Science Societies

Precision agriculture and soil health

By Jason P. Ackerson

August 10, 2022



This is the final article in the Soil Health Institute's 2022 series on Assessing Soil Health. In previous articles in this series, we covered aspects of soil carbon sampling and carbon marketplaces, provided details on the economics of soil health systems, and outlined a strategy for offering consulting services for soil health. In this article, we will discuss some of the ways precision agriculture can be used to enhance soil health. All articles in this series can be viewed online at **https://bit.ly/3aLJemR**. The Assessing Soil Health Series is part of a larger Soil Science Society of America webinar series produced in partnership with The Soil Health Institute and sponsored

by The Walton Family Foundation.

This is the final article in the Soil Health Institute's 2022 series on Assessing Soil Health. In previous articles in this series, we covered aspects of soil carbon sampling and carbon marketplaces, provided details on the economics of soil health systems, and outlined a strategy for offering consulting services for soil health. In this article, we will discuss some of the ways precision agriculture can be used to enhance soil health.

This article is not intended to be an exhaustive list of precision agriculture tools but rather an introduction for CCAs into some of the ways precision agriculture can be used to improve soil health. We will briefly introduce some important concepts in precision agriculture and then demonstrate some of the ways these tools can be integrated into a consulting strategy for soil health through measurement and monitoring of soil health and soil health management systems. Our aim is to provide a high-level overview of how precision agriculture can complement soil health and thereby give CCAs some ideas of how they could modify existing precision agriculture tools to provide soil-health-specific service.

Precision Agriculture

Over the last three decades, precision agriculture has become an integral component of agricultural management. Farmers and CCAs have increasingly relied on precision agriculture tools in their management with more than 90% of agriculture retailers offering some form of precision agriculture service (Erickson & Lowenberg-Deboer,

2020). In this section, we will define precision agriculture and identify some of the key concepts from precision agriculture that have direct application to soil health management.

The International Society of Precision Agriculture defines precision agriculture as: "a management strategy that gathers, processes, and analyzes temporal, spatial, and individual *data* and combines it with other information to *support management decisions* according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production."

Based on this definition, we can identify three key aspects of precision agriculture (Figure 1):

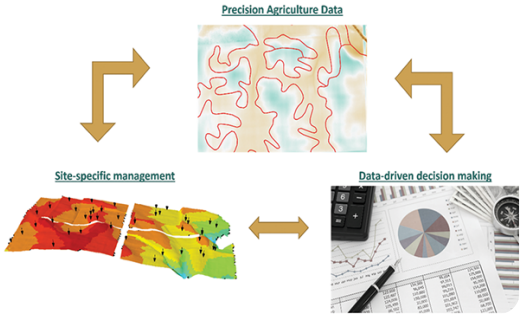


Figure 1, *Three aspects of precision agriculture relevant to soil health.*

1. **Spatial and temporal data**: Precision agriculture relies on rich data that describe the on-farm environment. Critically, these data describe how both the environment and agronomic system vary spatially (i.e., across a field) as well as temporally (i.e. within a growing season or across growing seasons). Examples of precision agriculture data include zone or grid soil sampling, yield maps, satellite or unmanned areal vehicle (UAV) imagery, soil maps, and weather data.
2. **Data-driven decision making**: Data alone is not sufficient to constitute precision agriculture. Ultimately, the real power of precision agriculture is using data to inform management. By adapting management to insights gained from data, CCAs and farmers can optimize their agronomic system to increase profitability, improve crop resilience, and improve environmental sustainability. Examples of data-based decision making include changing fertility reconditions based on precision soil

sampling, modifying seeding rates based on yield variability of yield maps, or applying crop protection based on pest damage identified with UAV imagery.

3. **Site-specific decision management**: The final aspect of precision agriculture is that, due to the high spatial resolution of precision agriculture data, management can be site specific. Site-specific management uses the spatial nature of precision agriculture data to tailor management to a particular environment within a field. For example, based on precision soil sampling, it is possible to apply fertilizer at variable rates according to the specific fertility requirements of soils within a field; the fertilizer rate at any location in a field (i.e., site) is specific to the fertility requirements of that location.

Site-Specific Management and Soil Health

One of the most relevant aspects of precision agriculture for soil health management is utilizing precision agriculture to adopt site-specific soil health management. As with other agronomic conditions, soil health and the potential for changes in soil health are not uniform within and between fields. For example, the capacity of soils to store carbon and organic matter depends on the soils.

