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UNIVERSITY OF WISCONSIN–MADISON

Precision Agriculture turned Assistive Technology

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WARNING!

There will be a lot of speculation in this presentation!

The goal is to inspire thought and focus us on the use of existing (and new) technologies as assistive.

Agriculture Advancements

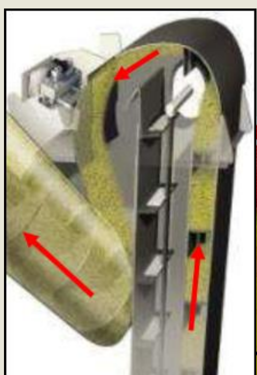
Precision Agriculture History

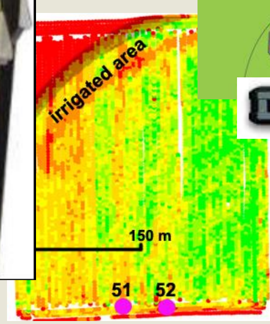
- Data Collection
  - GPS
  - Yield Monitoring
  - Spatial Measurements

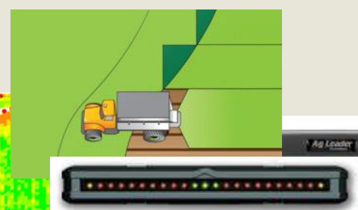
- Steering Control/ Variable Rate
  - Light Bar
  - Auto-Steer
  - VRA Nutrient Application

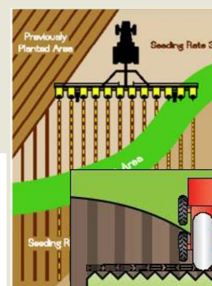
- Implement Control
  - Nozzle on/off
  - Planter Row Unit on/off
  - Implement Steering

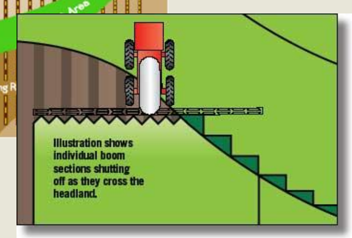
- Data/Control Refined
  - Variable Rate Seeding
  - Continuous Monitoring
  - Unmanned Aerial Vehicles
  - Data Collection and Management





