# SITE SPECIFIC MANAGEMENT: THE PROS, THE CONS, AND THE REALITIES

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Site specific management (SSM) for agriculture involves the variable management of soils and crops according to localized conditions within a field. Known by many other names, such as "Grid Farming", "Farming by Soils" or "Variable Rate Technology (VRT), SSM is a rapidly emerging set of technologies that allow farmers to manage their soils and crops on-the-go as equipment moves across a field. In essence, SSM is about doing the right thing, at the right time, in the right place, in the right way. Thus, SSM is intuitively appealing because it represents a means of improving the economic and environmental performance of cropping systems. However, while proponents of SSM will endorse its great potential, the fact is that SSM is an emerging technology that is best described as still in its infancy. Thus, at this stage in its development, SSM has its strengths (Pros) and its weaknesses (Cons) which in combination clearly define the current status of SSM for agriculture (Realities). What follows is a brief overview describing some essential elements of SSM and the degree to which these elements have or have not been developed.

For our discussion, we will describe SSM in basic terms as a two step process: the first step involves the assessment of variability, the second step deals with the management of that variability. The first step is critical since SSM is potentially useful only if variation within a field is known, is of sufficient magnitude, and is non-random (spatially structured). The second step is often limited by lack of site specific recommendations and/or the lack of precision in the application of inputs. Thus, the component technologies of SSM all deal with some aspect of assessing or managing variation.

## Assessing Variation

Currently, a number of techniques are available to assess variation within a field. Each is important to SSM and each has their pros and cons. Some of the important ones are briefly presented here.

**Soil survey**
Pro: The soils of most of the private land in United States has been surveyed and digitization of the maps is underway. Soil survey maps will form the base maps for SSM maps.

Con: Mapping scale of 1:24,000 or larger may be too coarse for SSM; 1:6000 or less scale may be needed to adequately define field variability. Some of the soil .surveys are dated and digitized surveys are not available everywhere.

**Remote Sensing**
Pro: A powerful tool for assessment of variability in soils and plants. Information on a large area can be obtained quickly and repeated frequently.

Con: Expensive and not readily available to the agricultural community.

**Soil Sampling**
Pro: A traditional method for assessing soil fertility and forms the basis for fertilizer recommendations.

Con: Focus in SSM has been on grid sampling since variation in soil fertility has not correlated well to soil map units. A grid size of 330 ft is frequently used, but the appropriate grid size and frequency of sampling required for variability assessment are under discussion. The cost of grid sampling is inversely proportional to the square of the grid size. Crop yields not always correlated to variation in soil tests.

**Sensors**
Pro: Desirable for assessment of variability due to ease and rapidity of measurement. Grain flow, speed, and grain moisture sensors and global positioning systems (GPS) have made yield mapping possible. Yield mapping is an essential component of SSM because crop yield forms the basis for many cropping inputs. A number of soil and plant sensors are commercially available. Sensors and sensing technologies make real-time SSM feasible and eliminate problems associated with more traditional, labor intensive measurements.

Con: Evaluation of available sensors is limited. The nature of sensing technologies is to generate large volumes of data that must be managed, stored, and interpreted. Sensor technology is limited and needs to be expanded to more facets of SSM.

**Decision Aids, Models, Expert Systems**
Pro: Expert systems, prediction equations, and simulation models are additional examples of techniques to predict variation within fields. A number of these are currently available and more are under development.

Con: Few of the available technologies in this category were developed for use at the farm field management level. Farmers have indigenous knowledge about their fields and can predict to some extent where managed inputs should change and this knowledge should be incorporated into SSM.

**Computerization**

Pro: It will become rather clear that assessing variation requires a means of managing large quantities of information. Geographic Information Systems (GIS) are systems designed to manage and analyze spatially referenced data and are being adapted for use in SSM. The county soil surveys are being digitized for use and different map layers, including field boundaries, roads, contours, etc. are available for many areas of the United States. When used in combination with measurement and location measuring techniques, GIS systems can be used for record keeping and performance mapping by within field location. Computers are increasingly becoming more powerful.

Con: SSM is software limited. A significant component of SSM is the management and analysis of large amounts of data. Getting the desired information in the needed form and quickly is a key goal in SSM.

**Education and Training**

Con: Assessing the spatial variability within farms fields is new to most agriculturalists. Education and training programs in SSM are grossly lacking and will need to be developed in both the public and private sector.

## Managing Variability

Once the variation within a field is recognized and documented, the goal in SSM is to match inputs to the needs of each management area within a field. This requires three fundamental steps: (1) the delineation of management areas within a field, (2) an appropriate recommendation for each managed input for each management area within a field and (3) the ability to apply the input in a precise manner (precision agriculture).

