Newground Magazine *e*-Interview Responses

…on the Future of Precision Ag

Prepared by Joseph K. Berry — February 5, 2014

Dr. Berry,

I'm writing for Newground magazine, a publication from Arysta LifeScience that goes to wheat and other grain growers in the Northern Plains and Western Canadian provinces and doing a futuristic article on precision ag. I thought you would be a great source for this article after seeing you on the agenda for the upcoming Canadian precision ag conference.

I have included some questions below this message. If you prefer, I can ask you these questions on the phone. Just let me know the best time and number to reach you. If you have any questions, just give me a call at 573-819-6163.

I do have a very tight deadline on this article and need to have your answers by this Thursday, Jan. 30. Sorry for the rush!

I will send you the final article before publishing so that you can let me know if the quotes are accurate.
I'm looking forward to hearing from you!

Thanks,

Ginger Merritt

Ginger— my area of expertise is in the application of Geotechnology (RS, GIS, GPS) to a wide array of fields (Precision Ag, Natural Resources, Infrastructure Routing and Geo-Business in particular). I have been involved in the geospatial sciences for over 40 years as an academic, consultant, software developer and entrepreneur.

General Statement: My early involvement in Precision Ag (PA) began in the 1970s with the NASA/USDA Large Area Crop Inventory Experiment (LACIE) funding my doctoral studies in Remote Sensing. There wasn't much "precision" in this work however, as the satellite images at that time had about a football field footprint (spatial Resolution) and passed over an area every few weeks (Temporal Resolution) hoping that there wasn't cloud cover. This relatively low level of detail supported regional/national level application. PA technology had to wait until the mid-1990s for accurate/reliable GPS, high resolution imagery, analytical capabilities and interest of agri-industry to develop the enabling RS, GIS, GPS and Robotics technologies supporting site-specific crop production.

In the 1990s, BASIS and Red Hen Systems developed very early expressions of PA while working with AgChem, John Deere, New Holland, several cooperatives. During this time I authored the "**Inside the GIS Toolbox**" columns published in the @gInnovator newsletter and @gOnline electronic forum (from 1993 through 1999) that were subsequently compiled into the **Precision Farming Primer**. Working with a variety of sponsors, over 30 seminars and "hands-on" workshops were presented at various universities, experiment stations, cooperatives and private companies.

I find PA applications fascinating. This is in large part because the field does not have a long legacy in traditional mapping. In many ways, early PA is more like Geo-business applications than either Natural Resources or Infrastructure applications— its focus is on new applications that emphasize analysis of mapped data more than automating existing mapping and geo-query practices. The lack of a mapping heritage has been more helpful than a hindrance in the young field's development.

Related Presentations and Papers. I am making two plenary presentations at the Calgary Precision Ag conference next week. A one-page handout describing each of the presentations and PowerPoint slide sets will be posted on my website by the end of the week… *http://www.innovativegis.com/basis/present/PAconf_Calgary2014/*

In addition there are several earlier presentations and articles that support these current thoughts on PA…

Who's Minding the Farm**,** GeoWorld, Adams Business Media, Chicago, Illinois, Feb 1998, 11:2 46-51. J.K. Berry.

Site-Specific Farming Comes of Age, FarmTech '98 Conference, Ricon Publishing, January, 1998, J.K. Berry.

So Where Is Precision Ag, 9th International Conference on Precision Agriculture, Denver, Colorado, July 21-23 2008. Keynote Address (link to PowerPoint; 7.6MB; Podcast; Podcast/Slide Time Marks for simultaneous viewing; related paper on "*New Advances and Practices for Precision Conservation*"); and Plenary Question Session (link to Question Responses).

….more detailed treatises…

The Precision Farming Primer: *GIS Technology and Site-Specific Management in Production Agriculture,* online book covering *Inside the GIS Toolbox* columns in AgInnovator, 1993-2000. J.K. Berry.

Applying Spatial Analysis for Precision Conservation Across the Landscape (select "Full Text" for free download), J. of Soil and Water Conservation, Nov/Dec 2005, Vol. 60, No. 6, pg 22-29. J.K. Berry, J. A. Delgado, R. Khosla and F.J. Pierce.