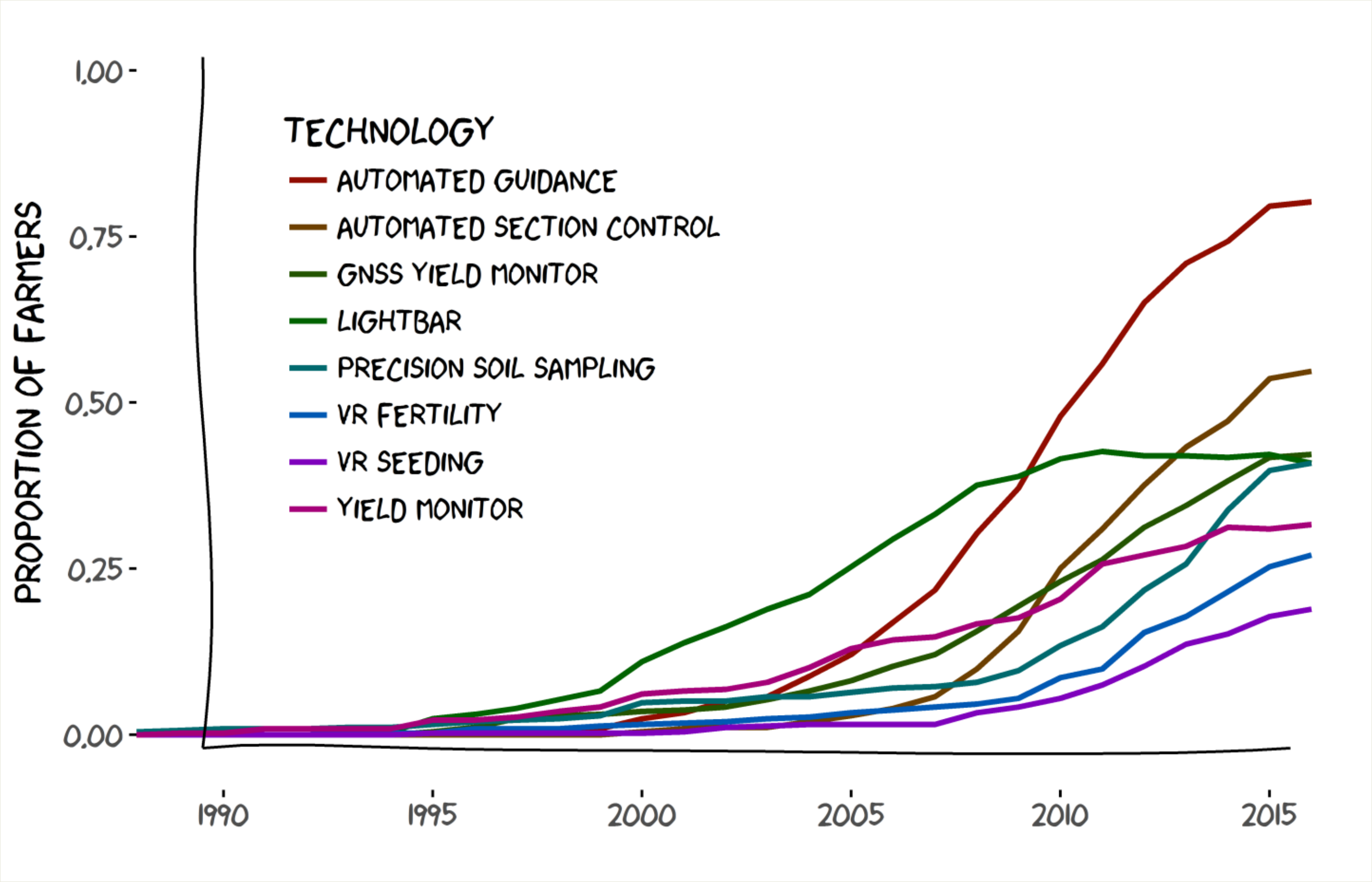






1992 — 1997 — 2002 — 2007 — 2017

Technology Adoption Rates



Erickson and Widmar, 2015

Types of Technology and Potential Returns

- Immediate Realization of Returns (profit or otherwise)
- Long-term Realization of Returns (profit or otherwise)
- Examples?

Future of Agriculture Topic Areas (Assistive Tech.)

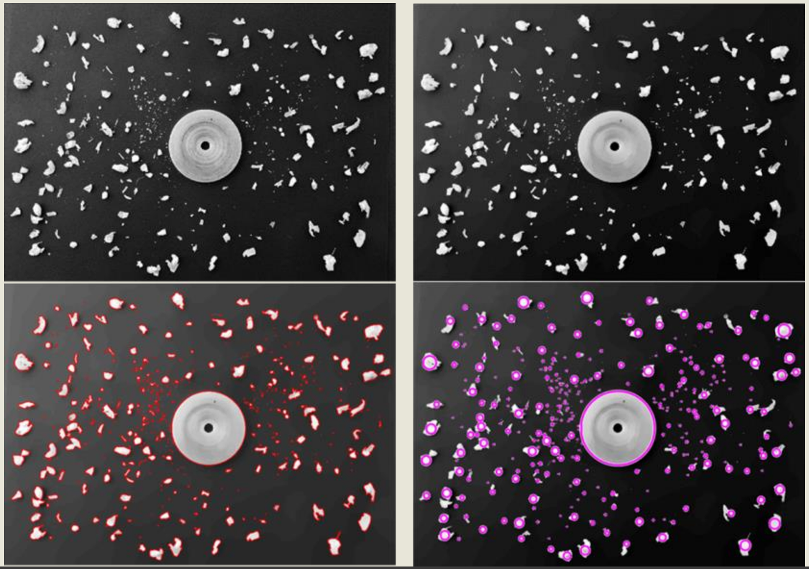
- Three different categories:
  - On Farm Tools
  - Analytics and Data Tools

On Farm Tools

- Computing power available to us?
- Apollo Guidance Computer = 64 KB memory/0.043 MHz
- Samsung Galaxy S7 = 4 GB memory/2x1.59 GHz and 2x2.15 GHz -> More than 2 Million times faster

On Farm Tools

- Smart Phone Applications:
  - Data collection at our fingertips
  - Capabilities of a computer
  - Connectivity for data transmission (real-time)



On Farm Tools

- Sensors
  - In Field
  - Flying
  - On Plant

UAV Visual Assessment

- Agricultural fields
  - Remote sensing
    - Common sensor is Normalized Difference Vegetative Index (NDVI) and Thermal
  - A lot of information can be gained from a picture/video (visible light)
  - Directed crop inspection based on initial UAV imagery

AgrAbility of Wisconsin Testing

WEARABLE PLANT SENSORS

ENGINEERS MAKE WEARABLE SENSORS FOR PLANTS, ENABLING MEASUREMENTS OF WATER USE IN CROPS.

