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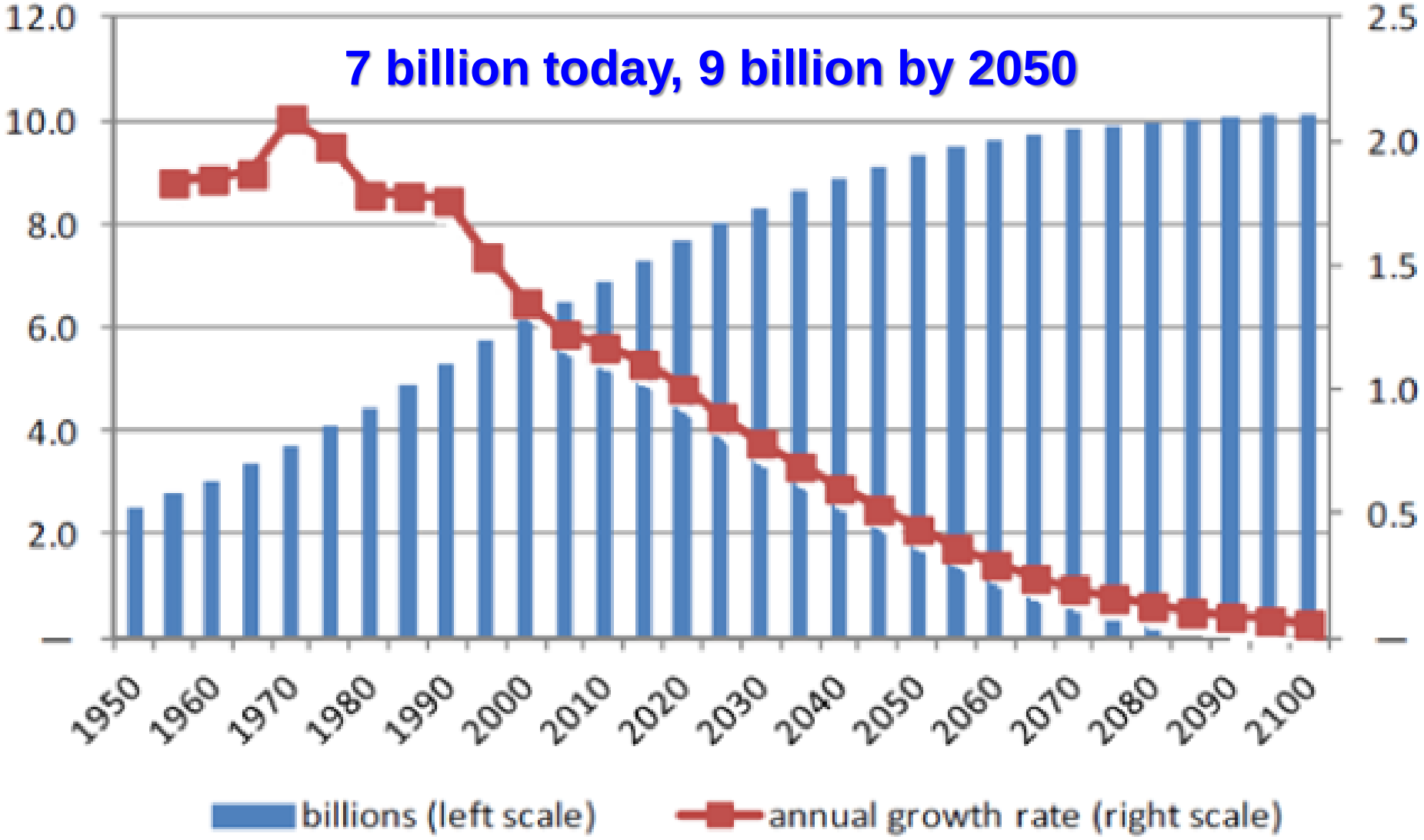
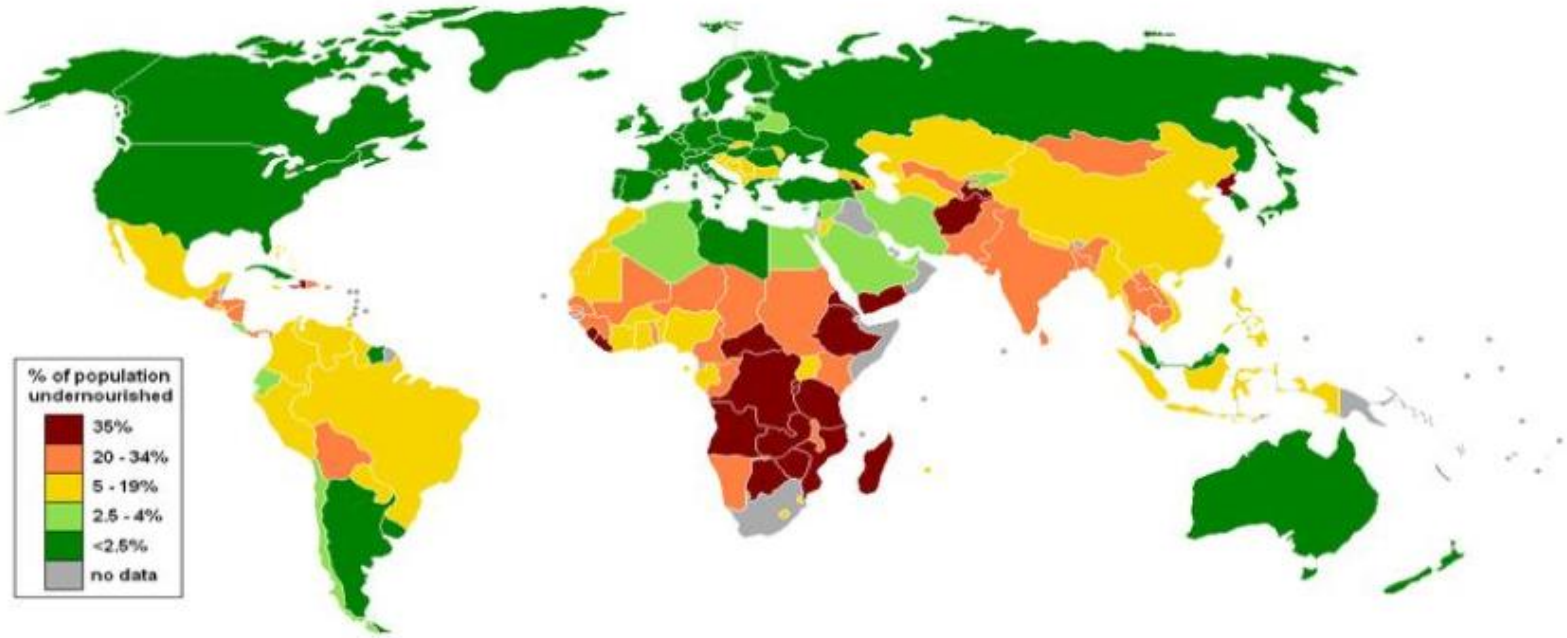
Leading Crop Production into the Future with Precision Agriculture

Steve Phillips, Ph.D.
Director, North American Program

World population prediction to 2100 (UN, 2010)



Global Population and Food Security



- Population increases are placing greater pressure on the food security of certain regions of the world
- Potential food security challenges are going to affect all world residents, regardless of their location.

- **Food production will have to increase 50 to 70% to meet global demand**
- **Fertilizers are responsible for 50% of food production and will likely increase**

- Micronutrient fertilization can improve nutrient quality of food
- Fertilization can increase food production (50 to 70% more food by 2050) – highest food insecurity is in regions using least fertilizer
- Promotion of fertilizer BMPs
- Focus on small-holder systems
- Fertilization can improve post-harvest integrity and nutritional quality

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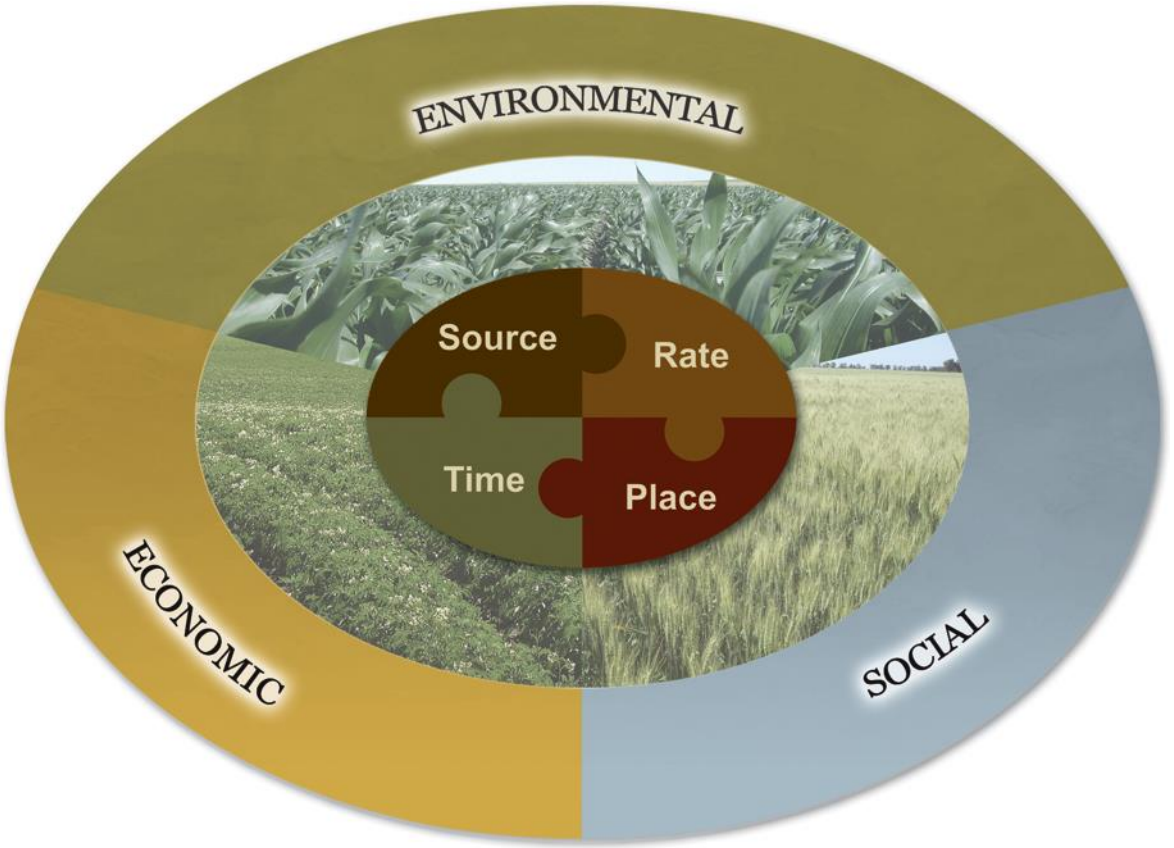
The Future of Crop Production

- **The foundation of fertilizer BMPs and efficient nutrient management can be aptly described as following the "4Rs"…**

  Applying the *Right Source* at the *Right Rate* at the *Right Time* and in the *Right Place*