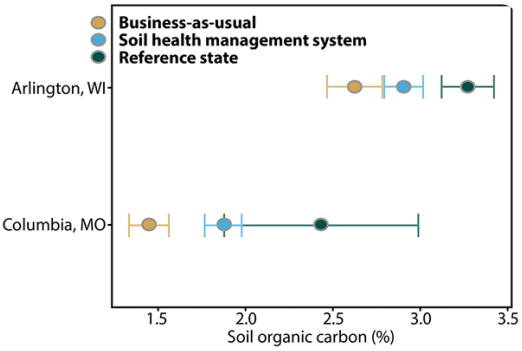


Figure 2, *Soil organic carbon concentrations of 0- to 15-cm soil depths. Data are from the North American Project to Evaluate Soil Health Mangement Practices,*

*NAPESHM (Norris et al., **2020**).*

In Figure **2**, we compare measured soil carbon concentrations for soils managed business-as-usual, soil health systems, and soil in a reference state (e.g., perennial). Clearly, the management system impacts carbon storage, and adoption of soil health management can improve carbon concentrations over business-as-usual management. However, there is also a strong site-specific effect with samples from Wisconsin having higher carbon than those from Missouri; the site impacts how much carbon a soil can store.

In addition to site-specific changes in potential soil carbon concentration, the magnitude of change of soil carbon concentration between sites also depends on the site. Differences in soil carbon concentration between business-as-usual and soil health management are approximately 0.5 and 0.25% for Missouri and Wisconsin, respectively. This shows that not only is the potential soil carbon concentration site specific, but the potential change in soil carbon concentration due to management is also site specific; the response of soils to management is site specific.

Many of the existing site-specific management tools from precision agriculture can be modified to manage soil health. By managing for soil health from a site-specific context, you can better quantify changes in soil health and tailor soil health management to yield the greatest improvements in soil health. In the last section of this article, we will explore how existing site-specific management tools can be tailored to soil health management.

Measurement and Monitoring Soil Health

Before you can start to improve soil health for your farm or the farms you manage, it is important to first understand how healthy those soils are. To do this, you will need to do some form of soil health testing. Soil health testing can provide a benchmark for understanding how healthy a soil currently is, and repeated testing can be used to

track changes in soil health over time.

As we discussed in the previous section, soil health and the response of soil health to management is site specific. Therefore, any measurement in soil health needs to account for this site-specific effect. Fortunately, existing soil-sampling techniques from precision agriculture are ideally suited for sampling soil health. Site-specific soil sampling is already widely used in precision agriculture with 92% of precision agriculture service providers offering zone or grid-based soil sampling, and these proven sampling tools can be very effective for measuring site-specific soil health.

Figure 3 illustrates one of the ways zone samplings can improve soil health testing. In this example, a field was divided into sampling zones based on the USDA-NRCS soil map. Each zone is represented by a different color on the map. To sample this field, we collected samples randomly within each zone (black dots) and aggregated these samples into a single zone average (i.e., combine all the data from each zone into a single number).

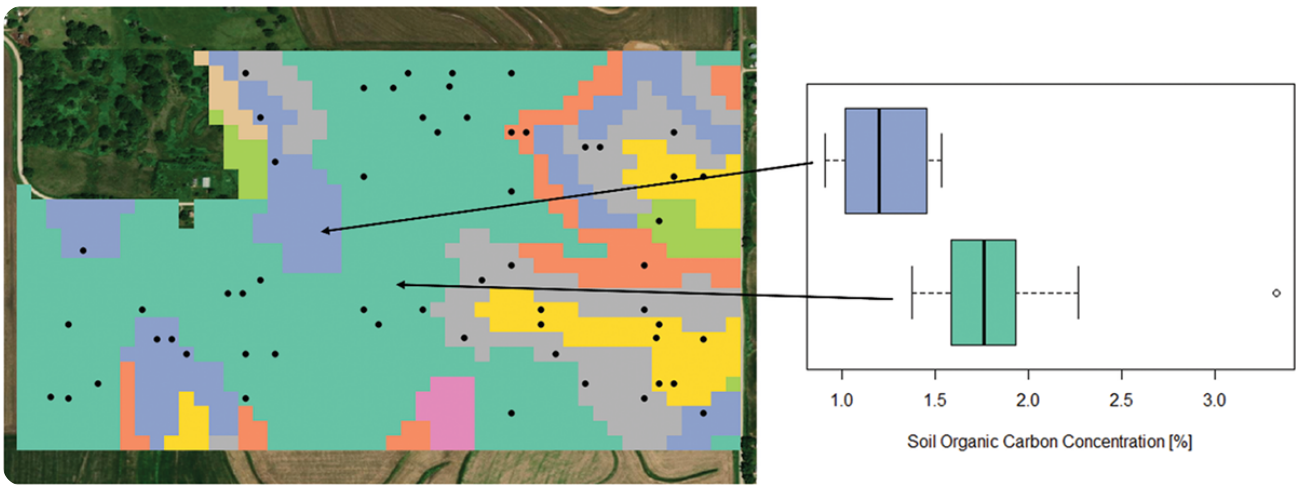


Figure 3, *An example of zone sampling for soil health assessment.*

As you can see from the box plots (Figure 3), each zone has different soil carbon concentrations with the blue and green zones having average soil organic carbon

concentrations of 1.25 and 1.75, respectively. This difference in soil organic carbon concentration highlights the importance of site-specific measurement of soil health; without site-specific sampling, we may not have identified these differences in soil carbon.

