SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter: 19
Precision Farming Opportunities

Jiyul Chang (Jiyul.Chang@sdstate.edu), Cheryl L. Reese (Cheryl.Reese@sdstate.edu),
Tulsi Kharel (Tulsi.Kharel@sdstate.edu), Sharon A. Clay (Sharon.Clay@sdstate.edu),
and David E. Clay (David.Clay@sdstate.edu)

Precision farming is the site-specific implementation of management practices that will economically optimize yields while maintaining the soil, water, atmospheric, plant, and animal natural resources. Precision farming can involve the use of integrated pest management (IPM), precision conservation, site-specific nutrient management, site-specific pest management, global positioning systems (GPS), geographic information systems (GIS), remote sensing, and detailed landscape analysis. In the past, the adoption of precision systems was limited by barriers related to complexity, economic returns, equipment breakdowns, incompatible software and hardware products, and time demands during critical periods. Today, many of these barriers have been resolved and adoption is mainly limited by the difficulty of converting locally collected information into practical solutions. The goal of this chapter is to provide an introduction to precision farming.

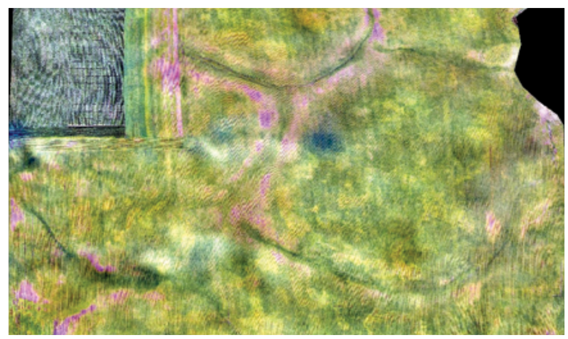

Figure 19.1 Image of a soybean field collected by a UAV on September 15 flying at 400 ft (spatial resolution is 1 inch). This field contains a large reflectance variability. In areas that are white, the soybean leaves have senesced and fallen to the soil. The moisture content in these soybeans is less than the green areas on the image. (Farm Intelligence2, Mankato, MN)

Precision Farming Basics

In precision farming, a wide variety of location-based information layers are used to develop better decisions. These layers include yield, remote sensing, scouting, soil nutrients, elevations, weeds, insects, and disease population information (Figs. 19.1, 19.2, 19.3). Precision farming may or may not lead to variable-rate treatments. Over the past several years there have been many technological advances that simplify precision farming. Some of these include:

1. Equipment improvements that simplify precision farming.

Table 19.1 General guidelines for precision farming:

1. Precision farming is the site-specific implementation of management practices that will economically optimize yields while maintaining the soil, water, atmospheric, plant, and animal natural resources.
2. Many tools are available to implement precision farming.
3. Precision farming includes identifying the goal, assessing the potential economic impact, and field testing the technique using on-farm research.

