farmdoc DAILY

Agricultural, Consumer & Environmental Sciences | University of Illinois Urbana-Champaign

The Evolving Nature of Precision Ag: The Confluence of Societal Interests and Precision Agriculture

Steve Sonka

Department of Agricultural and Consumer Economics
University of Illinois

December 2, 2024

***farmdoc daily* (14): 217**

Recommended citation format: Sonka, S. "The Evolving Nature of Precision Ag: The Confluence of Societal Interests and Precision Agriculture." *farmdoc daily* (14): 217, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, December 2, 2024.

Permalink: https://farmdocdaily.illinois.edu/2024/12/the-evolving-nature-of-precision-ag-the-confluence-of-societal-interests-and-precision-agriculture.html

This is the third of three articles exploring precision agriculture and its current and future impacts. The first article reviewed the path of precision agriculture over the last three decades (Sonka (a)). The second speculated about the future path of technologies and their effects (Sonka (b)). Both articles framed the discussion in terms of decision making and profitability within the boundaries of the farm. Today's article considers how technology may allow agriculture in the future to more effectively respond to societal interests that extend beyond the farm gate.

The term confluence refers to the coming together of two powerful forces – think of the Mississippi River's ***confluence*** with the Missouri River north of St. Louis. For precision agriculture, two driving forces are the emerging advances in technology and the evolution of society's expectations of the food and ag system. These forces mainly are outside the control of farmers and agriculture. However, just as settlers chose to take advantage of the coming together of two great rivers, the food and agricultural system can choose to benefit from emerging forces in technology and in society.

As with the prior two articles, this article will identify specific technologies and products. These are not recommendations, instead their inclusion is to provide tangible examples.

Introduction

What does society expect from its agriculture and food systems? For much of human history that question could be answered very simply – enough calories to survive. And not that long ago, a positive answer was seriously in doubt. This doubt was articulated in the 1968 book, "The Population Bomb", (Erhlich) with assertions such as:

- "The battle to feed all of humanity is over."
- "In the 1970's the world will undergo famines – hundreds of millions of people are going to starve to death in spite of any crash programs embarked upon now."

Fortunately, that future did not occur as malnutrition and famine are relatively less prevalent today; the global rate of malnutrition declining from 25% in 1970 to 9% in 2020. That said, the incidence of malnutrition and famine still are tragic problems throughout the world.

Increases in food production, however, came with increased pressure on natural resources. Recognition of those detrimental effects, and changing consumer preferences, have led to societal interest in more intensely monitoring how agriculture production occurs. Terms such as sustainability and regenerative agriculture aren't strictly or uniformly defined. However, they encompass a general desire for agricultural practices with reduced detrimental effects.

In the remainder of this article, a set of technology applications are discussed with the potential to reduce detrimental effects and/or provide means to verify that appropriate practices are being employed.

How Much – on My Fields? Attributed to the management guru, Peter Drucker, one of the most important sayings in management is some form of, "You Can't Manage, What You Can't Measure" (Lavinsky). And, indeed, farmers always used information to help them make better decisions. Historically, however, the cost of measurement limited the quality of information available.

GPS-based yield monitors and input controllers allowed much more accurate, low-cost information to be available. With this technology farmers could differentially apply input amounts and correlate those actions with resulting yields. While a major leap forward, those correlations don't tell the whole story and that whole story may affect important environmental consequences, such as for water quality, as well as for profits.

As a specific example, let's consider farm-based information quantifying relationships between nitrogen application levels, yields, and profits. The Precision Conservation Management (PCM) program is a commodity association-led not-for-profit that works with Midwestern farmers to assist in evaluation of in-field conservation decisions.

Data from a recent PCM publication provides some interesting questions. Based upon data collected from 2015 to 2023 on 5,000 fields of corn, two interesting patterns emerge:

- Pattern 1: higher nitrogen application levels tend to result in higher yields, with yields going from 208 bu/ac at the less than 150 lbs. rate of application to 229 bu/acre at the greater than 225 lbs. rate.

- Pattern 2: however, the highest level of net returns, $371 per acre, occurred at the 151 to 175 lbs. application rate. Returns at the greater than 225 lbs. rate, $346 per acre, were $25 per acre lower than those at the lesser fertilizer rate (Precision Conservation Management).