By Kacey Birchmier
1/5/2018

Plant scientists are now able to measure the time it takes for corn plants to move water from their roots, to their lower leaves, and then to their upper leaves.

Patrick Schnable, Iowa State University plant scientist, says, this new, low-cost, easily produced, graphene-based, sensors-on-tape can be attached to plants and provide new kinds of data to researchers and farmers.

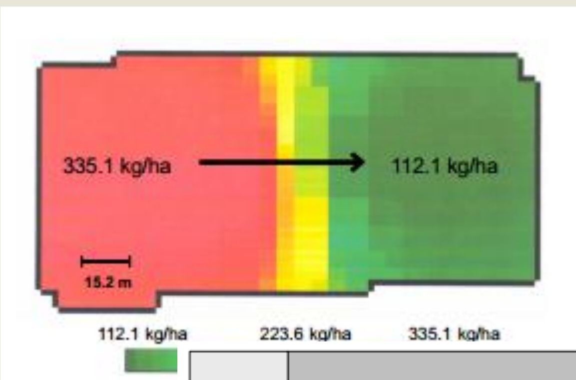
Liang Dong

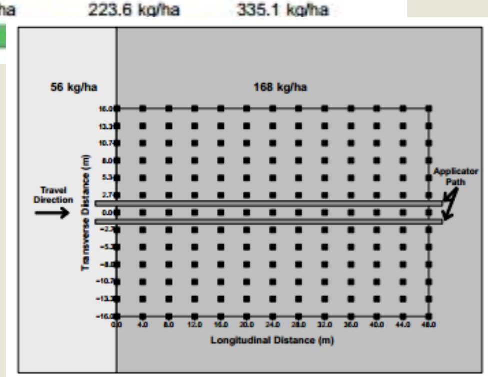
Current Precision Ag. Tech.

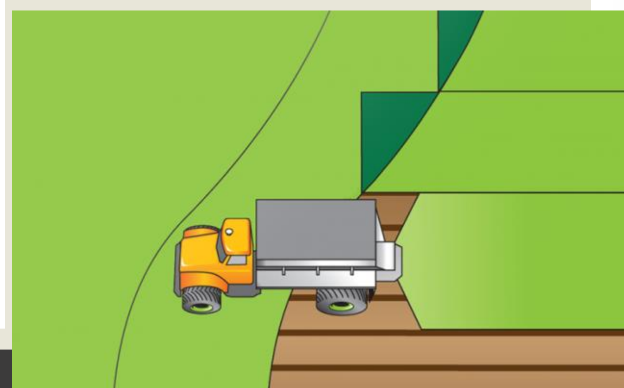
- General thought is for in-field management of inputs.
- What if we thought about it in terms of:
  - Loads hauled?
  - Bags of seed handled?
  - Gallons of spray loaded/applied?
- Savings on inputs lends itself to being an assistive technology.
  - Not to mention economic and environmental benefits.

