Big Data: The Future of Precision Agriculture

The InfoAg Conference
Union Station, St. Louis, MO
June 29, 2014

S.A. Shearer
Food, Agricultural and Biological Engineering
Presentation Ground Rules

• I will talk about the future… no guarantees that I’m right (or wrong)!
• No intent to endorse one product or technology over another.
• I will connect observations (mine and others) to suggest how agriculture will change.
• I’ve borrowed heavily from materials available via the internet and through research publications, and have tried my best to credit the respective individuals.
• Scarlet and Gray are the primary colors of the presentation -- observation of who pays my salary.
2013 GAP REPORT®
GLOBAL AGRICULTURAL PRODUCTIVITY REPORT®
SUSTAINABLE PATHWAYS TO SUFFICIENT NUTRITIOUS AND AFFORDABLE FOOD

Global Harvest Initiative

MEMBERS

DU PONT
The miracles of science®

IBM

Elanco

MONSANTO

CONSULTATIVE PARTNERS

ACDI/VOCA
Expanding Opportunities Worldwide

IIAC®

PURDUE AGRICULTURE
CONSERVATION INTERNATIONAL

The Nature Conservancy
Protecting nature. Preserving life.

WWF
Water for Food

NML

TransFarm Africa

THE OHIO STATE UNIVERSITY
In 40 years, agricultural output will need to increase by 100%.
Technologies that will shape the future of agriculture...
Google Glass?

http://www.agriculture.com/farm-management/technology/google-glass-is-on-its-way-to-farm_322-sl32330
Topcon Positioning Systems IP-S2 HD

http://www.topconpositioning.com/products/mobile-mapping
What Is Watson?

Watson is a cognitive technology that processes information more like a human than a computer—by understanding natural language, generating hypotheses based on evidence and learning as it goes.

Watch the video
Google Car

http://www.extremetech.com/ extreme/147940-google-self-driving-cars-in-3-5-years-feds-not-so-fast
Forbes Magazine: *Internet of Things* (7-23-12)

- **Sensors Are Everywhere** – “from listening for gun shots to monitoring a chicken coop, sensors are cropping up in every area of your life.”

- **Machine to Machine [M2M] Relationships** – “will generate connected data that will affect every aspect of your life.”

- **Sustainability** -- “it isn’t about saving the planet, it’s about saving money.”

Internet of Things: Applications in Agriculture
Crop Monitoring - Technical University of Madrid
Big Update: The Truth That Beer Companies Have Not Made Public Yet

By Food Babe

June 17, 2014

On June 11, 2014, I launched a petition to ask 2 major beer companies — Anheuser-Busch and MillerCoors to disclose their ingredients online. The alcohol industry lobbied for years to keep this information secret from us — and now finally due to your support, signatures and activism, we’re finally going to get some information. The Food Babe Army succeeded where other organizations have not. To think beer companies have gotten away with this for decades is mind-boggling.

“This is pretty incredible. 24 hours and 43,000 signatures after her petition went online, Vani Hari, aka the “Food Babe,” has convinced Anheuser-Busch to publicly reveal the list of ingredients for its beers. To put that into context, the Center for Science in the Public Interest has been lobbying the government to require beer companies to list their ingredients — something they’re not currently required to do by law — for three decades.” — Salon

I am so amazed by the power of the FoodBabeArmy. What we have done is truly astounding. In just one day, we received not only responses from these huge multi-billion dollar corporations, but they are already taking steps in the right direction and beginning to publish their ingredients online. But the fight is not over, I’m still going to need you to pay attention and learn the facts about what’s happening right now. I spent last weekend gathering this critical information to share with you — I want you to have all the details.

On the afternoon of June 12, 2014, I received a phone call and a letter from Anheuser-Busch, in which they told me that they will agree to publish their ingredients online at TapIntoYourBeer.com and invited me to meet with their head brewmasters in St. Louis. When I heard the news, I was obviously thrilled (one of my lovely team members took a photo right at that moment, see below). I had been thinking and preparing for this petition for almost a year and was honestly quite shocked at the fast response.

http://foodbabe.com/
Nutrient Management - Lake Erie


http://wordpress.vermontlaw.edu/environmentalhealth/2013/03/04/whats-next-for-the-great-lakes/
Reducing Fertilizer Use in Agriculture. Walmart is requiring suppliers who use commodity grains, such as corn, wheat and soy in their products, to develop a fertilizer optimization plan that outlines clear goals to improve performance based on Index research. Through this program, the company and its suppliers have the potential to reduce fertilizer use on 14 million acres of farmland in the U.S. by 2020.
• “We want to be proactive – not reactive in how we source our ingredients. Our business relies on these natural resources, so we need to do everything we can to protect and conserve them.”