This result is understandable if we express the Drucker quotation a bit differently – "we manage to what we can measure". Throughout history, yield has been the data point that dominated the farmer's perceptions of results. And estimates of yield, even if not perfect, have been most readily available.

However, the total cost of applying "too much" fertilizer is not limited to lower profits. Those higher levels likely are linked to excess amounts of fertilizer which will tend to end up negatively affecting ground and river water systems.

But the PCM data just presented also are correlations. There may be some fields for which applying nitrogen at the higher rate is more efficient. To address this issue, we need to be able to assess the "how much" question; how much fertilizer is best for individual fields and subfields?

Last week's article introduced the Data Intensive Farm Management (DIFM) program. That discussion focused on profitability. This article illustrates how the same tool could be employed to enhance environmental stewardship.

The DIFM s effort is developing the capabilities to allow farmers to explore the "how much" question based upon data from field trials conducted on their own farm. Figure 1 depicts the layout of a field trial conducted on a farmer's field where five levels of nitrogen application are compared. Each level of nitrogen is shown by its own shaded block. The pattern illustrates how the different nitrogen levels are tested throughout the field, with each small block being an experimental plot. Importantly, the associated field operations (input applications and harvesting) can be done with the farmer's existing equipment and processes. More information about this innovation is available from the DIFM program (https://difm.farm).

Figure 1. Example of a Field Trial Layout

Source: Data Intensive Farm Management program

It's not likely that an individual farmer would conduct such trials every year and on every field. However, a farmer group approach, fueled by the DIFM method and possibly organized by ag retailers and/or Extension, would seem to be an extremely effective means to advance learning. Importantly, the findings could improve environmental, as well as economic performance. In some cases, use of methods such DIFM could provide documentation to earn payments for improved environmental outcomes.

Understanding Trends in Water Quality and Agricultural Practices:

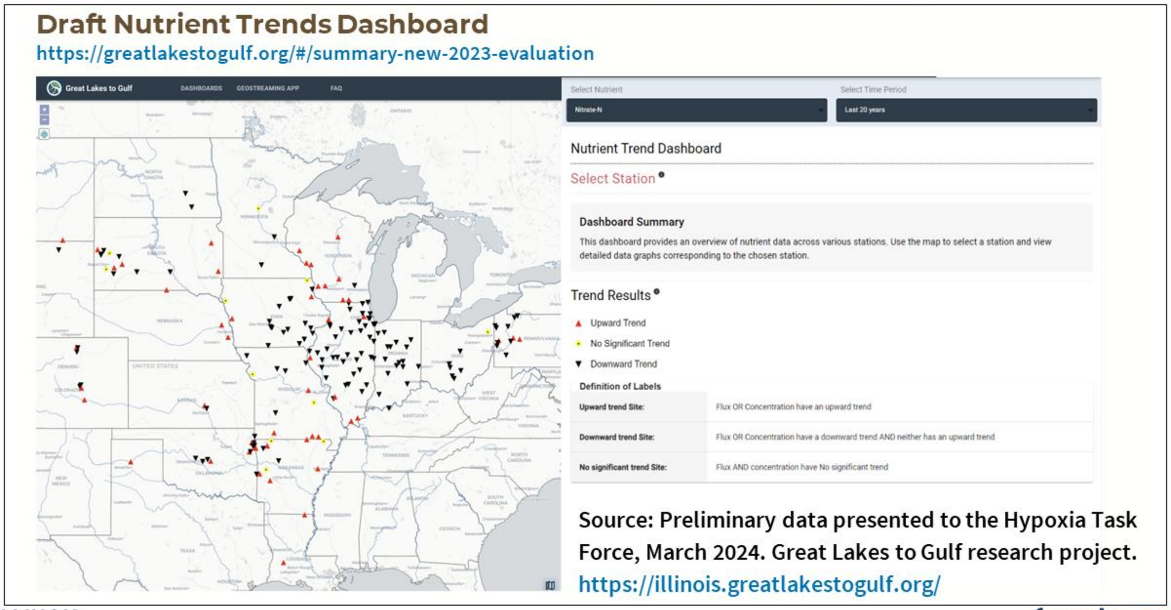
Water quality: The quality of our rivers and streams affects us all. An effect of agricultural production is that byproducts of the production process, such as soil particles and excess nutrients, can migrate to those surface water ecosystems. Minimizing those negative effects, while maintaining production levels that satisfy consumer and farmer needs, is challenging. Historically, obtaining real-time, consistent, and scientifically appropriate measurements at both small and large scale has not been possible.

