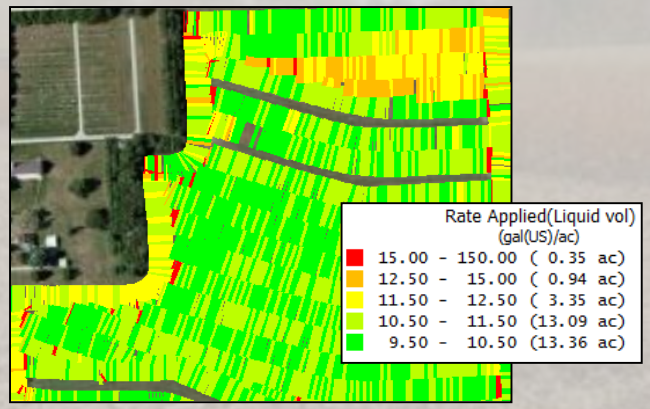
Precision Pesticide Application Technology

2015 USDA NRCS Training Webinar
May 6th, 2015



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N EXTENSION

Current Issues with Pesticide Application

- Operators must be concerned with:
  - Spray drift
  - Herbicide resistance development in weeds
  - Crop damage
  - Timeliness
- Methods to address these issues may include:
  - Drift reduction technologies
  - Integrated pest management
  - Advanced application equipment technologies

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Presentation Overview

- Application improvement with Automatic Section Control Technology
- Application data logging
- Current operator feedback
- Case study into higher resolution data mapping
- Advanced Technologies:
  - Boom Height Control
  - PWM
  - Direct Injection
  - Weed Sensing

EXTENSION

Current Rate Control Systems

- The vast majority of sprayers in the field today utilize technology that was developed decades ago…

GPS

Field Computer

Spray Rate Controller

Control Valve

Flow

Flowmeter

Flow

EXTENSION

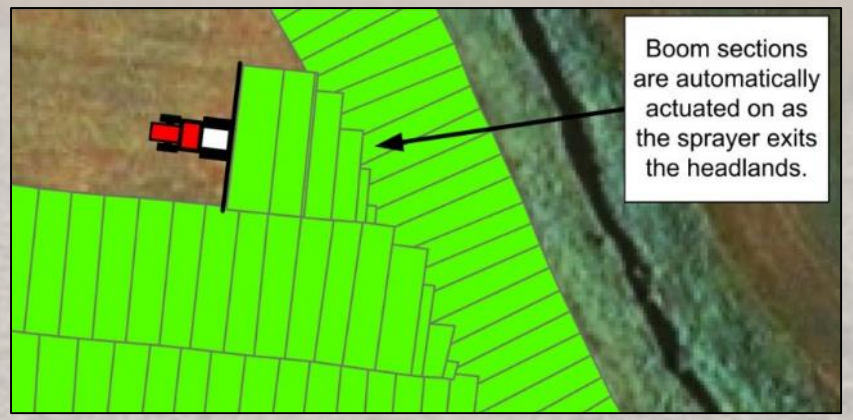
Control Hardware

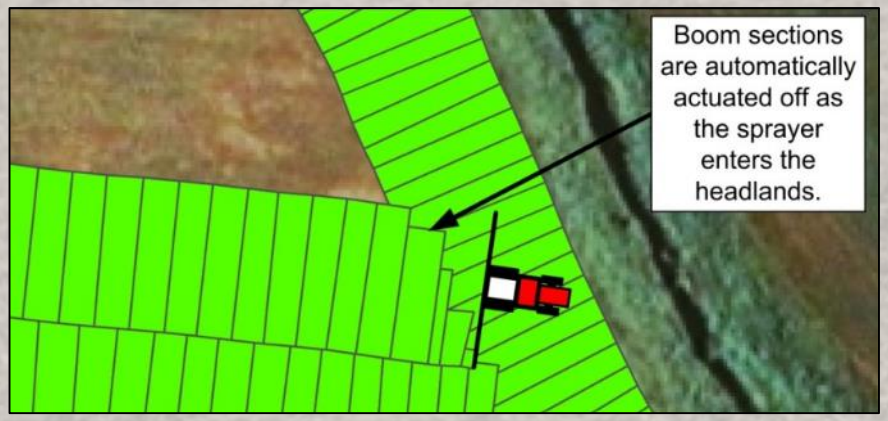
- Proportional motorized control valves
  - Electric motors geared for higher torque
  - Two and three way valve functions
  - Fluid types/ operating pressures determine valve body materials
  - Hydraulic valves used to control motor (pump) speed