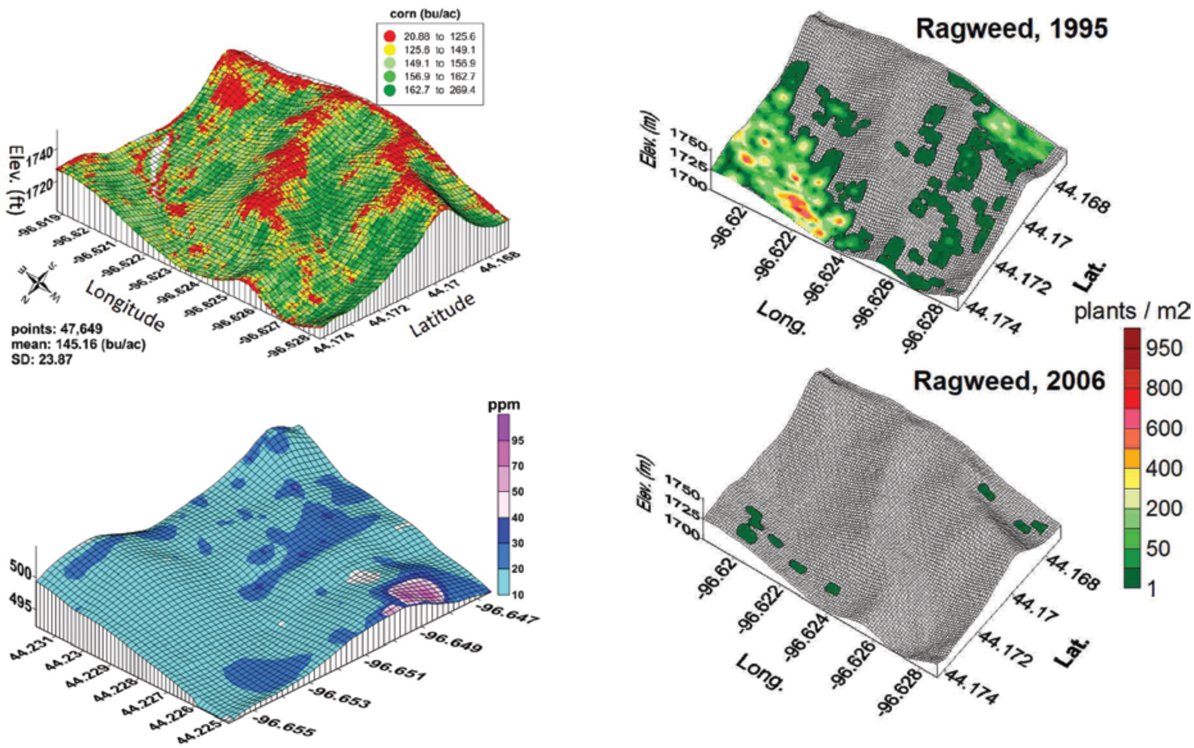

Figure 19.2 Corn yield, soil P, and ragweed maps superimposed on totpography map (Courtesy: SDSU)

2. Electronics improvements that improve communication.
3. The development of Unmanned Aerial Vehicles/Systems (UAV/S) that collect high-resolution images.
4. The wide-scale availability of digital databases, making highly accurate elevation information publicly accessible.
5. Training is available that reduces adoption barriers.

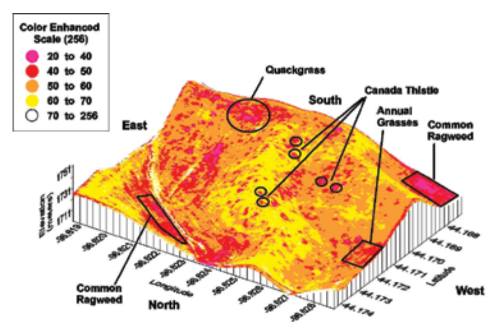

Figure 19.3 The use of remote sensing superimposed on totpography map to identify area that needed to be scouted. Remote-sensing layer is near infrared (NIR) band taken from airplane in 1997. Weed patches were identified by field scouting. (Courtesy: SDSU)

Spatial Data

Spatial information contains longitude (X), latitude (Y), elevation, and one or more measured values. The longitude and latitude values can be identified with a differentially corrected global positioning system (DGPS). When using GPS it is important to remember that complex mathematics is used to solve very difficult problems. The complexity of the mathematics has resulted in slightly different techniques that are based on a projection and datum, to convert a curved surface to a flat map. Two commonly used projections are UTM and Geographic, and two common datum are NAD-83 and WGS-84. The latitude and longitude values can be different for different projections. When using geographic information system (GIS)

Table 19.2 The types and formats of spatial data that are used for precision agriculture.

Types	Vector			Raster
Data	Point	Line	Polygon	Images
Formats	Text (txt, csv), Shape	Shape	Shape	tif, jp2, sid, img, las
Data sets	Yield monitor data, Soil test data, Veris Cart EC data		Soil survey data	Satellite image, Aerial image, Elevation data (LiDAR, DEM)

software, the projection and datum for each spatial data set needs to be specified. Geospatial information can also be stored in a wide range of formats (Table 19.2), which are often unique for each collection system or data type (Table 19.2).

Collecting Spatial Information

Yield monitor, elevation, soil nutrient and pest maps, remote sensing, soil electrical conductivity, and soil maps are information layers that can be used to produce useful site-specific implementation maps. However, each data layer may have unique characteristics that influence its usefulness.

Yield Monitor Data

Combines equipped with yield monitors can be used to collect yield data. Each collection system has unique characteristics. For example, Ag Leader's PF3000 / PF Advantage / YM2000 models have *.yld format and INTEGRA / VERSA / COMPASS have *.agdata format. John Deere's Greenstar 2 or 3 have *.ver format and Greenstar GSY or GSD have *.gsy or *.gsd formats. To ensure that the data is correct, the monitors must be calibrated. Yield-monitor data can be used to identify yield goal management zones, nutrient removal maps, and variable seeding maps (Chapters 8 and 29).

Elevation Data

Elevation information can be obtained from several different sources, including combine GPS data collected when harvesting a field, a topographic survey that you have conducted, or a publically available digital elevation model (DEM). More recently, elevation maps are being created from LiDAR data. Light Detection and Ranging (LiDAR) technology uses a pulsed laser to measure distance between the sensor and the surface of a target. Based on this information, accurate 3-D maps and images can be created. Other information layers such as yield, remote sensing, and electrical conductivity maps can be overlaid onto LiDAR elevation maps. LiDAR has a vertical error of less than 1 foot.