Precision Conservation for Environmental Sustainability (select "Full Text" for free download), J. of Soil and Water Conservation, Nov/Dec 2003, Vol. 58, No. 6, pg 332-339. J.K. Berry, J. A. Delgado, R. Khosla and F.J. Pierce

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Interview Questions …see the PowerPoints for the conference for graphics and further explanation of most of the following answers (*http://www.innovativegis.com/basis/present/PAconf_Calgary2014/*)

1. What is your name, title and company (as you would want them published)?

Joseph K. Berry, Principal, Berry & Associates // Spatial Information Systems (BASIS)

…not needed for article reference, but I am also an adjunct Faculty member at the University of Denver, Geography Department and at Colorado State University, Warner College of Natural Resources.

a. What is the best email and phone # to reach you for a fact check of quotes and surrounding text if I use them in the article?
Email Jberry@innovativegis.com Website http://www.innovativegis.com/basis/

2. What is your vision of future of precision ag?

GIS has been evolving for four decades. First it focused on GIS as a mapping tool (*Automated Cartography, 1970s*), then a data management tool (*Spatial Database Management, 1980s*), then a data analysis tool (*Map Analysis, 1990s*) and more recently on Internet delivery and multimedia mapping (*GeoWeb and Mobile Devices, 2000s*). The first two decades were of limited use in PA; however the later two thrusts form the cornerstones of PA.

The early 1990s saw PA focused on the fundamental approaches, required data and software supporting site-specific crop production ("Analytical Tools"). This focus was enlarged to "in-cab navigation" at the turn of the century ("Technical Tools").

What I see as the future of PA lies in three broad arenas— 1) major advances in Geotechnology, 2) extending PA to Precision Conservation, and 3) increased spatial analytics in agricultural science (SpatialSTEM).

Major Advances in Geotechnology. A major advancement in GIS's future involves reinventing how we conceptualize and organize **geographic referencing**. The current Cartesian Coordinate system was first introduced over 400 years ago and uses intersecting lines (XY coordinates) to locate spatial objects in space (discrete Vector mindset based on points, lines and polygons). Another, and more useful framework for PA, is to treat the intersecting lines as forming a grid matrix (continuous Raster mindset of grid cells).

Researchers and developers in GIS are replacing the "squares" of the grid (PA's current expression) with nesting hexagonal shapes (like in a beehive) in planimetric space and *Pentagonal Dodecahedrals* (solid object formed by 12 pentagons …imagine a soccer ball of squares sewn together—it wouldn't roll properly). While all this might sound like academic dribble— not so. The new 2D and 3D referencing systems are much more map-ematically "robust" and provides for vastly improved (and entirely new) **analytical capabilities** that will revolutionize PA's applications.

Extending PA to Precision Conservation. Whereas Precision Ag tends to focus on crop production on individual fields and farms, **Precision Conservation** focuses more on ecosystem flows at watershed and regional scales. However, PC is the natural extension of PA as they both utilize the geospatial toolbox in assessing spatial patterns and relationships and have good land stewardship as their underlying theme.

For example, PC uses surface flow modeling to identify "variable-width buffers" around sensitive streams which consider intervening terrain conditions (soil, slope, vegetative cover, land use) to extend the buffer in highly erodible areas and contract the buffer in areas of minimal erosion potential. A variable-width buffer identifies where mitigation could reduce the size of the buffer to regain use of the land. Contrast this spatially-aware regulatory expression with current practices that extend buffers a fixed distance regardless of actual on-site conditions. Often this "spatially simplistic" approach fails to attain its goal as under some conditions the buffer reach should be more as sediment still clouds the stream (fish impacted), while under other conditions the reach too much than conditions warrant (land owner impacted).

Increased Spatial Analytics (SpatialSTEM). The STEM disciplines (agriculture included) share a common language, tool set and approach (scientific method)— quantitative data analysis. **SpatialSTEM** is a direct extension of traditional mathematics/statistics framework into the spatial realm that is radically changing science and technology by considering the spatial distribution of data, as well as its numerical distribution …it "sees" maps a spatially organized set of numbers.

