# USE OF PRECISION AG IN U.S. FARMING SYSTEMS

Precision Agriculture [PA], Satellite Farming, or Site-Specific Crop Management [SSCM] is a farming management concept based on measuring and responding to both within- and among-field variability in site properties and crop production. It generally encompasses using a suite of information technologies, such as soil and yield mapping using global positioning system [GPS], GPS tractor and harvester guidance systems, precision application equipment, and variable-rate application [VRA] of inputs such as fertilizers and pesticides in order to decrease input costs and labor requirements, support a more efficient use of production inputs, and potentially increase yields.

Precision Ag is becoming a significant component of U.S. farming systems. To better understand what PA is and what it encompasses, its definition, along with definitions and descriptions of technical terms and acronyms used in PA applications, are warranted.

In a publication titled "A General Introduction to Precision Agriculture" from the Australian Grains Research and Development Corporation [GRDC], authors Taylor and Whelan provide definitions for PA and SSCM.

- Precision Agriculture is "an integrated information- and production-based farming system that is designed to increase long-term, site-specific and whole farm production efficiency, productivity, and profitability, while minimizing unintended impacts on wildlife and the environment". Notice that PA is identified as a whole-farm strategy and not just for individual fields.
- Site-Specific Crop Management [SSCM] is "a form of PA whereby decisions on resource application and agronomic practices are improved to better match soil and crop requirements as they vary in the field". This definition narrows the concept to resource use in cropping systems.

Precision Agriculture is a management philosophy that allows inputs to be tailored to meet production requirements across an entire field. This should result in a subsequent increase in net return to any applied input to that field. The combined end result thus should be optimization of input efficiency and lowered environmental risk that can be associated with PA application of some inputs.

The below definitions of terms and phrases dealing with PA are summarized from a publication titled "Precision Agriculture: Terms and Definitions". This is a good reference to ensure that commonly used PA terminology is understood. Some of the terms in this publication as well as additional ones are defined in detail in a USDA-NRCS publication titled "Precision Agriculture: NRCS Support for Emerging Technologies".

**Aerial Imagery.** Photos taken from airplanes, satellites, and UAVs to assist in determining variations in plants and soils within a field.
**Algorithm.** A mathematical formula used to control variable rate applications.
**Auto-Steer.** A GPS guidance system that steers agricultural equipment with pinpoint accuracy. It is an add-on component for equipment.
**Contour map.** Field map that combines dots of the same intensity or level of a variable such as yield.
**Controlled-Traffic Farming [CTF].** Using machinery guidance and auto-steering to minimize soil compaction and input overlap.
**Data Base.** A collection of different pieces of geo-referenced information for variables such as yield, soil type, soil fertility level, etc.
**Decision Support System [DSS].** Uses agronomic and environmental data, combined with information on management techniques, to determine optimum management strategy for production.
**Flow sensor.** A sensor that measures the amount of flow of a material over time through a tube or housing.
**Geographic Information System [GIS].** A computer-based system used to input, store, retrieve, and analyze geographic data sets.
**Georeferencing.** The process of adding geographic data to yield or field attributes either in real time or by post-processing; the process of associating data points with specific locations on the earth's surface.
**Global Positioning System [GPS].** A system that uses satellite signals to locate and track the position of

a receiver on the Earth.

**Grid Mapping.** Predetermined field locations where soil or plant samples are to be obtained for analyses.

**Grid Sampling.** Collection of samples from uniform-sized cells on a systematic grid laid out across a field.

**LANDSAT [LAND SATellite].** A series of US satellites used to ascertain surface qualities of the Earth using remote sensing techniques.

**Lightbar [in machine guidance].** A device connected to a GPS receiver that provides the equipment operator with a visual guide.

**NDVI Image.** **N**ormalized **D**ifference **V**egetation **I**ndex [NDVI], a graphical indicator that can be used to analyze remote sensing measurements; assesses whether or not the observed target is living or dead.

**Precision Farming.** Often synonymous with PA; managing crop production inputs such as seed, fertilizer and lime, and pesticides on a site-specific basis in order to cut costs, increase yield and profits, reduce application of unnecessary inputs, and maintain environmental quality.

**Remote Sensing.** The act of monitoring an object without direct contact between the sensor and the object.

**Site-Specific Crop Management [SSCM].** The use of yield maps, grid/zone sampling, and other precision tools to manage the variability of soil and crop parameters. SSCM is the application of information technologies in consort with production history to 1) optimize production efficiency, 2) optimize quality, 3) minimize environmental impact, and 4) minimize risk at the site- or zone-specific level. SSCM is dependent on variability at a given site; conversely, if spatial variability does not exist, then a uniform management system for the site is likely the cheapest and most effective management strategy. The aim of SSCM is to optimize crop performance and subsequent returns across a site/field that has inherent variability by optimizing production within each identified zone within that field.

**Spatial Data.** Data that contains information about the spatial location or position of variables such as yield, soil properties, plant variables, plant population, etc.

**Spatial Resolution.** The size of the smallest unit that can be identified by a remote sensing technique.

**Spatial Variability.** Differences in attributes of observed variables among locations within a field. Spatial variability occurs over a measurable distance.

