can result in the identification of yield productivity patterns, which provide baseline information for SSM. In addition, these data serve as a report card for management strategies.	Geo-referenced yield monitors allow collection of site-specific yield data during harvesting.

Table2. List of agricultural inputs suitable for variable rate application and data often used to delineate management zones for these inputs.†

<b>Input suitable for VRA or differential management</b>	<b>Data used to delineate management zones</b>
Seeding rate	Soil EC <sub>a</sub> , topography, soil survey, historic yield data, soil OM
Nematicides*	Soil EC <sub>a</sub> , topography
Lime	Soil EC <sub>a</sub> , grid or zone-sampled soil pH, buffer pH, soil survey, topography, bare soil imagery, historic yield data
Nitrogen	Soil texture, soil OM, soil color imagery, crop spectral reflectance using sensors like GreenSeeker or Crop Circle, yield data
Other nutrients	Soil EC <sub>a</sub> , crop spectral reflectance, CEC, soil survey
Irrigation	Soil EC <sub>a</sub> , soil color imagery, yield data, canopy imagery, soil survey, farmer's knowledge

†Because each field represents a particular combination of yield limiting factors, information provided in this table is only a guide to start management zone delineation.

\* Nematicides used to control Southern Root-Knot nematode.

### **Key considerations when implementing a management zone delineation strategy:**

- *Relationship between field characteristics and yield:* Look at factors that have the most direct impact on yield that can be targeted for MZ delineation. Some examples include terrain elevation, soil physical properties, and soil nutrient levels.
- *Use of quantitative and time-stable data:* Management Zones delineated from data that is stable year to year might be the most cost efficient strategy. Terrain elevation, soil electrical conductivity patterns and soil physical properties are examples. In the case of yield data, within-field yield variability can be assessed with a single year of data; however, multi-year yield data along with supplemental information (e.g., soil electrical conductivity or elevation) is recommended for zone delineation in order to identify consistent yield patterns.
- *Level and amount of data required:* Precision agriculture technologies allow the collection of data sets that provide discrimination of within-field features sufficient for MZ delineation. Some examples of these are yield monitor data, terrain elevation measured with real-time kinematic differential GPS (RTK-DGPS), high resolution aerial or satellite images, remote sensing data from on-the-go active remote sensors like GreenSeeker or Crop Circle, and soil EC<sub>a</sub>. In situations where there is no access to these data, county soil surveys provide a relatively coarse depiction of within-field variability that is often related to yield variability.
- *Cost of the data:* The implementation of a MZ strategy should not require a high initial capital investment. However, MZ delineation requires time. Using spatial data that is free and available on the Web may be a good start.

Examples of these data are:

- Alabama Soil Survey data by county ([http://www.aces.edu/waterquality/gis\\_data/table\\_all\\_ssurgo.php3](http://www.aces.edu/waterquality/gis_data/table_all_ssurgo.php3))
- Land use maps, aerial imagery from crops, elevation maps (<http://datagateway.nrcs.usda.gov/>)
- Aerial photos (<http://terraserver-usa.com/>) or Remote sensing images (<http://glovis.usgs.gov/>)

### ***How can information be processed into management zones?***

Data processing for MZ delineation involves the use of various computer software or web applications. Typically, individual maps for a single variable or factor are generated and later combined using a geographic information system (GIS). Various agricultural-oriented GIS packages have capabilities for MZ delineation (e.g., MapShots, Ag Leader SMS, EasiSuite, FarmWorks). Additional information about AgGIS packages can be found in the ACES Timely Information Sheet '[Agricultural Geographic Information Systems](#)'.

A free software package, [Management Zone Analyst \(MZA\)](#), developed by USDA-ARS scientists in Columbia, Mo., allows you to combine multiple layers of geographic data for MZ delineation. This software not only classifies the data set into zones but also suggests the best number of zones that should be created. Additional information can be found at:

<http://www.ars.usda.gov/Services/Services.htm?modecode=36-22-15-00>.

A new Web-based application with capabilities for MZ delineation and prescription map generation has been developed by the University of North Dakota and NASA (<http://zonemap.umac.org/>). Using the "[Zonemap](#)" application, you can combine your own data with historic satellite imagery available for your area to delineate zones, assign fertilizer rates for each zone, and then generate the fertilizer application maps in various digital formats compatible with the tractor's controller.

### ***How many management zones should be created?***

The number of unique zones in which a field should be divided is often left to the experience or knowledge of the farmer or consultant. There is no absolute number of zones in which a field should be divided, and that number typically depends on the field's variability. Improvements in variable rate applicators allow management of relatively small areas, but zones smaller than a few acres are typically not efficient. The advantage offered by the MZA software is that it provides an objective number of zones based on the variability of the data set. No matter the approach, the final MZ's should be evaluated based on historical performance of the field (e.g. farmer knowledge, yield maps) to ensure their relative accuracy.

In summary, even through multiple approaches can be used for MZ delineation; consider this is an evolving process.

### **Disclaimer**

The mention of trade names and commercial products is for informational purposes and does not necessarily imply endorsement by the Alabama Cooperative Extension System.

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