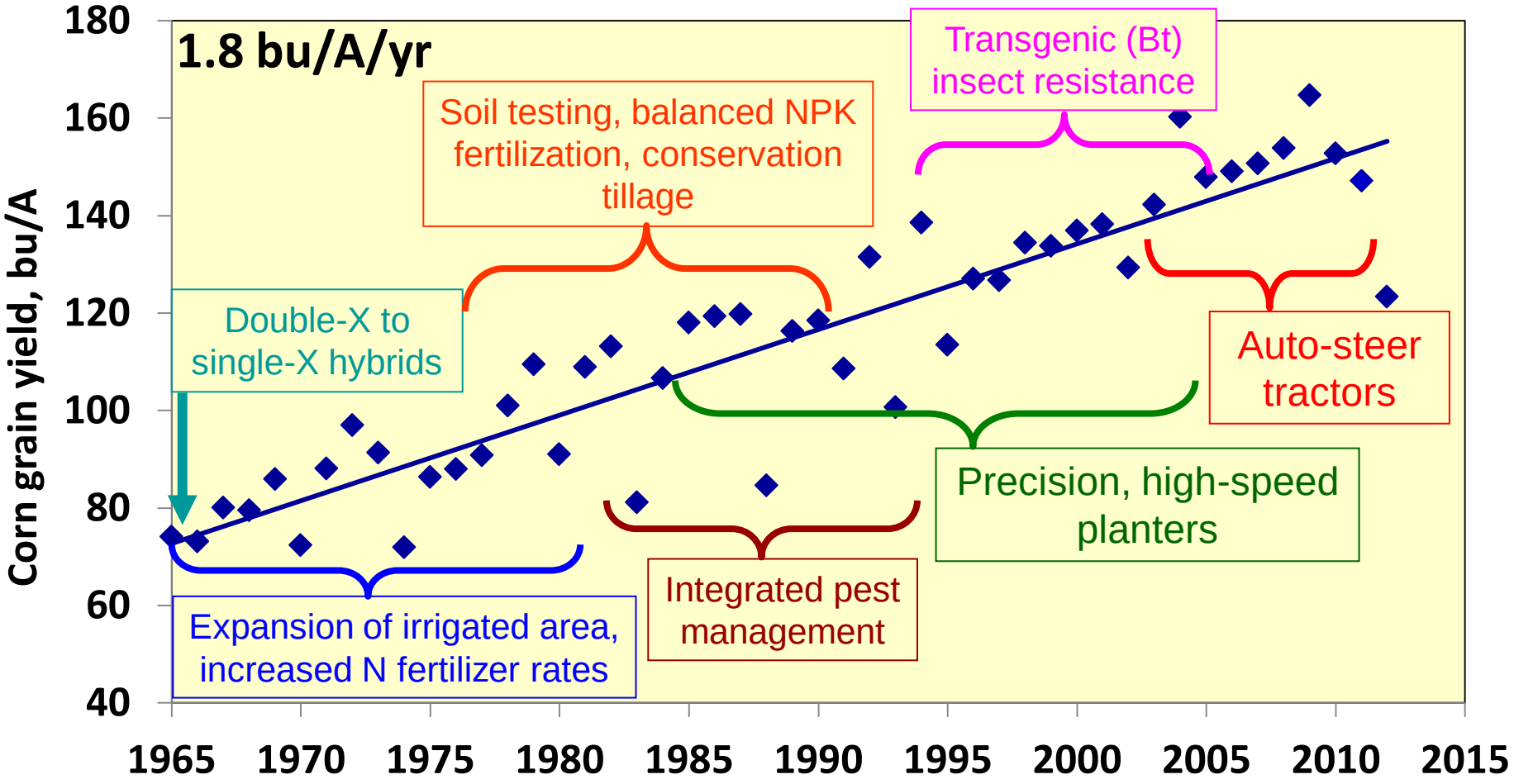


Global Food Security

- Recent study by the International Food Policy Research Institute (IFPRI) estimated that stacking agricultural technologies could increase global crop yields as much as 67% and cut food prices nearly in half by 2050.

- Key areas for prioritized investments:
  - No-till farming
  - Integrated soil fertility management
  - Improved crop protection
  - Irrigation
  - Precision agriculture

US average corn yields, 1965-2012



Modified w/ permission: Cassman et al., 2006. Convergence of Agriculture and Energy. CAST

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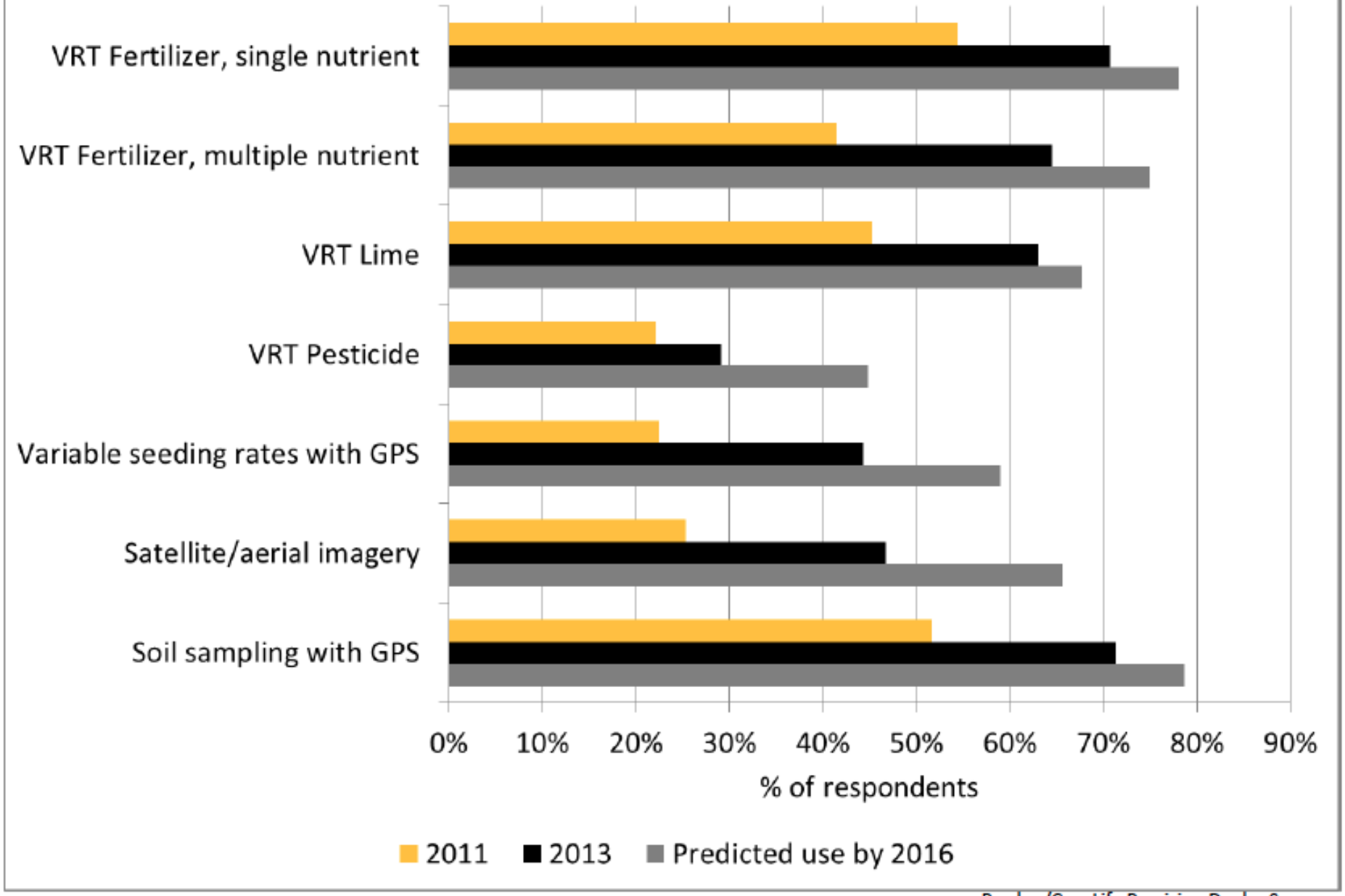
Precision Agriculture