Spatial Soil Nutrient and Pest Information

In the past, spatial soil-nutrient and pest information was expensive to obtain. Within a field, soil-nutrient maps were created by collecting soil samples from grid points, management zones, or grid cells. These samples were then analyzed for the nutrient(s) of interest (Fig. 19.2). Spatial pest maps were obtained by walking a field and counting the number of pests at a number of sampling points (Fig. 19.3).

Remote Sensing

In the future, it is likely that scouting will be augmented by remote sensing collected by satellite, aircraft, or UAV. Disadvantages of satellite and aircraft data include cost, resolution, timeliness, and availability (Fig. 19.4). They also rely on illumination from the sun, which introduces variability from one pass of a satellite to the next.

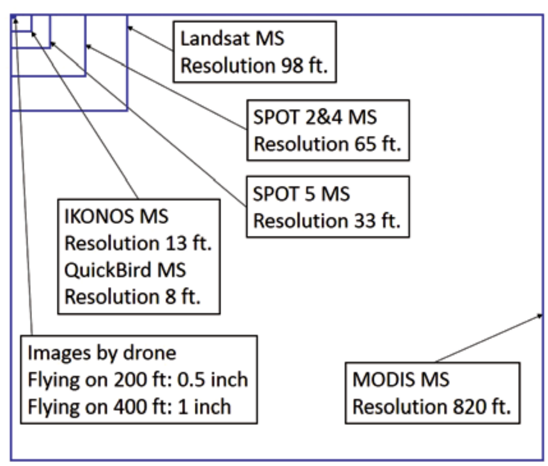

Figure 19.4 Different resolutions that can be collected by different sensors. (Dalsted et al., 2003)

In the past, many agronomists used Landsat images, which are multi-spectral images with a 30 m (98 ft) resolution (Fig. 19.4). Images are captured every 16 days, and the information from different wavelengths (bands) can be combined (Fig. 19.5) to calculate the normalized difference vegetation index (NDVI) and the green normalized difference vegetation index (GNDVI) values. These indices have been used to identify stress in crop plants. These indices are related to plant stress and the values are calculated with the equations:

$$NDVI = (NIR-Red) / (NIR+Red)$$
$$GNDVI = (NIR-Green) / (NIR+Green)$$

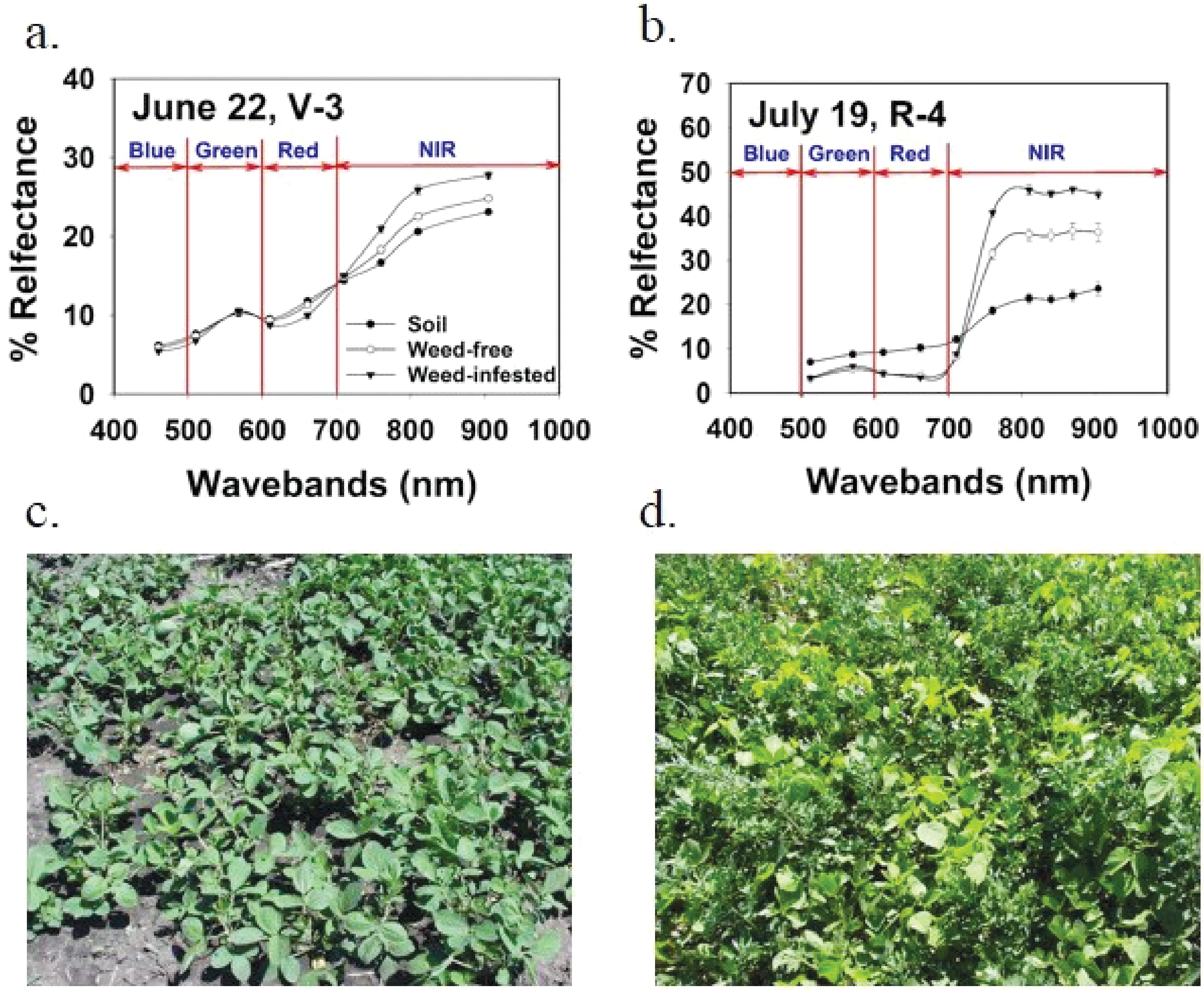

Figure 19.5 The relationship between the wavelengths and bands as well as the influence of vegetation on the reflectance within a band. (Courtesy: SDSU)

The recent availability of UAVs has the potential to increase the use of remote sensing for management decisions (Fig. 19.1). UAVs have the potential to collect high-resolution information quickly when you need it. Some UAV systems collect geometrically corrected data.

Soil Electrical Conductivity (EC)

High salt areas can be identified by conducting a visual survey or an apparent electrical conductivity survey, using a Geonics EM38 (Mississauga, Ontario, Canada) or the Veris Soil EC Mapping System manufactured by Veris Technologies (Salina, Kansas). Maps produced by these systems are quick to collect and provide information that can be used to identify management zones (Fig. 19.6). The electrical conductivity is the ability of a material to transmit (conduct) an electrical current and high values are often correlated with poor drainage.

Soil Survey Information

STATSGO2 (State Soil Geographic) has a scale of 1:250,000 and is designed for broad-based planning and management at the regional, state, and multi-state areas. The database is maintained and distributed as spatial and tabular data sets by the USDA-NRCS. The original STATSGO data for South Dakota was published in 1995. SSURGO (Soil Survey Geographic database) is mapped and described at a smaller scale than STATSGO2. The intended use of SSURGO is for natural resource planning and management by landowners, townships, and counties. Details for accessing this data layer are available in Chapters 16 and 17.

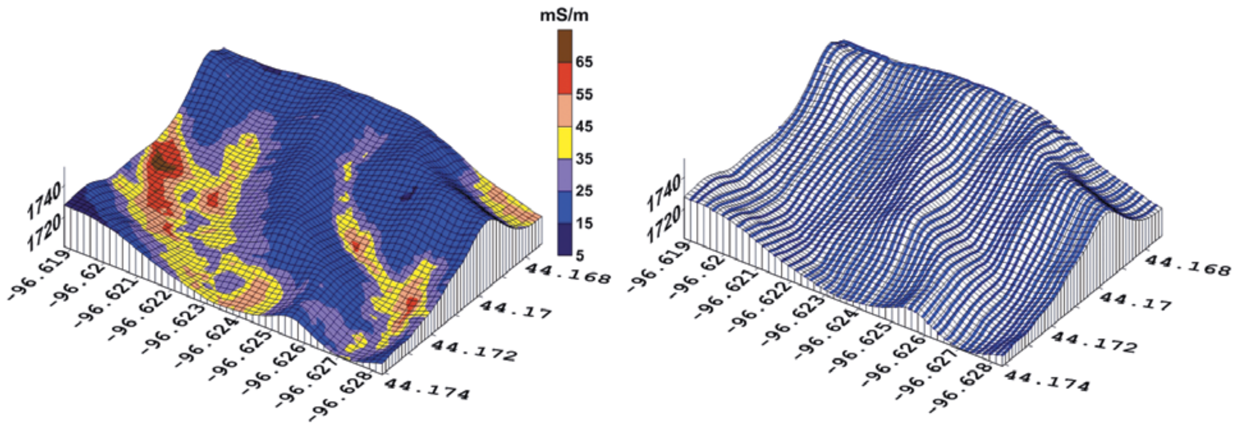

Figure 19.6 Soil EC map (left) taken by Veris Cart and sampling points for EC measurement (right). (Courtesy: SDSU)