Jerry Lynch, Vice President, General Mills
Current precision ag technologies...
What is Big Data?

*NSF* recently referred to Big Data as large, diverse, complex, longitudinal, and/or distributed data sets generated from instruments, sensors, Internet transactions, email, video, click streams, and/or all other digital sources.
What is the value of “Big Data” if we don’t produce actionable information?
Planter development and Big Data?

MAKE YOUR STAND

DRAWN, INTEGRAL AND UNIT PLANTERS
What’s driving planter development?
Individual Row Electric Drives

Precision Planting vDrive

Maestro CC. Horsch Maschinen GmbH

Kinze Electric Drives
Precision Planting Sensing/Control

http://precisionagsystems.com/
IFS and Precision Planting

• "IFS (Integrated Farming Systems) is really about matching the right corn hybrid to the yield environments in the field and then determining the optimal agronomic practices to bring out the very best performance in that hybrid for farmers," Crosbie said. "IFS represents a new way of thinking about agriculture and the resources behind it."
Raven OmniRow Multi-Hybrid

Weather data…

Monsanto to Buy Climate Corp…
*Deal Deepens Seed Giant's Push Into Data Science*
By DAVID KESMODEL

“Monsanto is betting that tapping vast databases to help farmers increase their production will be one of the fastest-growing areas of agribusiness in coming years.”

FIELD INFORMATION

<table>
<thead>
<tr>
<th>Soil Type:</th>
<th>Available Water Capacity:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt Loam</td>
<td>5.17 in</td>
</tr>
</tbody>
</table>
The push for speed... Deere announces a new planter!

Precision Planting at it again...


http://precisionpays.com/2014/01/precision-planting-introduces-new-speedtube/
OSU/Beck’s Field Investigations
OSU/Beck’s Field Investigations
Telematics offerings…
GPS and Fuel Use Rate
Fuel Use Rate Distributions

**Planting**

![Planting Fuel Use Rate Distribution Graph]

**NH₃ Application**

![NH₃ Application Fuel Use Rate Distribution Graph]
How big is too big?

https://www.bauerbuiltmfg.com/db-series-planters.html
Spray Application Accuracy

(Fulton, et al.)
Trends in ballasted GVW?

**Spark Ignition Engines**

**Compression Ignition Engines**

Note: Maximum tractor weight is increasing at a rate of 900 lb/yr.
Now 685 Hp (85,000 lb.)?
Firestone RCI Series 52?

Tire OD (in.) vs RCI Index

\[ y = 6.2884e^{0.0534x} \]

\[ R^2 = 0.9992 \]
Additional Concepts


http://farmofthefuture.net/#/slideshow/autonomous-tractors-take-field

http://www.ivtinternational.com/design_challenge_jon_pope_june_10.php
Compaction Yield Penalty

Axle Load vs Yield Loss
Corn 2003-2010

Yield Loss (%)

-15% -10% 0% 5% 10% 15% 20% 25% 30%

Axle Load (kg)