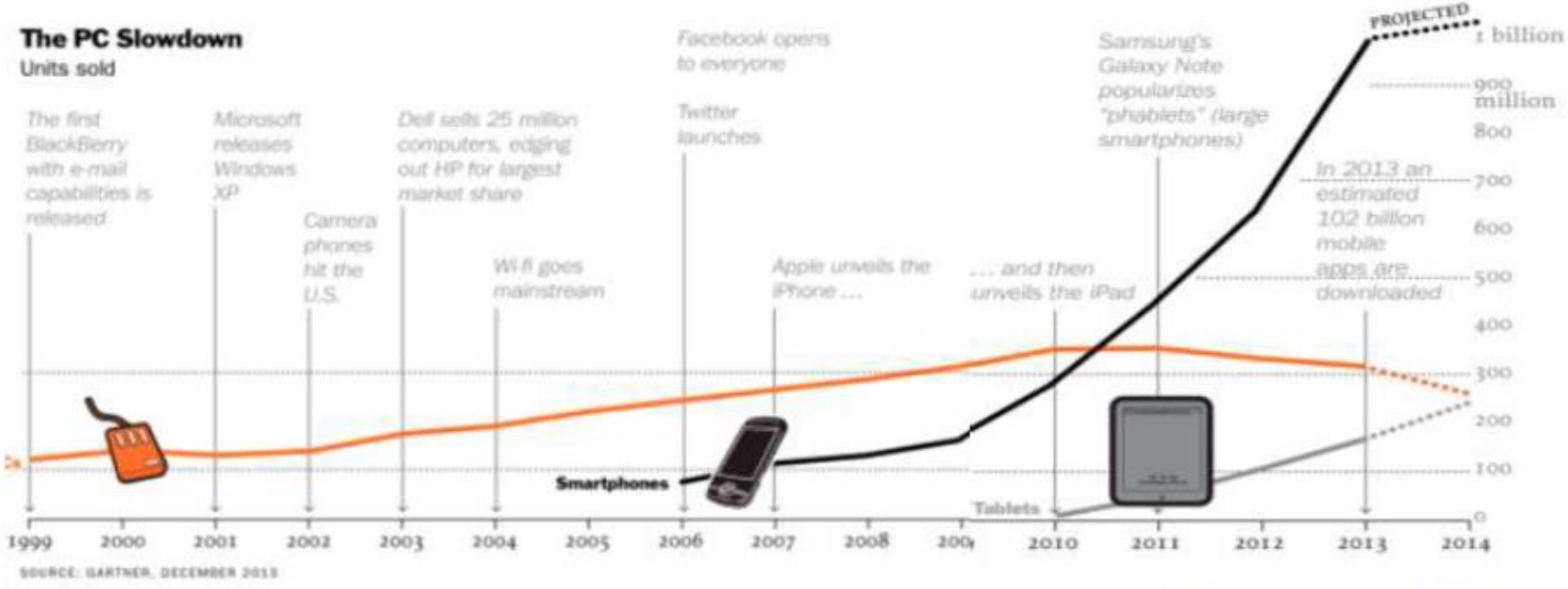


Purdue/CropLife Precision Dealer Survey

Top Five Trends in Precision Agriculture - 2013

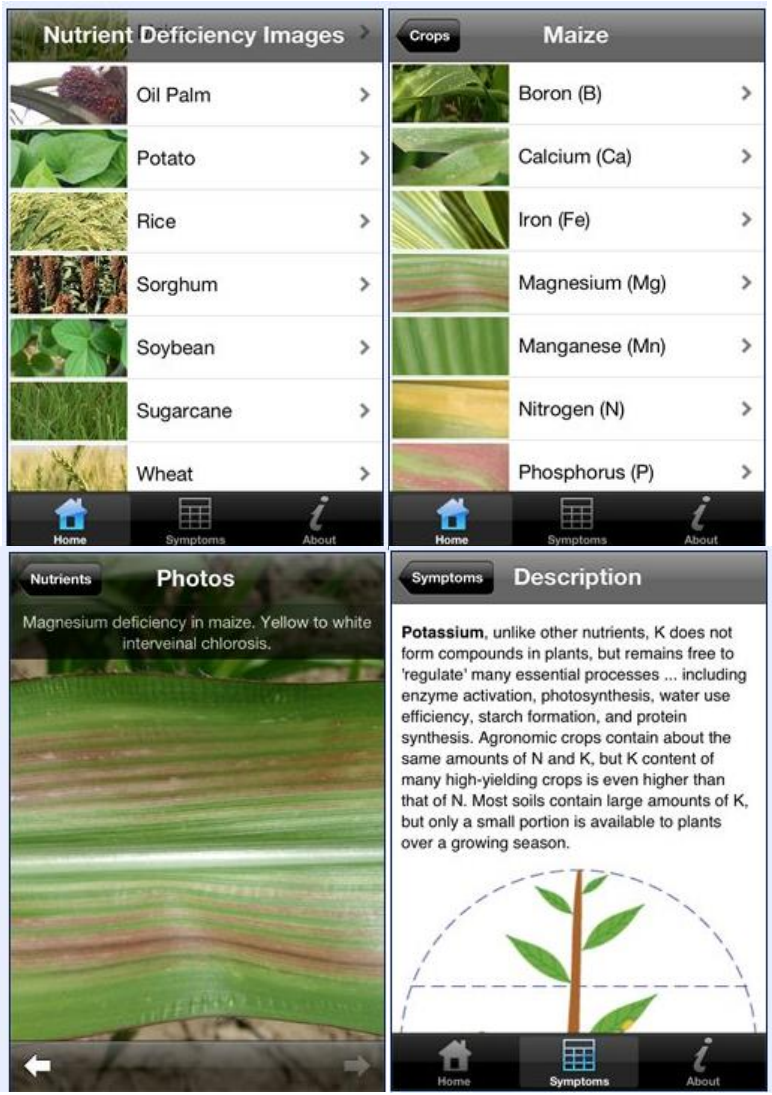
1. Mobile Devices
2. Database Integration
3. Variable-Rate Applications
4. In-Cab Solutions
5. Unmanned Aerial Vehicles

Top Trend #1: Mobile Devices

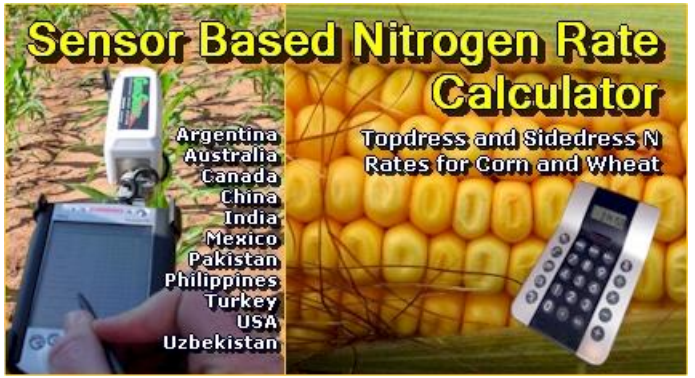


Source: Time, January 13, 2014

Agricultural Applications

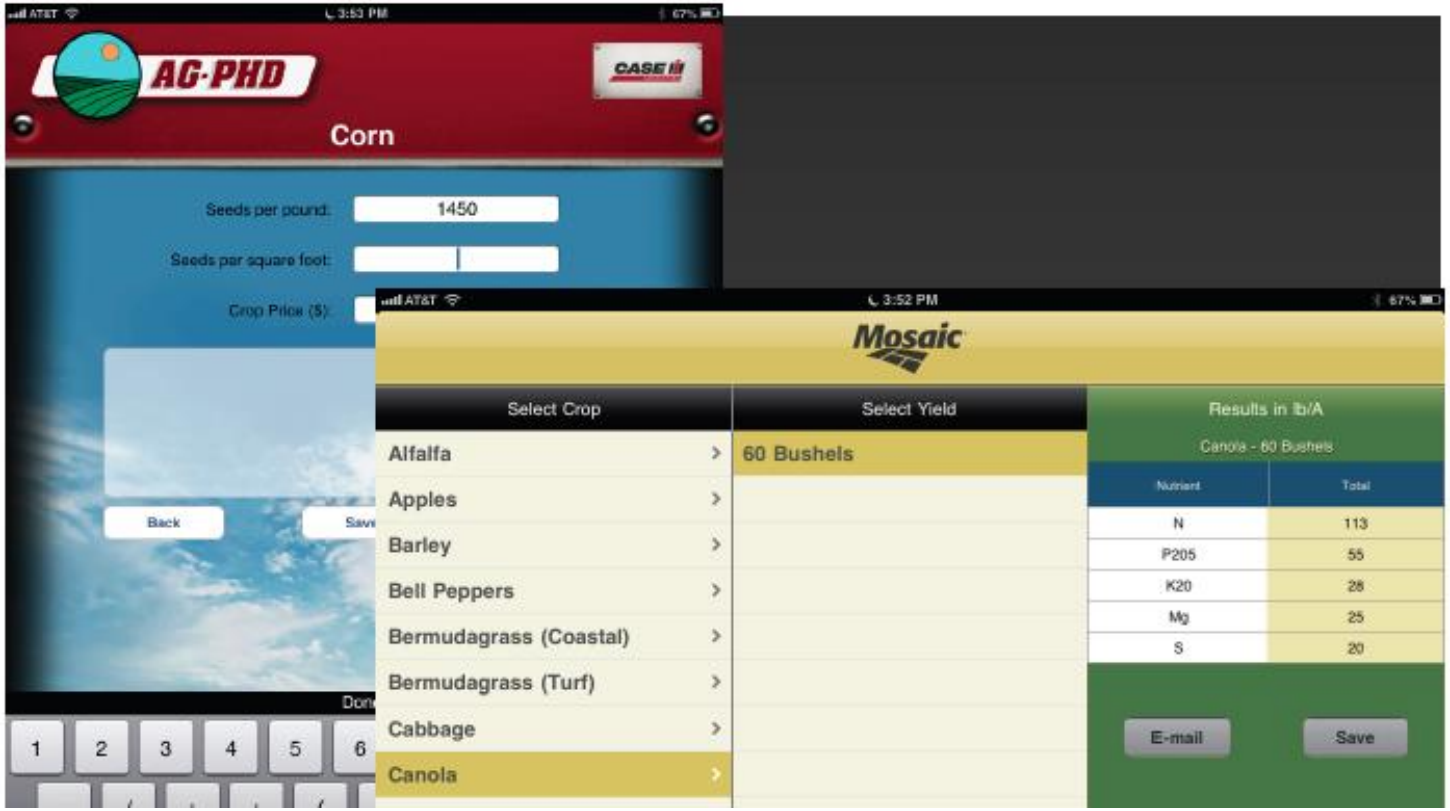


- **Identification tools**
  - Weeds, Nutrient Deficiency, Pests
- **Input Calculators**
  - Seed, Chemical, Fertilizer



- **News, Weather, Market Updates**

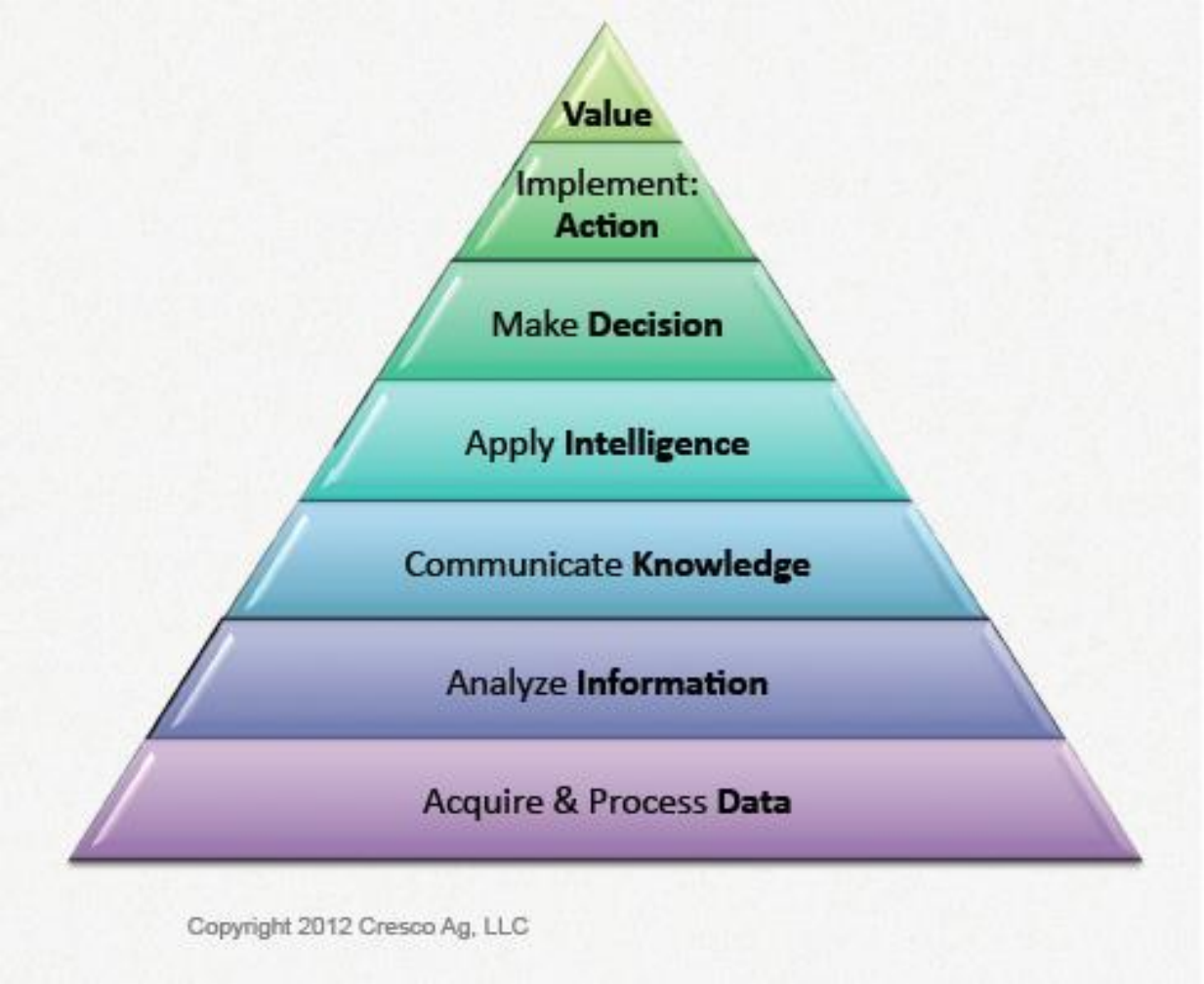
- **Other Calculators**
  - Plant Population, Nutrient Removal



Top Trend #2: Database Integration

- Compatibility of tools
- Integration of outside data
- Improvements in decision making
- Wireless data transfer