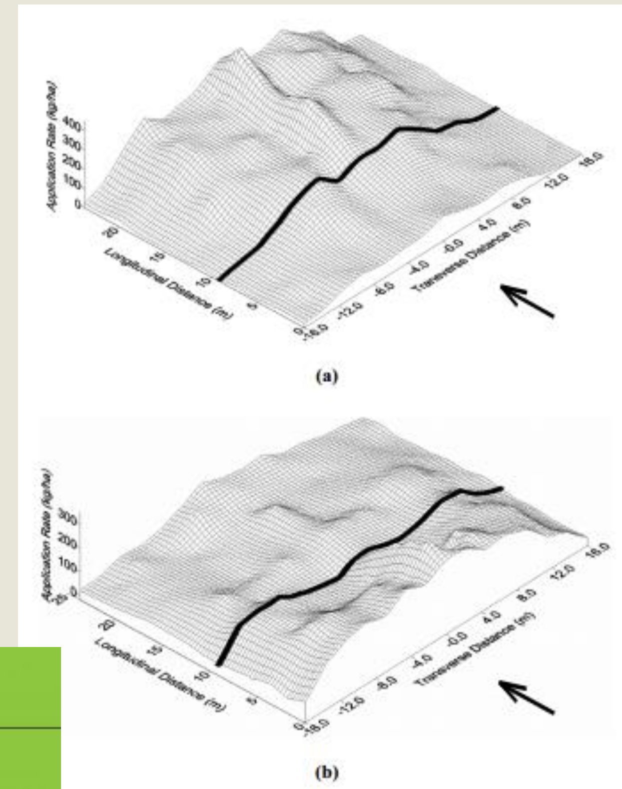
Example 1 – Variable Rate Application

- Spinner/Spreader Control
  - On/off capabilities
  - Variable rate control









Example 1 – Lime Application

- Dunn County Field Lime Application
  - 1 ac grid soil sampling @ 120 ac
  - 2 ton/ac applied in spring @ $26/ton = $6,240
  - Soil sampling showed variation from 0 – 15 ton/ac
    - Not practical, I know…assume 5 ton/ac max
  - Aim for the middle @ 3 ton/ac additional application = $9,360 additional cost in the fall
  - Variable rate came out to be an average rate of 1.57 ton/ac with some areas getting 3 ton/ac while others received 0 ton/ac.
  - Total applied 188.33 ton costing $4,897! ($4,463 dif.)
  - Soil sampling in 2 – 3 years should show less variation in soil pH across the field.

Seeding/Planting

- Row Unit Drives
  - Hydraulic
    - Multiple row control
  - Electric
    - Individual row control

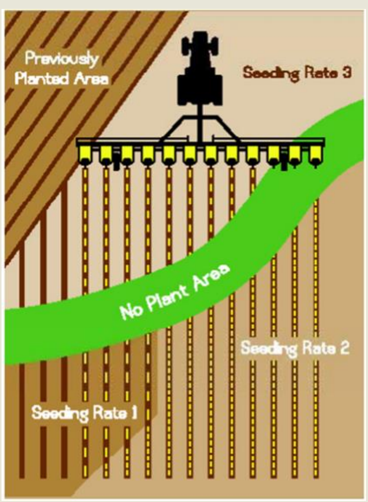


Photo courtesy of Alabama Precision Ag Online (@AL_Prec_Ag)

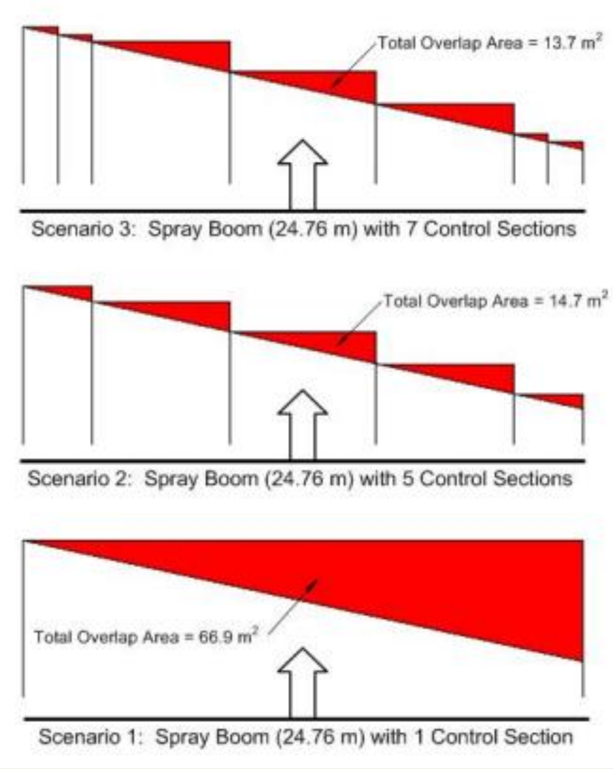
Row/Section Control

147.5 ft^2

158.2 ft^2

720.1 ft^2

80 ft boom



Economics Study (Shockley et al. 2012)

- Four fields assessed
- Taking into account cost of equipment and ownership
- Recovering skips and overlaps
- Yield and weather accounted for over a 30 year period.
- Field size and shape is a major factor!
    - Field 3 most net returns