Applications of advanced technology are beginning to offer a means to overcome this constraint. For example:

> 'The Great Lakes to Gulf Virtual Observatory (GLTG) is a partnership between National Great Rivers and the National Center for Supercomputing Applications (NSCA) at the University of Illinois and is funded by the Walton Family Foundation. It is an interactive website that provides user-friendly visualizations of water quality and land use data in the Mississippi/Atchafalaya River Basin (MARB). GLTG draws data from 1,300 sensor sites covering 122,233 contributing waterways and over 44 million data points. Together, the data create a comprehensive model of nutrient loads entering the Mississippi River and the Gulf of Mexico." (GLTG)

Although still in the proof-of-concept stage today, the power of this approach is demonstrated in Figure 2, where 20 years of data on trends in nitrogen loading are documented across measuring stations in the Mississippi River Basin. A black downward facing arrow indicates a decline in nitrogen loads whereas a red upward facing arrow indicates an increase in nitrogen loads. Because of the density of data observations underlying the GLTG system, similar results can be determined at varying levels of geographic scale and time periods. Linking these capabilities to federal and state policies could provide needed feedback on the most effective means to optimize the water/agriculture interface.

Figure 2. Depiction of Ongoing Research Depicting the Direction of 20-Year Trends in Nutrient Loads at Specific Sites Within the Mississippi River Basin



ILLINOIS farmdocDAILY

Agricultural practices: But what if we had better data on agricultural practices on the land to pair up with the data on water quality trends? While the GLTG effort relies upon water quality measuring stations, technological advances in remote sensing also are enabling a better understanding of the extent and impact of farming practices. In addition to identifying the crops that are being grown, the ability to document the application of practices which support regenerative agriculture are under development. Two examples that illustrate this rapidly advancing area of research and development are:

- A recent article documented the rapid increase in the use of cover crops in the Midwest (Zhou). Although from a small base, this is positive news and it is based upon direct observation rather than survey results.

- Another recent report indicated that cover crops could be effective in increasing soil organic carbon in Midwest agricultural systems (Qin). Further management practices could enhance that effect.

The role of regenerative practices, such as cover crops, is potentially important in reducing adverse environment effects on water quality and in enhancing soil organic carbon. Both outcomes have direct societal implications. Incentive payments for farmers to expand these activities are emerging from both governmental and private sectors.

However, verification is essential if significant actions are required and substantial payments are involved. Concerns already exist that claims of regenerative agriculture, without measurable metrics, could be no more than “greenwashing” (Little). To be useful, verification must be trusted and it must be economically conducted. Remote sensing seems to be a potentially effective tool to fit these criteria and, therefore, could be central to future growth of regenerative agriculture.

Small Autonomous Vehicles

The term, autonomous farm equipment, evokes images of the very large tractors and harvesters of today – absent the steering wheel. And that is a likely future reality. However, small autonomous vehicles, robots and drones, may well be playing new roles. This section discusses three such roles.

Mechanical Weed Control, Back to the Future: Those of us of a certain age may remember being a 12 year-old pulling into an 80 acre corn field with a tractor equipped with a **2 row** cultivator. We wondered how 80 acres could seem so big!

Figure 3 shows a prototype of a robotic weeding machine. The idea is that this little machine would run up and down the rows dislodging the small weeds as it went – and probably knocking down fewer corn plants than the 12-year-old tractor driver did. Why is this potentially important? The phenomenon of herbicide resistant weeds is becoming a problem.

Figure 3. Example of a Robot in Development in Operation at I-FARM: Farm of the Future

A mechanical approach minimizes the resistance problem and it can be targeted to those areas where the problem emerges. Further, the 12-year-old couldn't be in the field 24 hours a day. A recent i-FARM webinar explores future costs and benefits of this approach (Atallah).