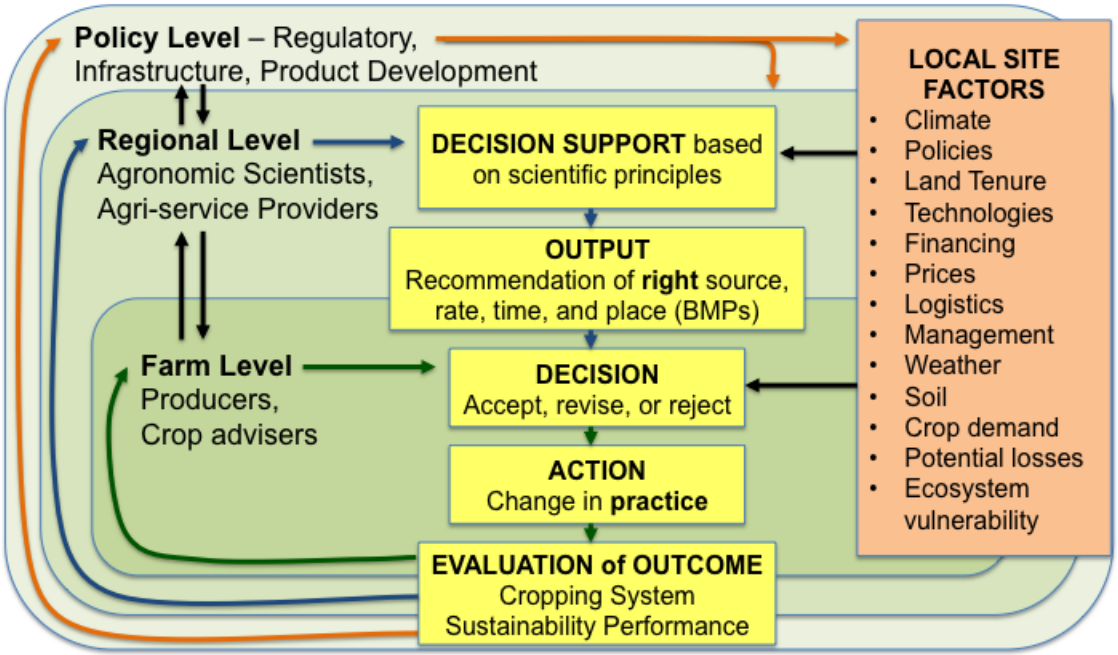
Data have no value…



Accountability

- The inclusion of accountability is another way 4R stewardship moves beyond traditional nutrient management. One of the main ways this is accomplished is through the inclusion of a dynamic feedback mechanism.

- Precision agriculture tools can provide the feedback and recordkeeping necessary for the accountability that is needed in nutrient management.

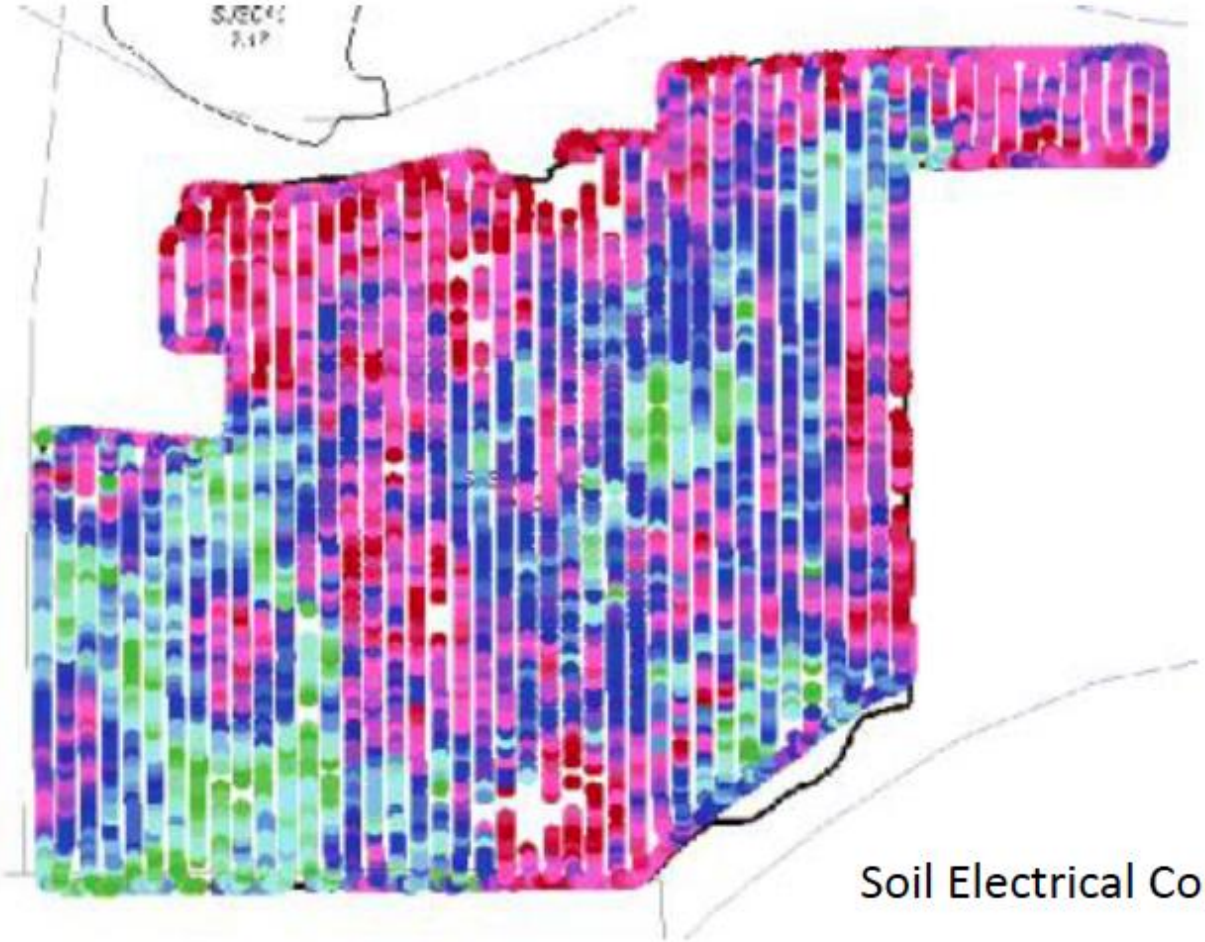


Top Trend #3: Variable Rate Applications

- Application based on field and crop variability
- Apply only what is needed
- Deliver inputs more accurately

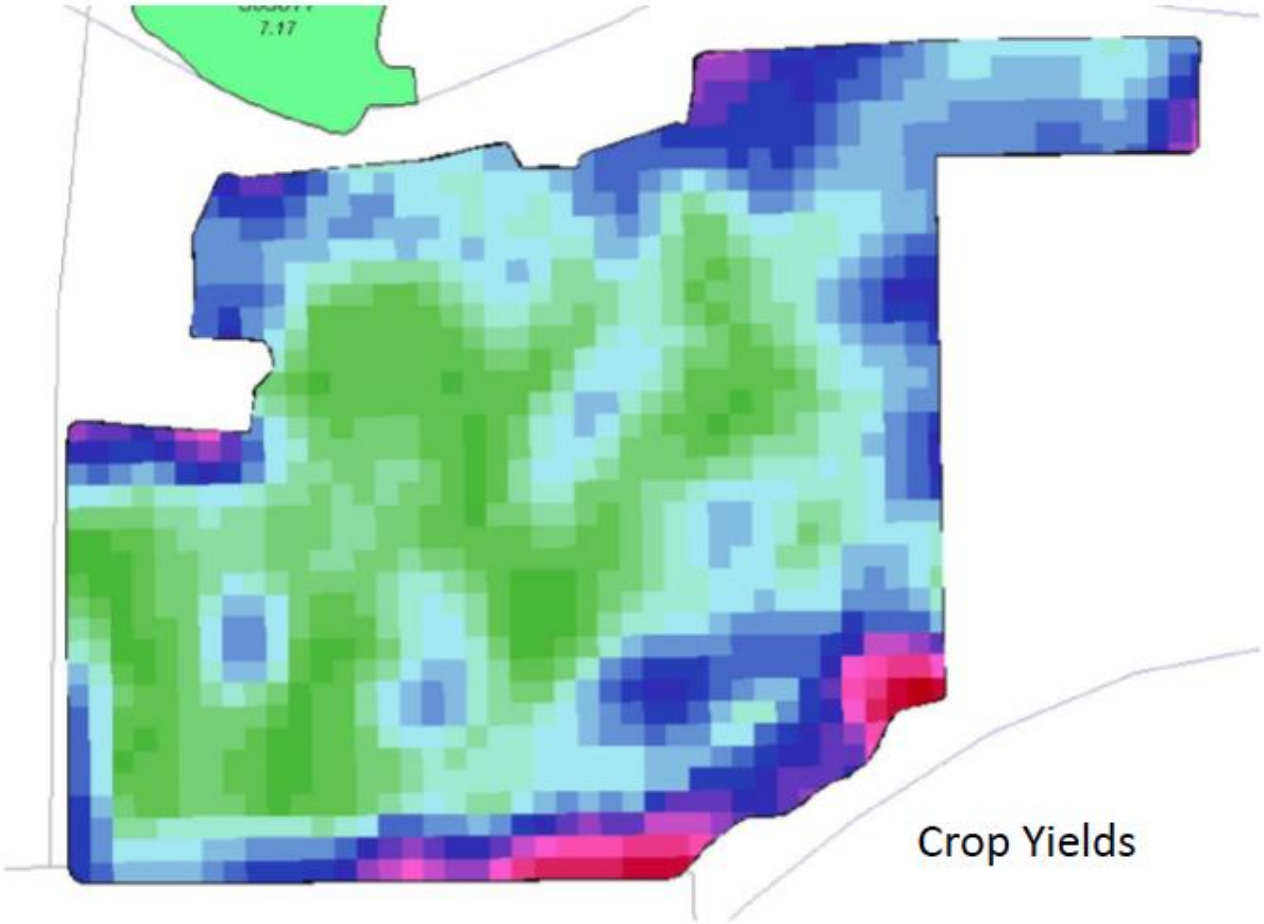
Applying only what the plant needs, or soil can handle.