**Temporal Variability.** Differences in attributes that occur over a measurable time period such as a growing season.

**Unmanned Aerial Vehicles [UAV's].** An aircraft such as a drone without a human pilot that is typically used to survey crops. They are equipped with cameras and are guided by GPS.

**Variable-Rate Application [VRA].** On-the-move adjustment of a crop input such as fertilizer to match predetermined conditions in a field.

**Variable-Rate Technology [VRT].** System of sensors, controllers, and machinery used to perform VRA's of crop inputs.

**Yield Map.** A map using data collected by a yield monitor to show differences in crop yield within a field.

**Yield Monitor.** Electronic device in a harvester that continuously measures and records crop yield and moisture on-the-go.

**Zone Management.** Information-based division of large areas such as fields into smaller zones or areas that have like properties or similar crop responses for SSCM applications. Not as rigid as grid sampling/management.

In the GRDC publication, the authors list the following as things that PA is not.

- PA is not yield mapping–rather, yield mapping is a first-step tool towards an SSCM strategy.
- PA is not to be confused with sustainable agriculture, but it can be used to make agriculture more sustainable.
- PA tools such as machinery guidance, auto-steer, and remote sensing are part of SSCM, but by themselves are not PA.

USDA-ERS articles titled "Global Adoption of Precision Agriculture: An Update on Trends and Emerging Technologies" and "America's Farms and Ranches at a Glance: 2024 Edition" by McFadden et al. provide a summary of just how important PA use has become in U.S. corn and soybean farming systems.

The following are points that should be considered if/when PA is adopted by Midsouth soybean producers.

- Two key measures of farm profit–operating profit, or crop revenue minus variable production costs, and net returns, or crop revenue minus all costs that include overhead–should be considered.
- Capital expenditures needed to implement PA could raise overhead costs, but should also allow producers to substitute these costs for those used for operating inputs and labor.
- GPS-based computer mapping of yield data from harvester-mounted yield monitors and soil maps can be used to determine VRA's of applied inputs.
- Soil maps may come from public sources such as USDA's National Agriculture Imagery Program [NAIP], which acquires publicly-available aerial imagery during the growing season, and from USDA-NRCS's Web Soil Survey. Data from these sources can be supplemented with results from onsite soil sampling and subsequent analyses.
- Guidance systems are most often used on tractors, but harvesters are also being fitted with these systems. Most of today's tractors are guidance-system ready, but require additional investment for the necessary add-on equipment.
- The capital cost of VRT-equipped farm implements is high, and this has resulted in many smaller operations hiring service providers.
- Adoption rates for PA technologies on U.S. corn [2021] and soybean [2023] acreage, respectively, are:

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| Yield monitor | 70% and 79% |
| Yield map | 54% and 48% |
| Soil GPS map | 21% and 27% |
| Guidance system | 67% and 72% |
| VRT | 37% and 34% |
| Drones/UAV use | 5% and 6% |

- A higher percentage of PA technologies was adopted on U.S. corn and soybean acreage than on U.S. corn and soybean farms, which indicates their adoption is higher on larger farms. This is likely because adoption of these systems will benefit large farming operations more than it will benefit smaller farm operations
- According to these estimates from the latest Agricultural Resource Management Surveys conducted by USDA-ERS and NASS [2021 for corn and 2023 for soybeans], the use of drones in agricultural applications is quite limited.
- PA investments include purchases of equipment, installation charges, and time and effort spent learning to use and maintain the technologies. These costs, unlike those for land and equipment, are generally not recoverable if the equipment is not used or its use is discontinued. These factors increase the risk associated with PA adoption; thus, outsourcing to a custom service provider is often considered an option.
- Adoption of PA technology leads to greater machinery and equipment expenditures, and these costs must be offset by increased production efficiency or greater yield, or both, for PA to be profitable.
- The modeled positive impact of PA technologies on farm operating profit and net returns is positive. This estimated impact from adopting these technologies does not include the perceived positive environmental impacts that will or should be realized.

Precision agriculture as a management philosophy will likely become the standard cropping practice for corn and soybeans in the U.S. However, a positive economic return on the investment in PA equipment must be consistently realized for this to happen.

A secondary benefit of resource protection may also result from increased adoption of PA. This can be accomplished with PA technologies that can be used to 1) site- or zone-specifically apply nutrients, pesticides, and irrigation water, 2) reduce over-application of agricultural chemicals, 3) reduce soil compaction through controlled-traffic farming, and 4) reduce equipment traffic effects on water infiltration and runoff.

An offshoot of increasing use of PA is the accumulation of vast amounts of data that must be handled in such a way to ensure its privacy and maximum usefulness. The subject of such "Big Data" is covered in a White Paper on this website.

Links to resources for additional information about PA follow.

Precision Agriculture–Benefits and Challenges for Technology Adoption and Use, US-GAO–Jan. 2024.

Precision Agriculture in Crop Production, USDA-NIFA.

Benefits and Evolution of Precision Agriculture, USDA-ARS, Jan. 2025.

What is Precision Agriculture or Precision Farming? [2024 Guide], Point One Navigation, Apr. 2024.

Precision Agriculture Technology, The Ohio State Univ., 2025.

Precision Agriculture journal, Springer publishing

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