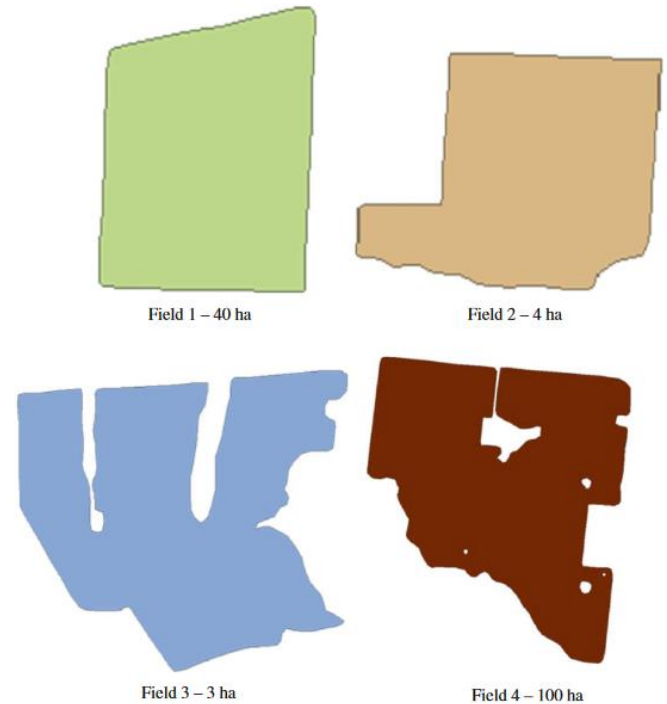


Fig. 1 Four different Kentucky field shapes representing the base overlap scenarios used to investigate the economic potential of automatic section control

Table 3 Summary of economic results for the base cases required for comparison

	No navigation	Sub-meter auto-steer on sprayer	RTK auto-steer on planter	Both[a]
Avg. net returns (US$)[b]	868 468	873 314	871 018	875 264
Coeff. of var. (%)	17.11	17.13	17.23	17.14
Min. net returns (US$)	552 026	554 807	551 502	555 748
Max. net returns (US$)	1 152 022	1 158 257	1 156 660	1 160 906
Avg. annual costs (US$)[c]	508 148	503 903	506 474	496 349

[a] Includes operating with both sub-meter auto-steer on the sprayer and RTK auto-steer on the planter

[b] Net returns were average across 30 years give simulated crop production based on historical weather

[c] Average annual cost includes total input costs of production and ownership cost of the respective auto-steer navigation when applicable

Example 2 – Row Shut-Off

- Theoretical 12 row corn planter @ 30 in. row spacing
- Perfectly square 1 ac field (209 x 209 ft) =
~7 passes with the planter.
- Plant into the first end-row every time (30 in over planting on each end-row).
- How much do we over plant?

Example 2 – Row Shut-off

- 1044 ft^2 overplanted (0.024 ac)
- @ 30,000 seeds/ac = 720 seeds wasted
- Assuming 80,000 seeds/50 lb bag ~= 2.4% of seed wasted
- Assuming $230/bag Round-Up ready = $5.52/ac cost (Seed Alone!)

What happens to yield when we double the plant population?

Guidance (Auto-Steer)

- Farmers must have straight rows!
  - That’s why I was never allowed to plant corn!
- Over 80 acers a 2 ft overlap on a 20 ft implement results in about 5 extra passes at the end of the field.
  - Saves Fuel
- Other benefits:
  - Fatigue reduction
  - Implement observation
  - Contour farming made easy!

- Robotics

- Robotics are much further along in the dairy industry…
  - Not just milking machines!

Science Fiction Thinking

- This is a bit “out there”, but stick with me!

Internet of Things (Ag.)

- Internet of Things
  - Everything is connected
  - Examples for Ag?
  - Security?

Big Data Analytics

- Assistive Technology?
- Simple Data Example
  - Collect 10 years' worth of yield data on a 100 ac. field.
  - Collect 10 years' worth of soil sample data on the same 100 ac field.
  - Equal inputs every year (unrealistic, but stick with me)
- Two types of variation
  - Temporal (over time)
  - Spatial (within the field)
- What do we gain?
- What happens if I pool the entire state/country/world?

Big Data Analytics

- Translate any type of data analysis into:
  - Steps/trips saved
  - Inputs used or not used
  - Help called (maybe foaling/calving situation)
- Any gains in efficiency can be considered assistive technology.

Why use Precision Ag as Assistive Tech?

- Reduction in injury and secondary injuries
  - Less time spent on/ in machinery in the fields
    - Reduce back pain and joint stiffness
    - Reduced fatigue, less potential for accidents with machinery
- Less getting on and off machinery
  - Reduce joint strain
- Reduce the amount of time moving through crops and animal pastures to check for health, water, etc.

Additional Benefits

- Potential input savings = $$$
  - Also saves wear and tear on farmers
- Efficiency gains = $$$
  - Optimizes effort to maintain business viability and well being
- I’m no economist:
  - Cost/benefit or ROI must be considered, but from an assistive tech. standpoint justification may be easier.

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