Like STATSGO2, SSURGO consists of polygons called map units that may be composed of several soil components. Map units have defined spatial boundaries but components have discrete boundaries. Components have unique properties, interpretations, and productivity ratings that map units do not. Map unit properties are derived from aggregating component properties and can be different depending on the method of aggregation. STATSGO2 and SSURGO provide information about soil types, drainage classes, soil textures, and slope. The soil survey maps can be used to make management zones.

Analyzing Spatial Information

Management Zones

The management-zone approach separates fields into unique areas where it is assumed that a common management strategy can be implemented. Digital information obtained from the Web Soil Survey search engine is based on this concept. Within a management zone, it is assumed that a given problem is uniform and that a single treatment should be implemented across the zone. For example, in high-yield areas, corn will be seeded at a rate of 38,000 seeds/acre, whereas in low-yield areas corn will be planted at a rate of 29,000 seeds/acre. Preparing data for mapping is beyond the scope of this manual. There are multiple software packages available for this purpose. Making good management-zone maps with given data set requires a skilled agronomist.

Prescriptions Based on Contour Maps

For some information layers, continuous information was collected. Examples of this type of data are remote sensing, LiDAR elevation, and yield-monitor data. This data can be used to create application maps using geographic information systems (GIS) software.

Creating Prescription Maps

The resolution of the prescription maps is dependent on the operator, equipment used to implement the prescriptions, and the given field. A prescription map tells the system controller how much product to apply based on the location in the field. Each controller needs the data in a different structure. For example, a prescription map written for an Ag Leader PF3000 Pro requires the *.tgt format, and a Raven Viper can read the *.shp format. Most agricultural GIS packages can create prescription maps in multiple formats. The prescription is written to a compact flash (CF), PCMCIA card (depending on equipment selections), USB hard drive, or other type of data storage device, which is then uploaded to the computer within the machine cab. Wireless transfer of prescription and as-applied maps are also available in many newer systems.

Precision farming is in its infancy and the technologies are rapidly changing. Across the US, scientists are developing and testing algorithms that seek to improve yields and reduce costs. Software companies are making prescription maps easier. We believe that implementing precision farming next year will be easier than implementing it today, and today it is much easier than it was 10 years ago.

References and Additional Information

Chang, J., D.E. Clay, C.G. Carlson, C.L. Reese, S,A, Clay, and M.M. Ellsberg. 2004. Defining yield goals and management zones to minimize yield and nitrogen and phosphorus fertilizer recommendation errors. Agron. J. 96:825-831.

Clay, S.A., J. Chang, D.E. Clay, C.L. Reese, and K. Dalsted. 2004. Using remote sensing to develop weed management zones. SSMG-42. In Site Specific Management Guidelines. Clay et al. (eds). International Plant Nutrition Institute

Dalsted, K., J.F. Paris, D.E. Clay, S.A. Clay, C.L. Reese, and J. Chang. 2003. Selecting the appropriate satellite remote sensing products in site-specific farming. SMG-40. In Site Specific Management Guidelines. Clay et al. (eds). International Plant Nutrition Institute

Doerge, T.A. 1998. Management zone concept. SSMG-2 In Site Specific Management Guidelines Clay et al. (eds). International Plant Nutrition Institute.

GIS Applications in Agriculture: Nutrient Management for Improved Energy Efficiency. Clay and Shanahan (eds). 2011.

GIS Applications in Agriculture, Volume Three Invasive Species. 2011. Clay, S.A. (ed) CRC Press Taylor and Francis Group.

Site-Specific Management Guideline. 1999. Clay, D.E. et al. (ed.). Potash and Phosphate Institute

Acknowledgements

Support for this document was provided by South Dakota State University, SDSU Extension, USDA-AFRI Higher Education Program, and the South Dakota Corn Utilization Council.

Chang, J., C.L. Reese, T. Kharel, S.A. Clay, and D.E. Clay. 2016. Chapter 19: Precision Farming Opportunities. In Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best Management Practices. South Dakota State University.

The preceding is presented for informational purposes only. SDSU does not endorse the services, methods or products described herein, and makes no representations or warranties of any kind regarding them.