0 5000 10000 15000 20000 25000

Wet

y = 1E-05x - 0.0113

Normal

y = 9E-06x - 0.0624

Dry

y = 5E-06x - 0.1136

Compaction Yield Penalty
## Compaction Penalty

<table>
<thead>
<tr>
<th>Machine</th>
<th>Trafficked Area (%)</th>
<th>Yield Reduction Prediction (200 bu/ac No-Till Corn Base)</th>
<th>Normal</th>
<th>Wet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Cart (Balzer 2000)</td>
<td>14.0</td>
<td>175</td>
<td>196</td>
<td><strong>148</strong></td>
</tr>
<tr>
<td>Planter, 36 Row (Case IH 1260)</td>
<td>6.7</td>
<td>190</td>
<td>199</td>
<td>171</td>
</tr>
<tr>
<td>Class IX Combine, 16 Row (Deere S690)</td>
<td>17.1</td>
<td>176</td>
<td>196</td>
<td><strong>150</strong></td>
</tr>
<tr>
<td>Self-Propelled Sprayer (RoGator RG1300)</td>
<td>4.5</td>
<td>198</td>
<td>200</td>
<td>182</td>
</tr>
<tr>
<td>Manure Application (Houle 48-8D)</td>
<td>44.7</td>
<td>189</td>
<td>195</td>
<td>168</td>
</tr>
</tbody>
</table>
Compaction Project
Data drive decisions… the future of precision ag!
Machine Data Generation

- As-Applied Files (.shp)
  - Spraying [0.3 MB/ac]
  - NH$_3$ application [4.3 MB/ac]
  - Planting [5.5 MB/ac]
- Yield Data [4.3 MB/ac]
- Prescription Files [0.01 MB/ac]
- Soil/Fertility Data [0.6 MB/ac]
- Total [0.5 KB/plant]
U.S. defense spending bill signed by President Barack Obama includes provisions that require LightSquared's wireless LTE network to meet congressional guidelines aimed at preventing GPS interference before the FCC can approve its operation.
Unmanned Aerial Vehicles (UAV)

http://www.nasa.gov/centers/glenn/technology/uav.html
Image Data Generation

- 24 bits per pixel
- 2.5 cm/pixel
- 17.2 MB/ac of image data
- 18.3 PB/yr

Corn
Wheat
Soybeans
High Resolution NIR Images

Woolpert, Dayton, OH
High Resolution NDVI Images

Woolpert, Dayton, OH
FSR Field Study
FSR Field Study
Current Products

Deere MachineSync

AGCO GuideConnect

http://www.deere.com

http://www.farms.com/FarmsPages/ChatDeshBoard/ChatThreadView
Fully Autonomous Equipment

Carnegie Mellon University - National Robotics Engineering Center
http://www.rec.ri.cmu.edu/

Deere Autonomous Vehicle Development Program
http://www.deere.com

Kinze-JayBridge Partnership
Fully Autonomous Equipment


http://www.asirobots.com/farming/#section1
Future of Agriculture?
Control Methodology - IRCA

Deliberative

Reactive

Actuator Command Arbitration

Reactive Behavior

Deliberative Behavior

Environment

Obstacle Detection

Wireless Communication

Path Planning

Point to Point

Tracking

Activity Planning

Field Activity Control

Automated Steering

Speed Control

Recharge

Obstacle Avoidance

Actuator Command Arbitration

Actuators

Where

- = Increasing Levels of Reasoning

- = Increasing Levels of Priority

= Data Flow

= Wireless Transmit

= Wireless Receive

IRCA Control Schematic
Autonomous Tractor vs. Baxter?

Break-Even Investment Cost for Intelligent, Autonomous Tractors (Shockley, et al.)
Tractor of the future...

• Technical obsolescence and mechanical life will coincide – life of 6-7 cropping seasons.
• Fully (or supervised) autonomous tractors will be 50-60 hp and under 8,000 lb. GVW.
• Will be reconfigurable for ground clearance and track width.
• Automation (sensor-rich environment) will accelerate data generation.
• Will utilize spark ignition engine – multi-fuel (gas, ethanol and CNG) and reduced emissions.
Data analytics and crop insurance?

Figure 1. 2012 Crop Insurance Loss Ratios (All but Group Products), As of 3/18/2013.

Loss Ratios
- 0.00 to 0.40
- 0.40 to 0.80
- 0.80 to 1.20
- 1.20 to 2.00
- 2.00 to 3.00
- 3.00 to 4.00
- Over 4.00
- No data

Source: Summary of Business, Risk Management Agency.
In-Field Phenotyping

http://www.plant-phenomics.ac.uk/en/

http://vigir.missouri.edu/targetgeolocation.htm

http://newsroom.hwtrek.com/?p=626
Nutrient Management

http://www.newtoncrouch.com/pages/view/32

http://www.farm-news.com/page/content.detail/id/508640/ILF--Strip-till---better-soil.html?nav=5005

NDVI and Crop Health Sensing


Questions?