Precision soil sampling is particularly important when you are trying to measure changes in soil health over time. We often re-sample soils every 1 to 2 years to measure changes in soil health parameters. In these re-sampling events, it is critical to locate subsequent samples in the same zones or locations as the previous sampling event. If re-sampling events are not located in the same location or soil zones, spatial variation can mask changes in soil health.

Consider the field shown in Figure **4**. There is an average difference of 0.5% carbon between soils in the neighboring green vs. blue zones. If you wanted to monitor changes in soil organic carbon concentration for the soil in the green zone, you would want to make sure each sampling event used the same zone (i.e., gold and blue dots in Figure **4**). If you were to ignore the spatial variation, and resample this field in a new location (i.e., ignoring sampling zones, blue dot in Figure **4**), even if the soil organic carbon concentration of the field increased by 0.5%, your new measurement may fail to detect a change in carbon concentration. If you do not utilize the site-specific soil sampling for soil health monitoring, the spatial variation in soils may mask any true changes in soil health, resulting in incorrect sampling results.

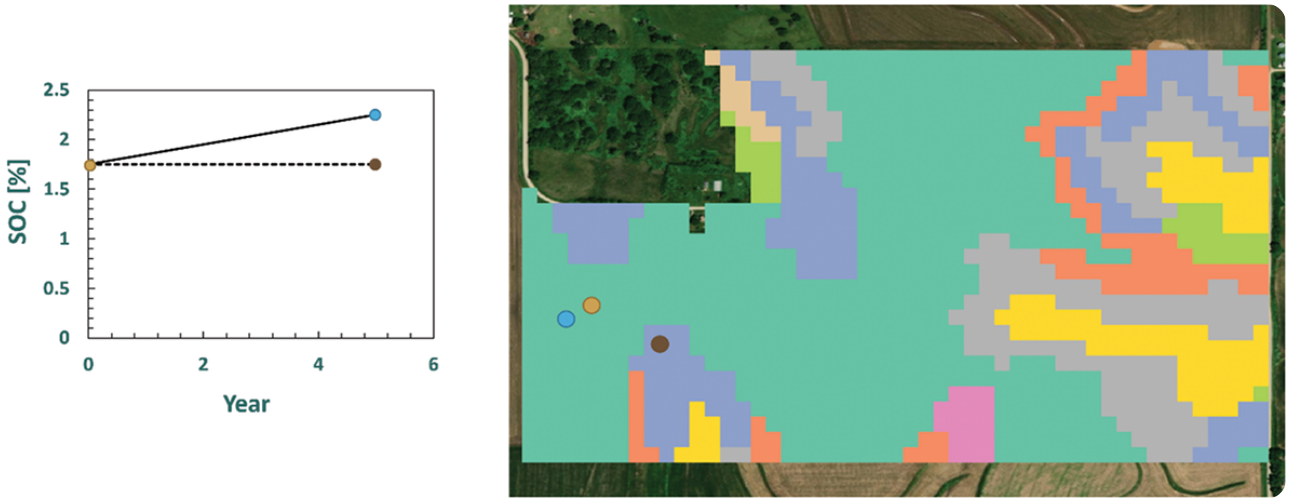


Figure 4, *Hypothetical soil organic carbon sampling scenario where it is assumed that there is a 0.5% increase in soil organic carbon for soils in all sampling zones during the five years between sampling events. The solid line shows the true change in soil organic carbon for the green zone while the dashed line shows the incorrect change in carbon that may arise from failing to employ site-specific soil sampling.*

Summary

Precision agriculture has many potential applications for improving management of soil health. Fortunately, many of the existing precision agriculture tools can be directly applied to soil health management. For example, precision soil sampling and site-specific management, which are widely used today, are invaluable tools for measuring and monitoring soil health. Beyond what we covered in this article, there are potentially many other applications of precision agriculture to managing soil health. Certified Crop Advisers can adapt their existing precision agriculture tools to solve existing and emerging challenges for soil health management.

References

Erickson, B., & Lowenberg-DeBoer, J. (2020). *Precision agriculture dealership survey*. Purdue University Extension. **https://bit.ly/3zhrbOB**

Norris, C.E., Bean, G.M., Cappellazzi, S.B., Cope, M., Greub, K.L.H., Liptzin, D., … & Honeycutt, C.W. (2020). Introducing the North American project to evaluate soil health measurements. *Agronomy Journal*, **112**(4), 3195–3215.

https://doi.org/10.1002/agj2.20234

More soil & water management

Back to issue

Back to home

Text © . The authors. CC BY-NC-ND 4.0. Except where otherwise noted, images are subject to copyright. Any reuse without express permission from the copyright owner is prohibited.