More Precise Application: As the growing season progresses, weed or pest infestations sometimes develop only in part of the field. Once the crop is fairly well along, use of large-scale equipment is not desirable to apply needed chemicals because of the damage that would be done to the growing crop.

Use of drones (such as in Figure 4) to deliver very targeted, relatively small area applications would seem to provide a means to address these problems. Use of helicopters or small planes also can provide coverage, if a large area application is needed. However, drift is a potential problem, that could be reduced through the use of drones.

Giving Cover Crops a Better Chance: For the reasons noted previously, cover crops seem to be part of the future for Midwestern row crop agriculture. A key challenge is planting the cover crop early enough in the fall so that a good stand can be accomplished before periods of severe winter cold start.

Figure 5 shows an example of a robot designed to spread the cover crop seed before the cash crop is harvested. Then the cover crop can take root and start to grow before the cash crop is harvested, getting a head start on winter weather.

Wrapping Up

The purpose of this and the preceding two articles was to give one glimpse of a possible agriculture 20 years or so into the future. The first article ended by emphasizing the growing influence of the farmer's use of pooled data as a key to future decision making. The second article highlighted a sampling of potential technology applications. While individually intriguing, the combined effect and application of these technologies will drive performance.

This article expanded the horizon of agricultural decisions to include technological applications enabling farmers to better respond to societal concerns, such as environmental effects and carbon sequestration. While presented individually, it is the integrated effect of these and other future technologies which should enhance profitability and effectively respond to societal interests. Farmers and managers who routinely search out and evaluate these opportunities are likely to earn the early adopter benefits.

References

Atallah, S.S. "Economics of Adopting Weeding Robots." *farmdoc Webinar*, October 10, 2024. https://farmdoc.illinois.edu/webinar/economics-of-adopting-weeding-robots

Carlson, A. 2023. "Hunger Is Not Eradicated: The Food Crisis in Africa." *Origins*. https://origins.osu.edu/read/hunger-not-eradicated-food-crisis-africa

DIFM. Data Intensive Farm Management program. 2024. https://difm.farm

Ehrlich, Paul R. 1968. *The population bomb*. New York, Ballantine Books.

GLTG. https://greatlakestogulf.org/

Lavinsky, D. "The two Most Important Quotes in Business." *growthink*. https://www.growthink.com/content/two-most-important-quotes-business

Little, J. 2024. "Without measurable metrics, 'regenerative agriculture' is often little more than a data-less claim and a form of greenwashing." *Genetic Literacy Project,* January 8, 2024. https://geneticliteracyproject.org/2024/01/08/viewpoint-without-measurable-metrics-regenerative-agriculture-is-often-little-more-than-a-data-less-claim-and-a-form-of-greenwashing-heres-how-to-make-it-more-science-bas/

NGRREC. National Great Rivers Research and Education Center

Precision Conservation Management. The Business Case for Conservation. https://www.precisionconservation.org/wp-content/uploads/2024/06/2024_PCM_Booklet_WEB2_FINAL.pdf

Qin, Z., Guan, K., Zhou, W., Peng, B., Tang, J., Jin, Z., Grant, R., Hu, T., Villamil, M. B., DeLucia, E., Margenot, A. J., Umakant, M., Chen, Z., & Coppess, J. (2023). Assessing long-term impacts of cover crops on soil organic carbon in the central US Midwestern agroecosystems. *Global Change Biology*, 29, 2572–2590. https://doi.org/10.1111/gcb.16632

Sonka, S (a). "The Evolving Nature of Precision Ag: Past as Prologue." *farmdoc daily* (14):210, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, November 18, 2024.

Sonka, S (b). "The Evolving Nature of Precision Ag: Forwards towards the 2040s." *farmdoc daily* (14):214, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, November 25, 2024.

Zhou, Q., Guan, K., Wang, S., Jiang, C., Huang, Y., Peng, B., et al. (2022). Recent rapid increase of cover crop adoption across the U.S. Midwest detected by fusing multi-source satellite data. *Geophysical Research Letters*, 49, e2022GL100249. https://doi.org/10.1029/2022GL100249