Crop Environments are Variable



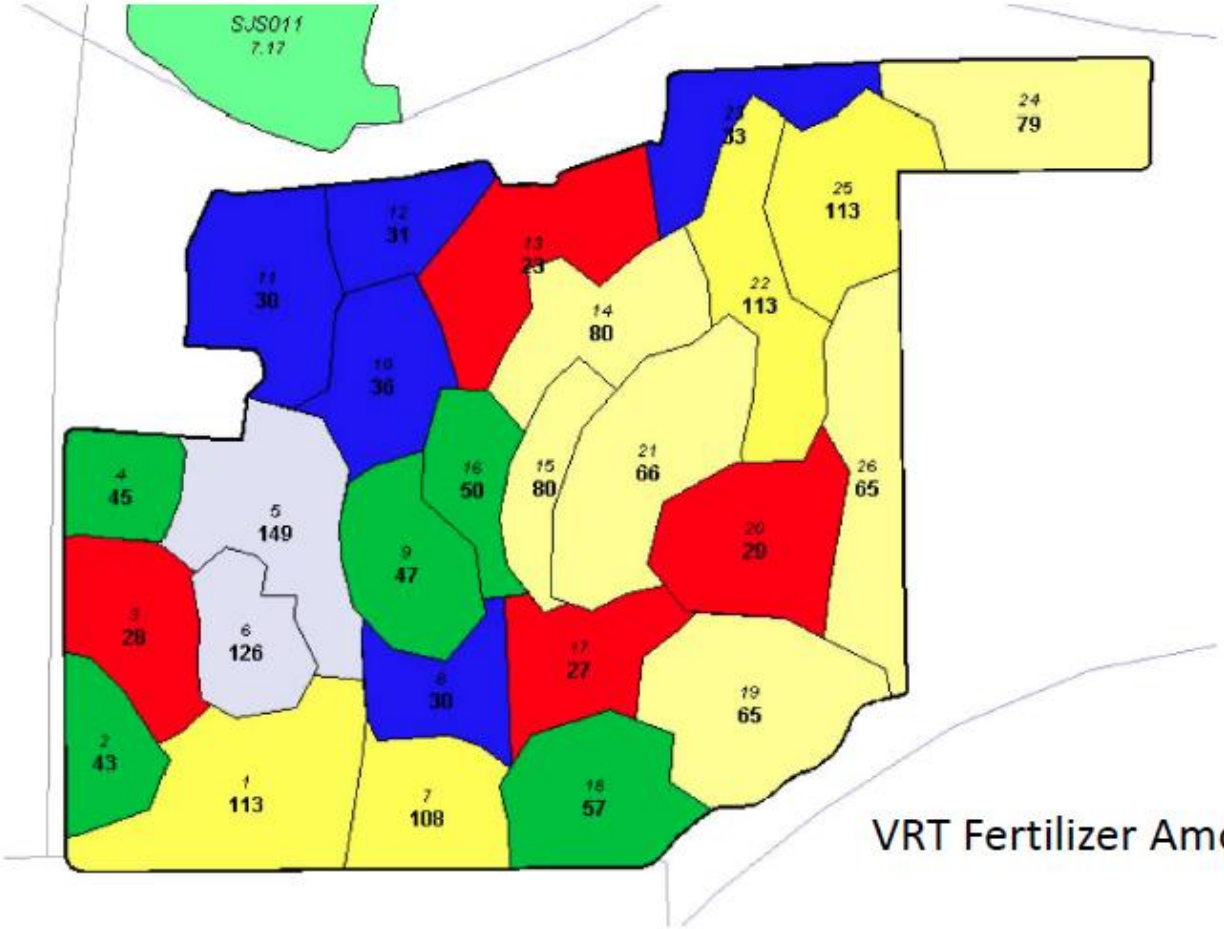
Soil Electrical Conductivity

Crop Outputs are Variable



Crop Yields

Crop Inputs are Variable



VRT Fertilizer Amounts

Precision Planting

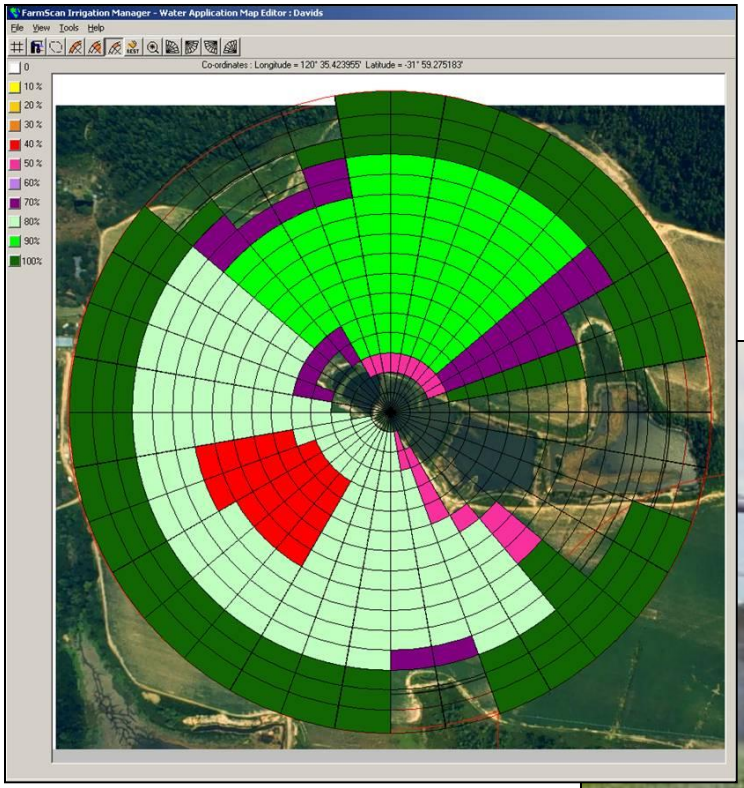
Variable Hybrid Planting

Variable-Rate Seeding

VR seeding as opposed to planting whole field at 64K

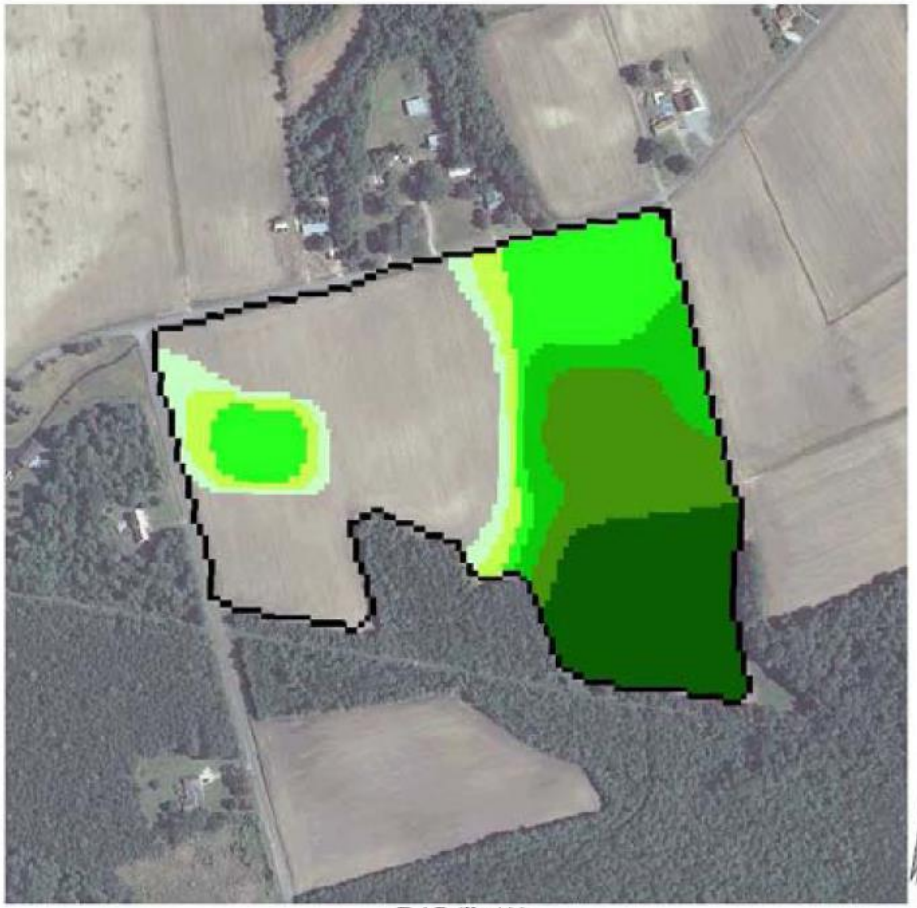
% of land with low yield potential	VR Seeding Savings
	---------$/ha--------
5%	0.32
10%	0.74
25%	11.68
50%	30.01
75%	48.04

Precision Water Management



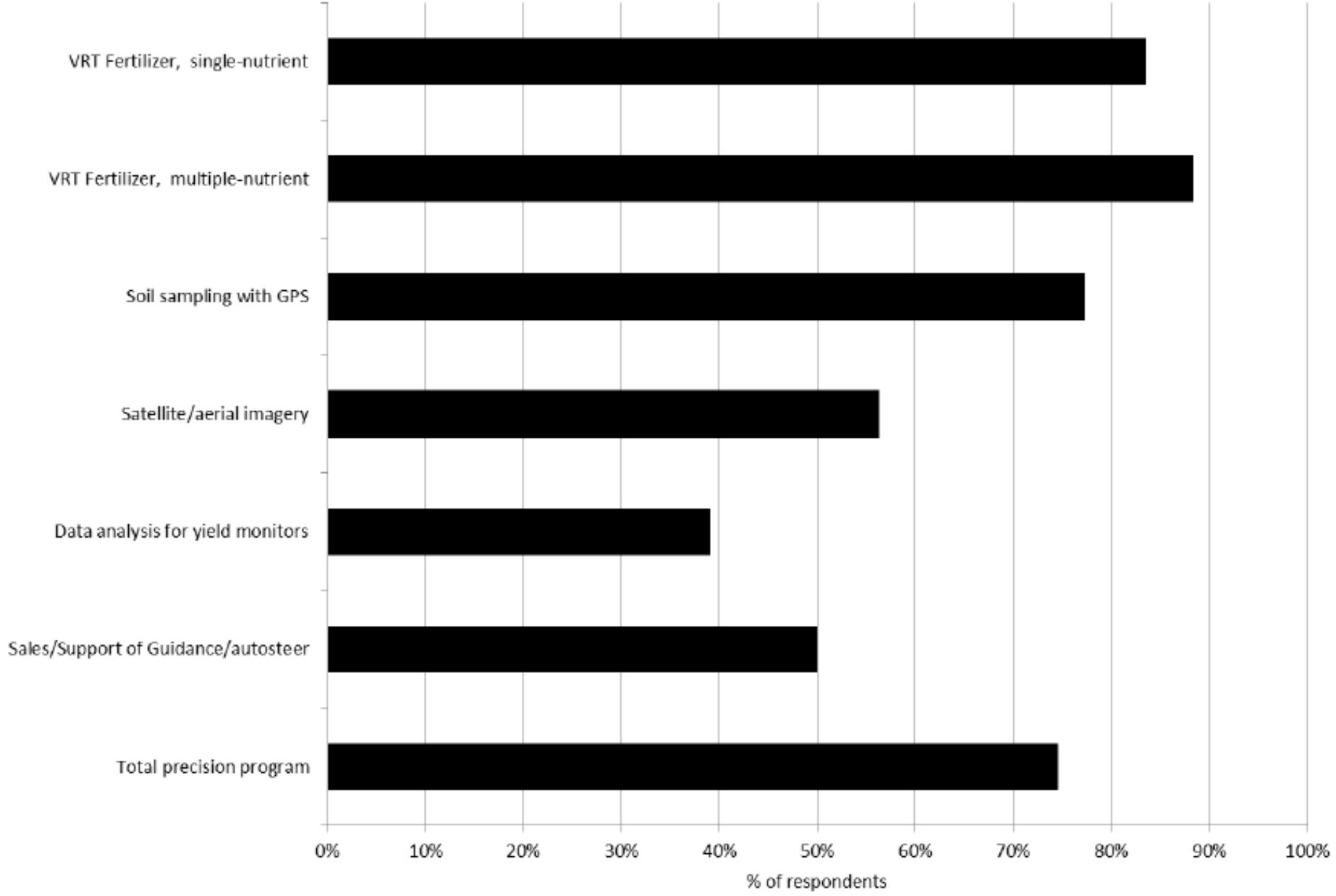

11:38 AM
96%
Schedule details
Save
01/07/2014
ACCUMULATED ETC
10.3 in
ROOTING DEPTH
12.8 in
WATER DEFICIT
20 % 0.3 in
IRRIGATION APPLIED
1.2 in
RAIN OBSERVED
0.5 in
11:37 AM
96%
Smartirrigation Cotton
Irrigation rate: 0.5 in
Edit field
WATER BALANCE
0
50
100
Deficit
16 %
(0.25 in)
Yesterday
Add irrigation
See details
Irrigation applied: 0.0 in
Rain observed: 0.25 in
PHENOLOGICAL PHASE
226 GDD
Yesterday
Emergence to First Square
90
550
Adjust GDD
Adjust phase
97%
12:53
Tuesday, January 7
SI Cotton
Field 1 is approaching the First Open Boll phase.
slide to unlock