Within this context, a set of primitive mathematical operations retrieve two or more geo-registered raster layers to produce a new raster layer using algebraic operations such as addition, subtraction, multiplication, division, exponentiation, logs, etc.— all of the buttons on a scientific calculator can be applied to raster map data. By sequencing operations through cyclical processing, a modeling process is created that is analogous to solving equations– it's just that the variables are entire map layers composed of thousands of numbers and the answer is a map that that carries the site-specific variation of the solution, instead of a single number assumed to be "representative" of an entire field.

This "new math" will completely change agriculture research methodologies, and in turn, will change its practical application. For example, digital terrain analysis (utilizing the **Spatial Analysis** operations of *spatial derivative* and *flow integral*) will be used to identify micro-terrain hummocks (ridges) and swales (pockets) affecting water, nutrient and fine particle flows throughout a field. This information will help drive variable rate implements (e.g., fertilization, seeding, spaying) deliver the "right input amount, at the right place and time."

Similarly, **Spatial Statistics** operations are providing a radically new perspective on quantitative data analysis. For example, a traditional T-test to determine if there are significant differences in two data sets uses an equation that normalizes the difference and compares the answer to a theoretical value to make the call. If the data was crop yield, historically it would use several plot samples from two years taken at random throughout a field. In today's PA environment, there are yield maps that, in effect, "sample the entire field." The thousands of yield values can be plugged into the T-test equation to determine if there is a significant overall difference between the two periods. More useful is to spatially evaluate the T-test equation using a "roving window" that collects yield values surrounding each grid location. The result is a T-test map that identifies where in the field there is a significant difference and where there is not. Furthermore, a map of the T-statistic itself provides a continuous distribution of the relative differences throughout a field.

3. In 5 years, what will be happening in precision ag? In 10 years? In 50 years?

In five years, Precision Ag will make modest innovation gains. While the enabling science and technologies will experience considerable advancement, technology transfer and practical realization of new approaches and devices at the producer level will be minimal. The bulk of this period will be enlarging the penetration of current PA technology—expanding the user base.

In ten years, the "setting of the stage" advancement in the supporting technologies (RS, GIS, GPS and robotics) will come into play. More and more farming practice will become spatially aware and accomplished through smarter and smarter intelligent implements. A larger portion of a producer's day will involve planning— financial, economic and agricultural decision-making. While he/she still might be in a tractor cab, it will be outfitted more like a mobile office.

In fifty years, farming will evolve even more toward the farmer as CEO with machines tending to more and more of the physical aspects of routine chores. PA advancements are more “pull” by other technologies than a “push” by internal ag innovation. Agriculture cannot ignore nor sit still on the sidelines of the digital revolution (“Even if you're on the right track, you'll get run over if you just sit there.” Will Rogers)

4. What is a far-fetched precision ag idea that you think will happen - something that is almost sci fi, etc.?

I can imagine iRobot’s Roomba vacuum cleaner as a prototype to tomorrow’s location-aware intelligent farm machinery. Instead of scurrying around your living room looking for dust balls, PA’s future expression will be semi-autonomous devices that rollout and fly-out of the barn to keep a farmer informed of conditions, as well as accomplishing routine tasks.

5. How do you think UAS (unmanned aerial systems) will factor into it?

I see drones as useful in the near future in three ways: onboard image analysis for *Field Scouting*, geometric registration for *Farm Mapping* (and *Compliance Mapping*) and possibly *Spot Spraying*. However, it is difficult to imagine practicality of drones as farming implements, as their costs are too high and payloads too limited.

In the more distant future, advances in remote sensing will take hold by utilizing periodic imaging (likely aircraft or satellite platforms) using *hyperspectral scanners* for detailed monitoring of crop development, insect infestations and disease outbreaks. In addition, *LiDAR* and *RTK GPS* will be employed for multistage collection of elevation data for terrain analysis (e.g., surface flows).