## Management Area Delineation

It is important to recognize that variability within a field can be managed in two ways. The first we will call "strategic management" in which variability is analyzed in such a way as to produce maps delineating management zones within a field. These management maps are then digitized and used in computer controlled equipment to vary rates of different inputs by management zone within the field. The application of nutrients and pesticides in this way is frequently called Variable Rate Technology (VRT). A second method for managing variability we will call "real-time management" in which the parameter to be managed is sensed and a prescription application is applied as equipment moves across the field. The prescription may be computer controlled based on a logic of "if [condition] then [action]" or it may be controlled by the equipment operator.

Pro: Numerous mathematical procedures are available for analyzing spatial variation and delineating areas with similar properties. Most notable is the increasing use of geostatistical procedures. Real-time management may fit certain management variables better, such as weed or pest control. Global positioning systems provide sufficient accuracy for position delineation for either strategic or real-time management.

Con: There is no "best method" of creating management zones for any given parameter. In fact, different analyses of the same data set will produce different management maps. The intensity of sampling of variation, e.g., grid size, will greatly impact the delineation of management zones in a field. Real-time management requires sensors and sensors for SSM are limited.

### Management Recommendations

The success of SSM depends a greatly on the appropriateness of the site specific recommendation for a given managed input.

Pro: A considerable body of knowledge from decades of agricultural research exists regarding recommendations for inputs of agricultural fertilizers, pesticides, seeding rates, tillage, variety selection, etc. Estimates of yield goals are available from soil surveys and soil productivity ratings. Yield mapping is proving to be a viable technology that will allow for accurate site specific yield goal determination.

Con: There is some reason to believe that recommendations for SSM may vary from those developed for field based crop management. Many input recommendations are based on the yield goal. While a yield history may be available for a given field, there is little information on site specific yields. Even with yield monitoring technology, site specific yield maps will take years to develop. Yield goals based on soil map units or soil productivity ratings may be appropriate in some areas, but evidence is growing that the scale of the soil survey is too coarse for accurate site specific yield estimation.

### Management Precision

Equipment control is really a main component of precision agriculture. It is essential that the equipment used to apply management inputs can be controlled at the necessary level of accuracy. Equipment is available that will control applications of solids and liquids, particularly bulk materials. However, the control may only be good at one point in the system while it may be necessary to have control at all points within a system. For example, anhydrous applicators are currently controlled at a single point (heat exchanger, where gas is converted to a liquid). However, variation of application at any given injection knife is not controlled and may be considerable. There are a number of manufacturers of controllers and control systems for application of fertilizers and pesticides. All currently available equipment is limited to some extent in what it can do with regard to SSM. To date, fertilizers, pesticides, anhydrous ammonia, seed population, variety, tillage, and irrigation have all been managed using the SSM concept.

Pro: Equipment for variable application of agricultural inputs is commercially available. Innovations in variable rate control technology is occurring rapidly.

Con: Concerns regarding SSM technology fall into the following categories.

- It's rapidly changing technology and therefore often expensive and quickly outdated
- Technology can be task specific rather than integrated across the SSM spectrum
- Technology is often proprietary and non-standard making integration across manufacturers impossible
- SSM is software limited and lack of standards is an issue in software development
- Service (Training) is limited or non-existent

## Other Issues

**Evaluation**
Evaluation is perhaps the most critical component of SSM. The questions about SSM are obvious. Is it profitable? How does it effect the environment? What are the socioeconomic considerations (is it, for example, scale neutral)? Are there policy considerations (Clean Water Act of 1995)? The evaluation of SSM is difficult and evaluations are limited. The value of SSM might be more in its impact on the environment than on farm profitability. We must be open to the possibility that after extensive evaluation, it may be determined that SSM is not worth the effort. Regardless, it appears that what is learned from working towards SSM will be valuable to agriculture.

**Performance Mapping**
One of the nice benefits of SSM technology is that it provides the opportunity to evaluate the performance of our management system. It is easy to visualize the creation of performance maps showing the distribution of seeds, fertilizers, and pesticides within a field created with the same equipment used in other activities in SSM. These performance maps will be useful in fine-tuning application equipment to increase efficiency and efficacy of production inputs.

**Service**
The importance of service in SSM cannot be overstated. There is a great need to offer information intense, analytical services throughout the agriculture industry, as information will serve as a foundation of site specific agriculture. Farmers, as well as many sectors of agriculture industry, will need training and service in various aspects of SSM and precision agriculture in general. Specifically to the agrichemical industry, as stated by Wolf and Nowak (University of Wisconsin), "the agrichemical dealer will play an important role in the development of site specific agriculture" and that this will require a change from fertilizer and pesticide product supply function to the application of information to agrichemical management to enhance the economic and environmental performance of cropping systems.

## Conclusion

Site specific management is an emerging technology that offers a positive means of improving the economic and environmental performance of cropping systems. There are many aspects to SSM, some are appealing, some are uncertain. There is certainly a ways to go before SSM is completely viable. We are excited about SSM, not so much about reaching the final goals of SSM, but about the innovation and useful knowledge gained as we attempt to bring it to fruition.