Map-Based VR Nutrient Application

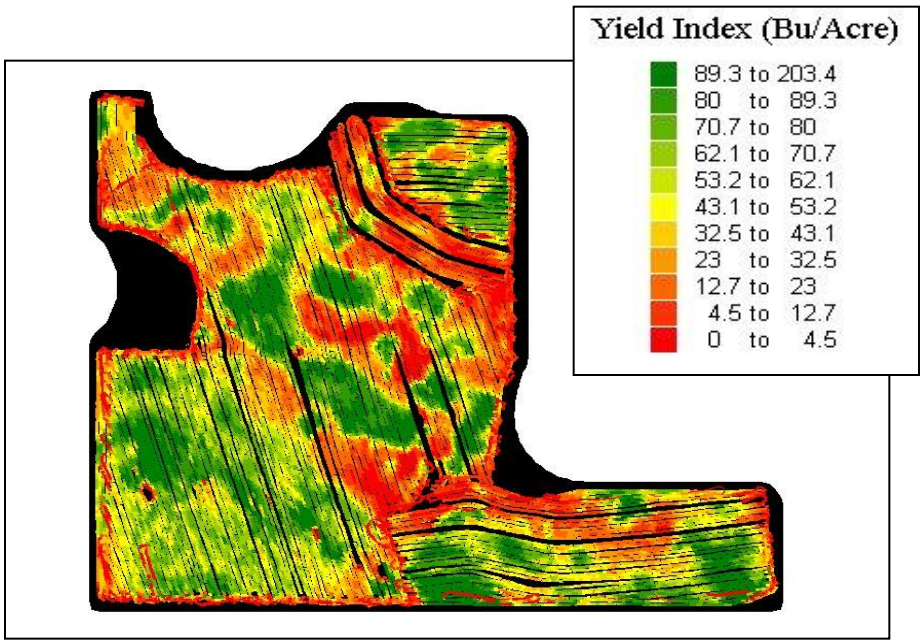


Product	
Addition/Deduction(lbs/ac):	None Entered
Percent of Original App:	100%
Minimum Application Rate:	54 kg/ha
Maximum Application Rate:	145 kg/ha
Field Average Rate:	108 kg/ha
Total Applied Acreage:	8.3 ha
Total Field Acreage:	13.1 ha
Total Field Acreage(lbs):	2001.6
Total Field Acreage(tons):	1.00

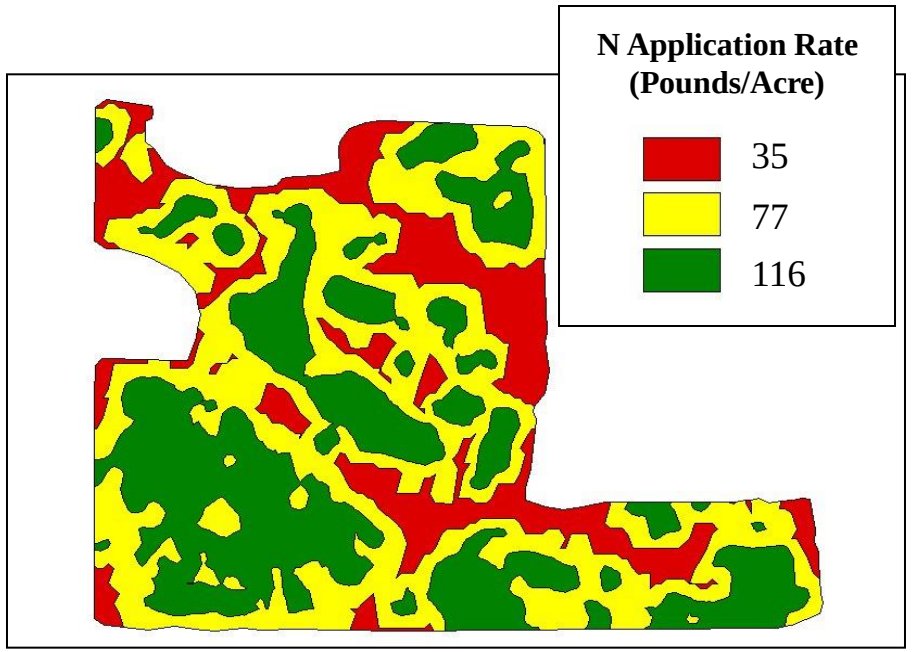
Figure 3. Dealerships Generating a Profit for Precision Services



Yield Monitoring

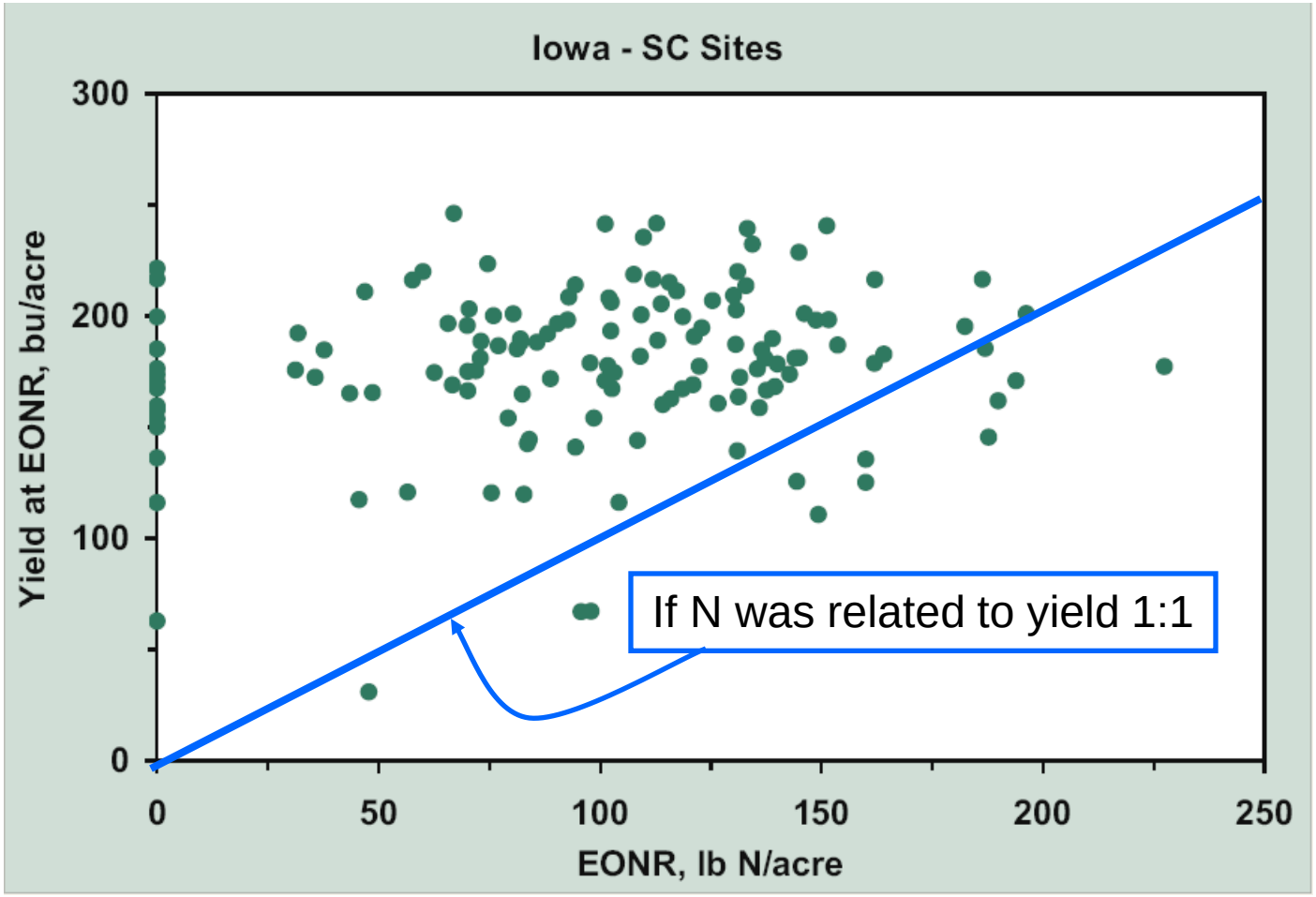


Yield Map



Following Year
Nitrogen Application Map

How does yield relate to N rate?



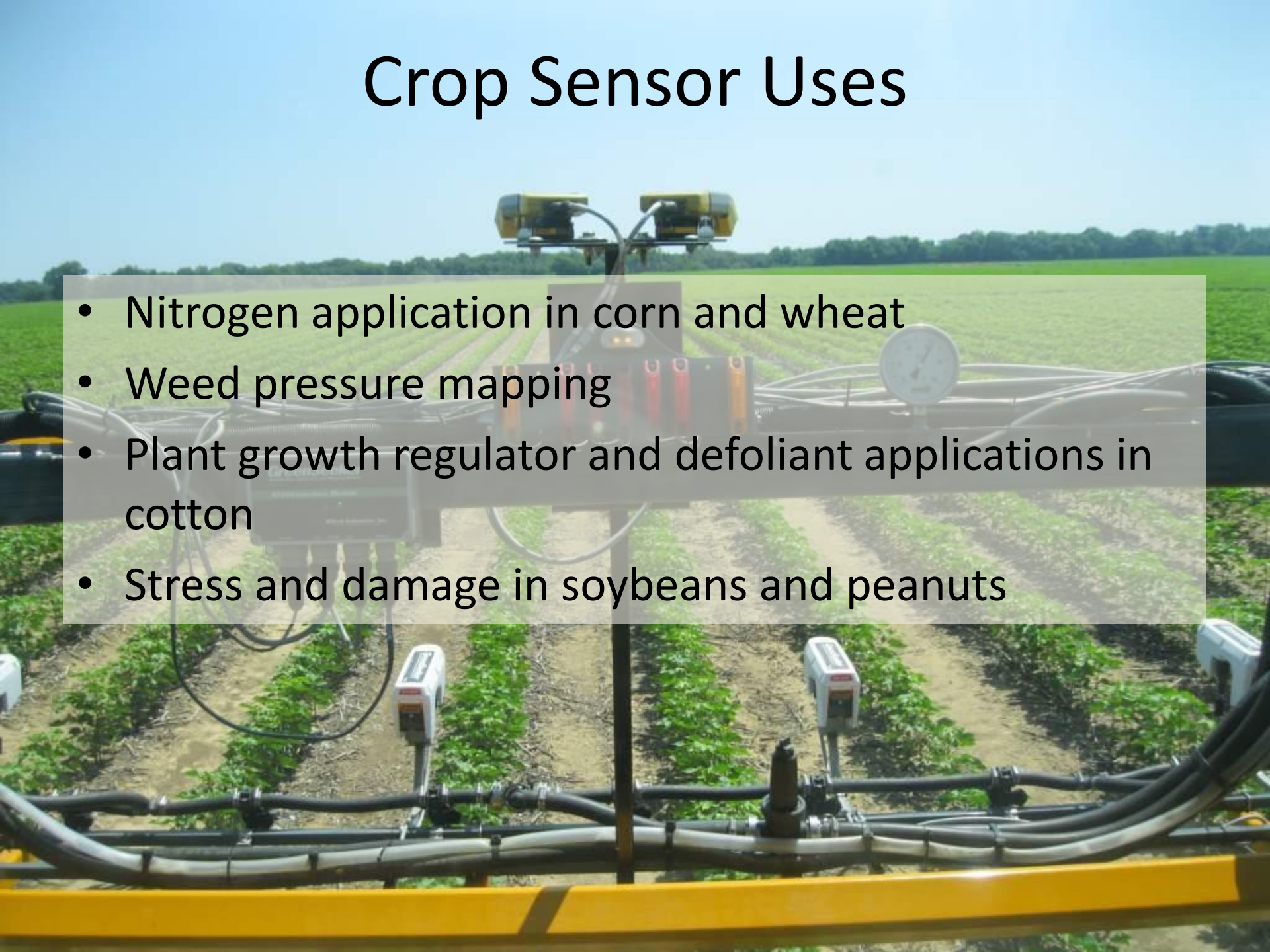
Up and Coming Technology: Crop Sensors

GreenSeeker®
Variable Rate Application and Mapping Systems

Estimated acreage of N-Sensor based fertilization in main European markets (2013)