6. How will farmers be affected by data sharing? How should they deal with it?

Cooperatives, crop consultants and local farmer groups will serve as primary data repositories for volunteered data sharing. In addition, on-farm research by USDA Extension units will hold volunteered data for participating farms. In these instances producers will elect to participate in data sharing. However, ”As Applied” maps for governmental regulatory compliance will be required for some substances and farming practices as proof of fulfillment of actions and increasingly needed as part of the loan application process (not volunteered). Data collection and sharing will increasingly become a routine part of doing business in the modern world.

7. Is the available data protected, and do farmers know what use might be made of their information by the companies who store it?

I see this as a non-issue for PA as general concern (nationally and globally) for big data security will drive security and privacy solutions: not PA. Producers need to take security recommendations to heart and form action plans. Hackers will continue to be the problem but there are two types with dramatically different motives—criminals motivated by financial gain and fanatics driven by ideology or notoriety. Both can inflict havoc but the criminal element at a much greater degree. Advances in computer technology, such as retina scans, decoy systems and “Honey Encryption,” will make data less vulnerable.

8. Whose data is it anyway? If you’re going to share your data, what’s it worth to the people you’re sharing it with?

Like many aspects of modern civilization, the service rendered often comes with a tacit (or contractual) agreement to “share” transaction data. The “fine print” determining the boundaries of ownership rarely favors the originator, who is rarely compensated beyond small gifts/discounts (e.g., reward cards from retailers). I suspect minimal (if any) positive "cash flow" from sharing PA data. The return will be in forms of improved service and benefits of improved information through aggregate data analysis.

However, site-specific data of farm operations will be viewed as an asset and required for loans or property sale. A farming entity with many years of PA data will prove to be more valuable than one without—sort of like aging of fine wine versus "young" wine; or "goodwill" as an asset on a business's books.

9. With all of this information, how will we integrate it all in order to use it to improve agriculture?

The underlying benefit of PA information is better stewardship (or at least more ammunition to document good stewardship), as well as increased efficiency, lower input costs and higher productivity. However, keep in mind that "data" is not "information" until it has been processed within a context or specific question. Simply viewing a rendering of a yield map and related maps of nutrient levels, Ph, organic matter, etc. more often raises more questions/confusion than answers.

Even good information is insufficient for most decisions as "understanding" is needed to comprehend the complex interactions among the spatial patterns and relationships among agronomic driving variables (data→ information→ understanding). …agriculture extension will evolve from traditional science and controlled experiments to on-site research which utilizes data collected by farmers

10. How about sustainability?

…demonstrating on-farm practices supporting sustainability will become a major factor
…recordkeeping/reporting documenting sustainable practices will increase for "certification"

11. How will the fact that the connection of separate precision ag systems will give us the ability to track exact applications of chemicals, etc.?

…"**As Applied**" maps will become essential as they validate "*Prescription Map*" application was meet within a specified time frame and under proper specified conditions (wind speed, outside protective buffers, etc)

12. How will the integration of predictive weather impact the future of precision ag?

…the obvious answer is in how better weather prediction impacts crop production
…a less obvious answer is in the "knock-off" product opportunities dependent on weather (wind power, transferable water rights, etc)
…for example, Regenesis Water Management initiative to address the "buy-and-dry" circumstances in the drought plagued West where the thirst fueled by metropolitan growth buys farms just for their water rights; better weather predictions and advanced evaporative transpiration models can give farmers a better handle on their water needs, so that they can lease portions of their water rights to cities rather than selling them off completely

13. How can ag transportation systems be affected by precision ag's future ability to predict weather?

…”Logistics” is a major program at most Business Schools and utilizes sophisticated mathematics and scheduling analysis to keep the planes in the air and packages at your door in a timely fashion with huge efficiency gains cost savings
…agriculture’s transportation and distribution networks are extensive (Intermodal science) and often time critical
…accurate weather prediction is a major consideration affecting routing from farms to collection points to storage facilities to manufacturers to production distribution centers to retail markets to end consumer

14. How will commodity market systems be impacted by all of the data sharing and/or predictive weather?

…commodity markets will “grade” farm products in part on their “paper trail” (data) that certifies” where, when and how” crops are grown, as well “how it was harvested and by whom”
…this data sharing is particularly important for organic, GMO, green certified and fair traded designations that yield different pricing structure throughout the industrial food chain