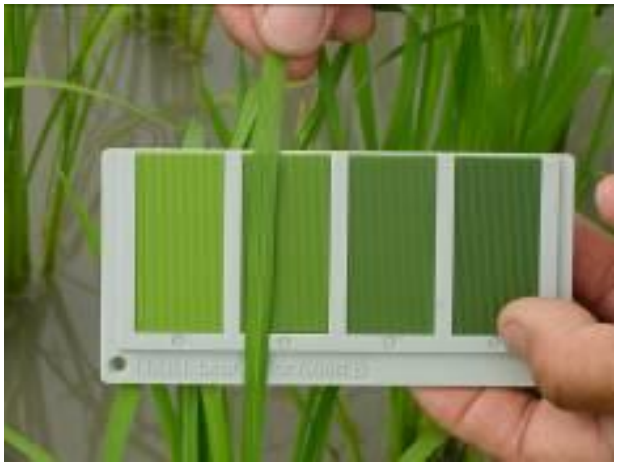
Country	No. of N-Sensor units	Acreage with N-Sensor fertilization
Germany	640	700,000 ha
UK	260	350,000 ha
Sweden	110	65,000 ha
Czech Republic	55	45,000 ha
France	55	35,000 ha
Denmark	55	30,000 ha
Total	1175	1,225,000 ha

Crop Sensor Uses



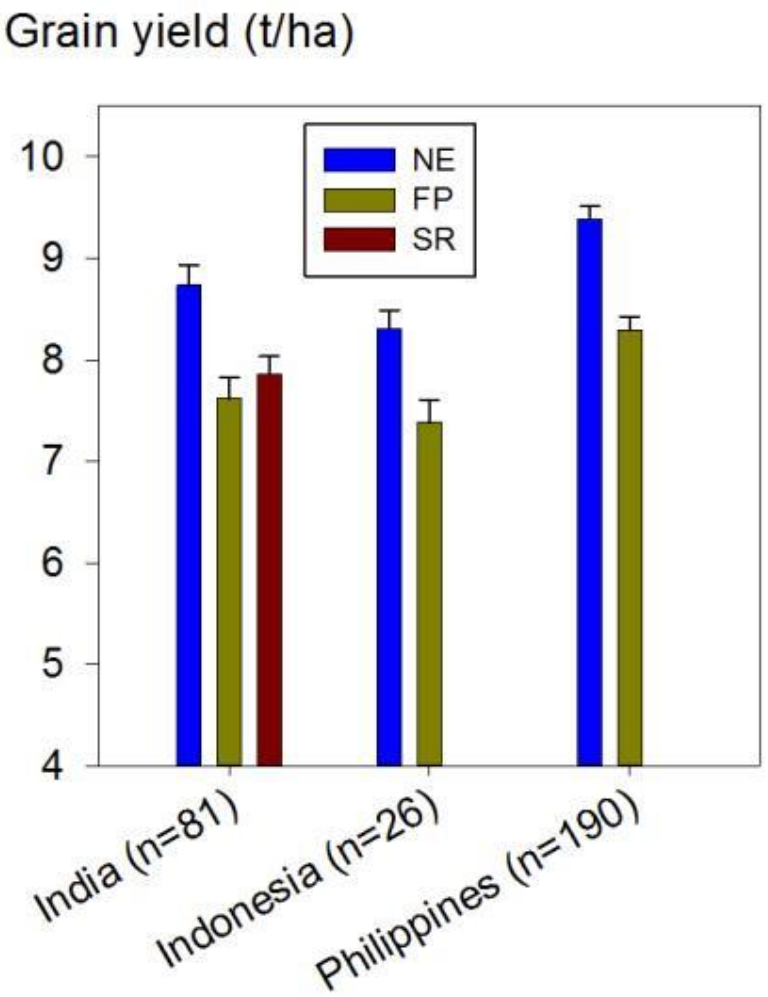
- Nitrogen application in corn and wheat
- Weed pressure mapping
- Plant growth regulator and defoliant applications in cotton
- Stress and damage in soybeans and peanuts

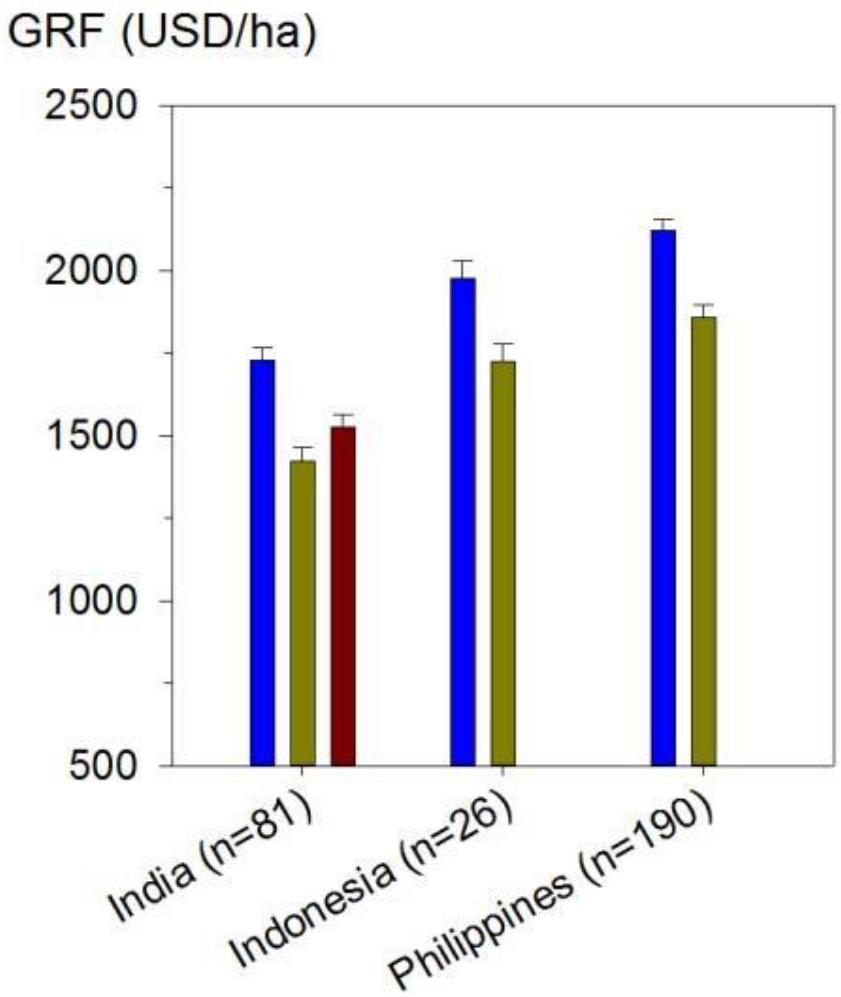
Decision Support Tools …. integrate the numerous site factors used in making decisions about nutrient management practices…



Field validation results of Nutrient Expert for maize

India, Indonesia, Philippines (2010-2013):
Farmers' current yield level < attainable yield





GRF = gross returns above seed and fertilizer costs

NE for maize performance across 24 sites in the Philippines

Parameter	Unit	FFP	NE	Difference (NE – FFP)
Grain yield	t/ha	7.49	9.16	**1.67** ***
Fertilizer N	kg/ha	114	132	18 ns
Fertilizer P_2O_5	kg/ha	26	36	10 ***
Fertilizer K_2O	kg/ha	18	35	17 ***
Fertilizer cost	USD/ha	176	241	65 ***
Gross return above seed & fertilizer	USD/ha	1730	2126	**395** ***

***, **, *: significant at <0.001, 0.01, and 0.05 level; ns = not significant

Data from 24 farmers' fields in six regions under favorable rainfed (maize-maize, rice-maize) environments, dry season 2010-2011

Price of seeds, fertilizer, and maize grain are based on actual local prices; USD 1 = Php 43

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FFP vs SSNM (NE) in Iloilo, Philippines

NE for maize performance across 27 sites in India

Andhra Pradesh (n = 27)

Parameter	Unit	FP	NE	NE – FP	
Grain yield	kg/ha	8568	9699	**1131**	***
Fertilizer N	kg/ha	288	203	-85	**
Fertilizer P_2O_5	kg/ha	153	54	-99	***
Fertilizer K_2O	kg/ha	68	74	6	ns
Fertilizer cost	INR/ha	9509	5459	-4050	**
GRF[1]	INR/ha	76167	91770	**15603**	***

***, **, *: significant at <0.001, 0.01, and 0.05 level; ns = not significant

[1] GRF = gross return above fertilizer cost

Prices (in INR/kg): maize = 10.00; N = 11.40; P_2O_5 = 32.20; K_2O = 18.80

Top Trend #4: In-Cab Solutions

- **Automated Guidance**
- **Boom Section Control**

Image courtesy of TeeJet

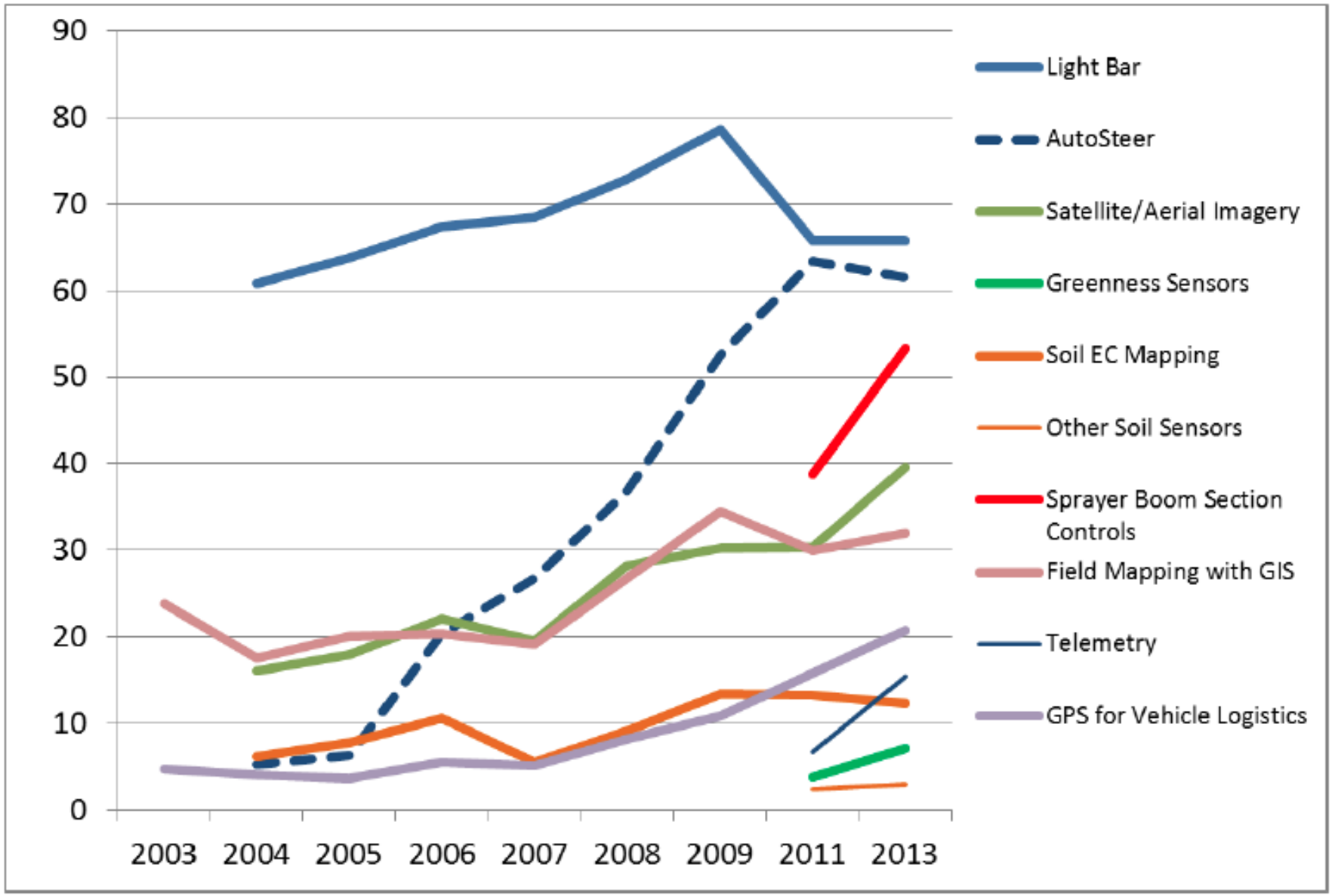
Automated Guidance

Boom Section Control

Improved Field Management

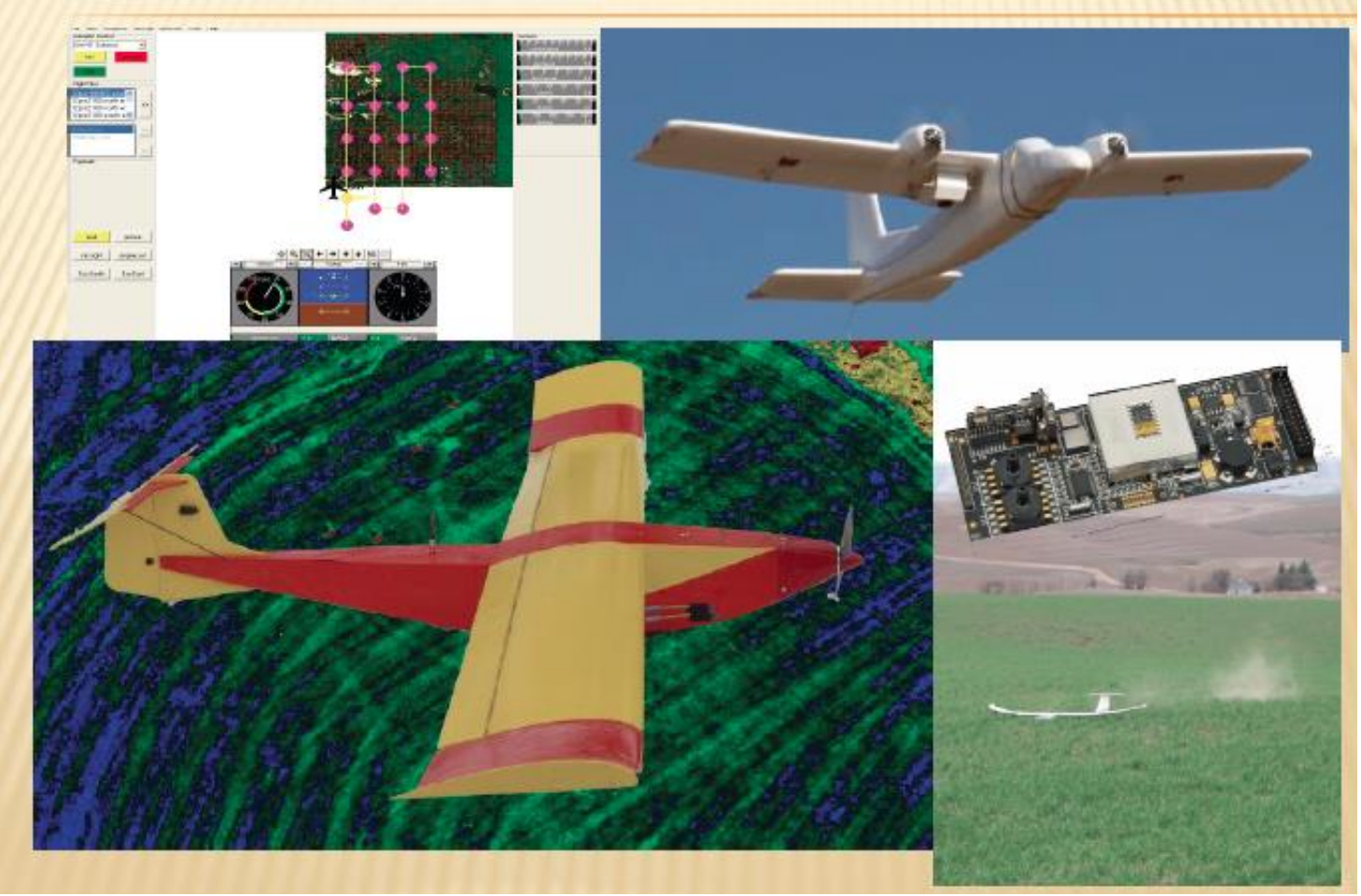
Preservation while Maintaining Production

Dealer Use Over Time



Purdue/CropLife Precision Dealer Survey

Top Trend #5: Unmanned Aerial Vehicles (UAV)



Unmanned Aerial Vehicle

DraganFly X6

http://www.draganfly.com

MicroDrone MD4-200

http://www.microdrones.com

Fixed-wing

Cropcam

Raven

eBee

http://www.sensefly.com

Yamaha

WASP III

UAV Sensors

NDVI Camera

Tau 640 thermal imaging camera

Multispectral camera array (MCA) imaging sensor

Potential Applications

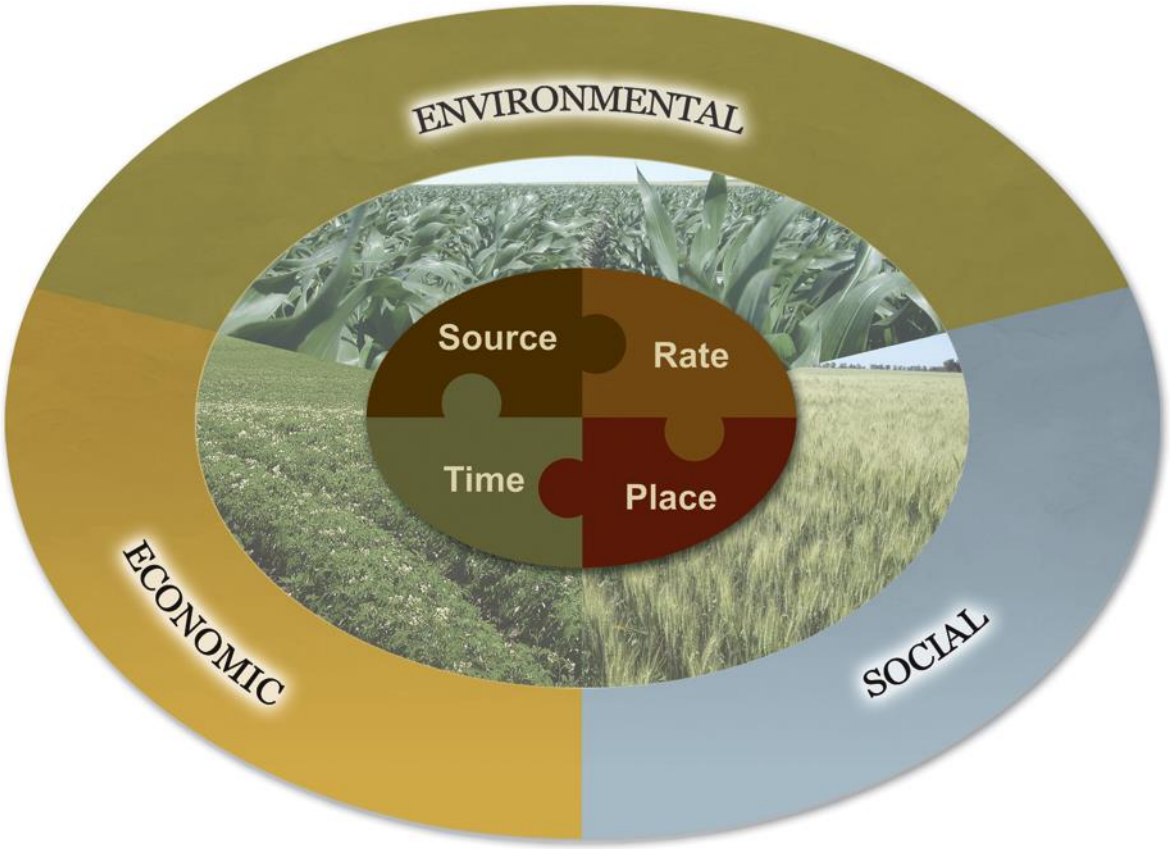
- ❑ Crop Scouting
- ❑ Bare soil imagery
- ❑ Irrigation and drainage planning
- ❑ Yield estimation and monitoring
- ❑ Inventory
- ❑ Diagnostic of herbicide injury in crops
- ❑ Selection of plants for further breeding
- ❑ Sampling plant pathogens in the air
- ❑ Academic and extension education

Future for UAVs

- UAV has a lot of potential applications in agriculture and horticulture crops
  - Small farms
- More research is needed
  - Develop tools and techniques
- Rules and regulations are not clear
- Lots of excitement among growers

4R is Precision Nutrient Management

- **Implementing precision agriculture technologies within the context of 4R nutrient stewardship is an efficient and effective way to help meet the environmental, economic, and social goals of sustainable agricultural systems**



4R nutrient stewardship

IPNI Member Companies and Industry Associations

- Agrium Inc.
- Arab Potash Company
- Belarusian Potash Company
- CF Industries Holdings, Inc.
- Compass Minerals Specialty Fertilizers
- International Raw Materials LTD.
- Intrepid Potash, Inc.
- K+S KALI GmbH
- The Mosaic Company
- OCP S.A.
- PotashCorp
- Qatar Fertiliser Company (QAFCO)
- Simplot
- Sinofert Holdings Limited
- SQM
- Toros Tarım
- Uralchem
- Uralkali
- ANDA - Associação Nacional para Difusão de Adubos
- Arab Fertilizer Association (AFA)
- Canadian Fertilizer Institute (CFI)
- The Fertiliser Association of India
- The Fertilizer Institute
- International Fertilizer Industry Association (IFA)
- International Potash Institute (IPI)

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