EXTENSION

Precision Ag Technologies

- Automatic Section Control (ASC) is a technology that has reduced pesticide over-application
- Sprayed areas are constantly monitored using GPS and boom sections are turned on and off to compensate
- ASC is an easy addition to most sprayers and takes little time to realize benefits
- Example coverage maps:





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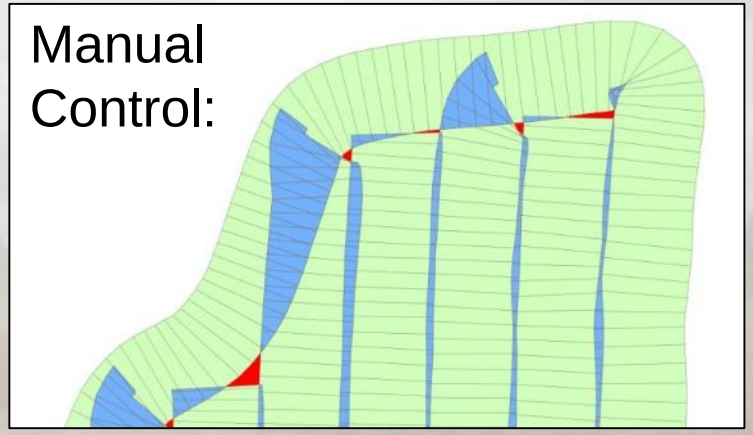
Precision Ag Technologies

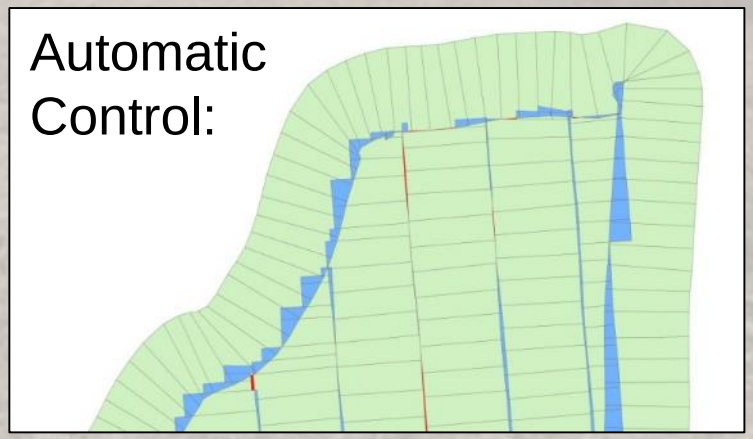
- Data logging features allow us to diagnose issues after application
- Based on previous research, ASC systems can have a significant impact on product applied
- Boom setup and field shape/size can have an impact on payback

Sprayer control system	Boom width (ft)	Over-application (% of field area)
Manual-5 section	80	14.5
ASC-7 section	80	5.7
ASC-9 section	80	4.7
ASC-30 section	100	2.3

Manual Control:



Automatic Control:



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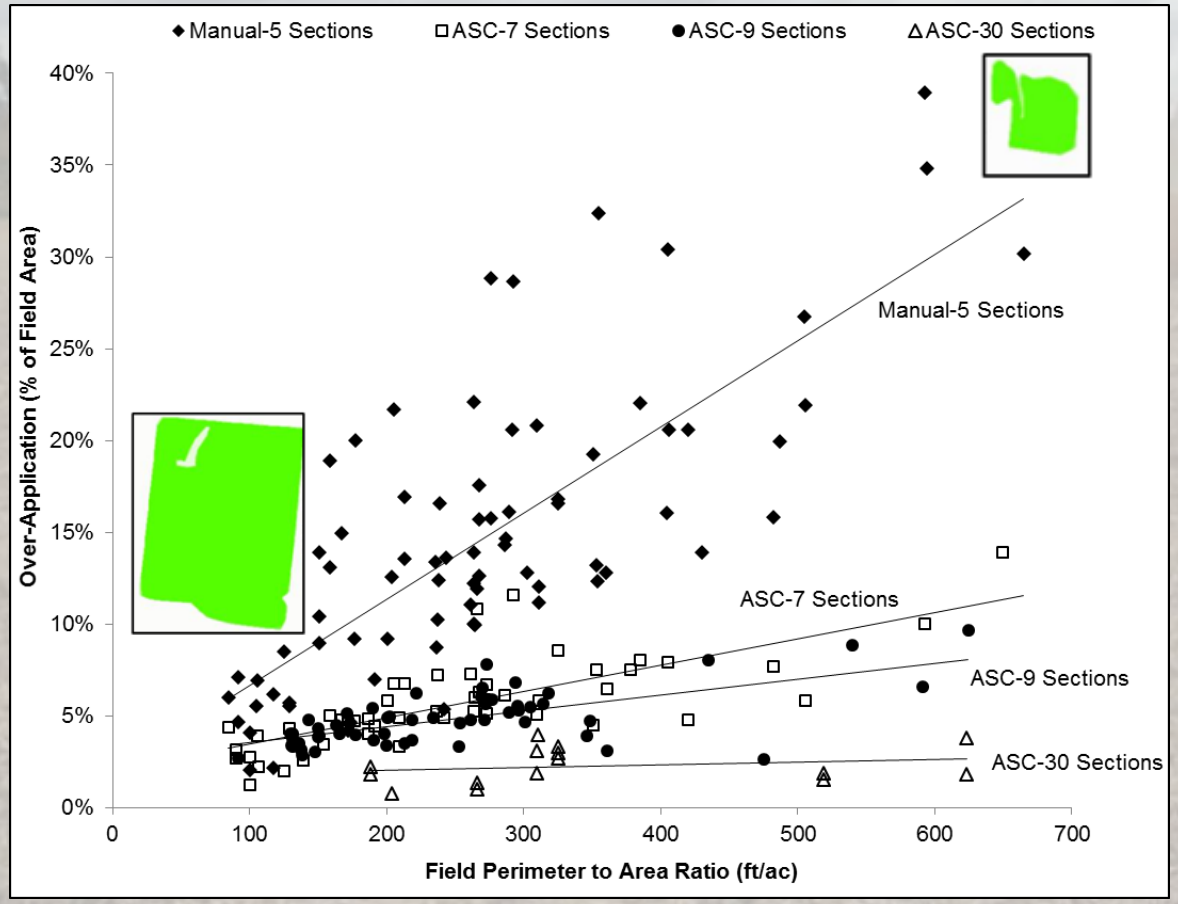
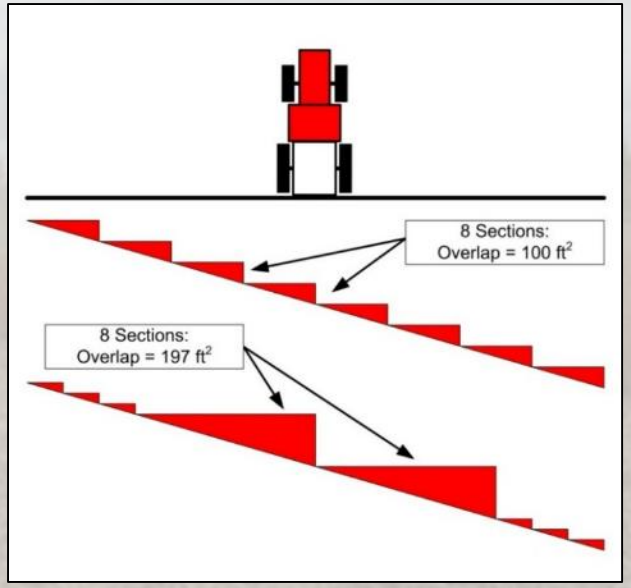
Precision Ag Technologies

- Field shape and size can greatly affect overlap reductions as can boom setup:





Boom section divisions can affect overlap reduction

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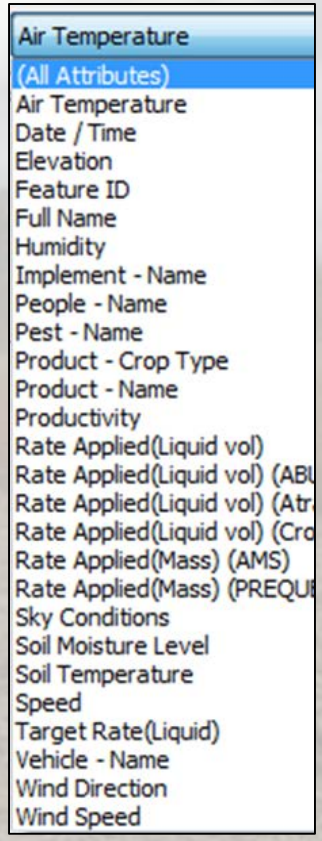
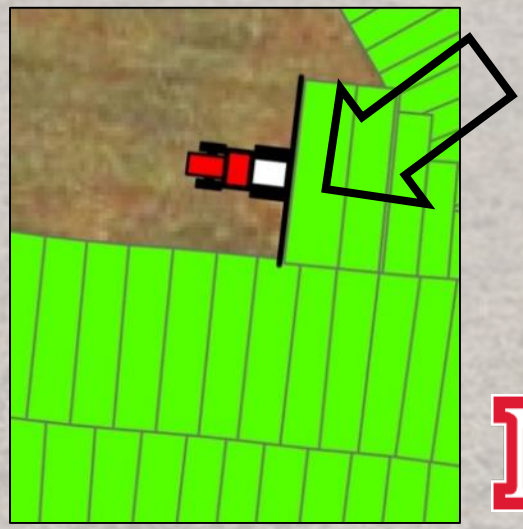
Application Data Logging Features

- As with most Precision Ag technologies, information is logged from different sources as a data layer
- Along with GPS coordinates, each coverage polygon in that layer has many attributes
- Farm Management Information Software (FMIS) provide access to this information (if available)
- Product Name
- Target Rate
- Rate Applied





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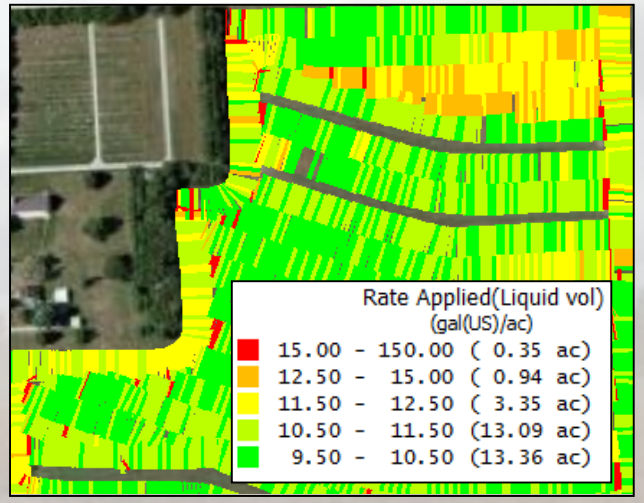
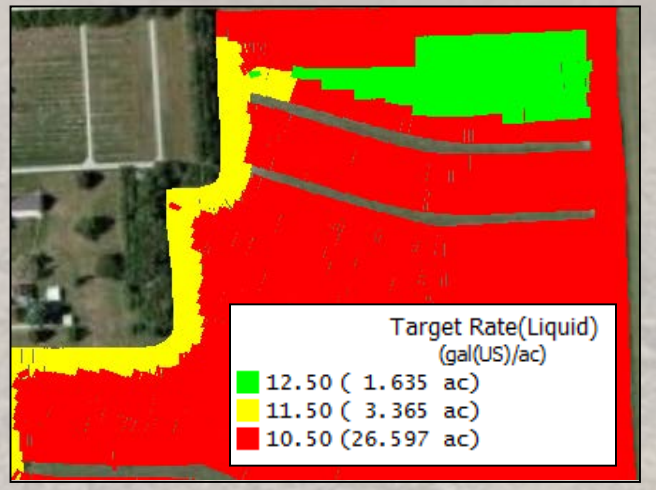
Application Data Logging Features

- We can now track our prescriptions for different products seed, chemical, fertilizer (with some degree of accuracy)
- Comparisons with as-applied data will allow us to determine where improvements can be made in our operations
- Why did Rate Applied vary to such a great extent?
- The target rate was modified





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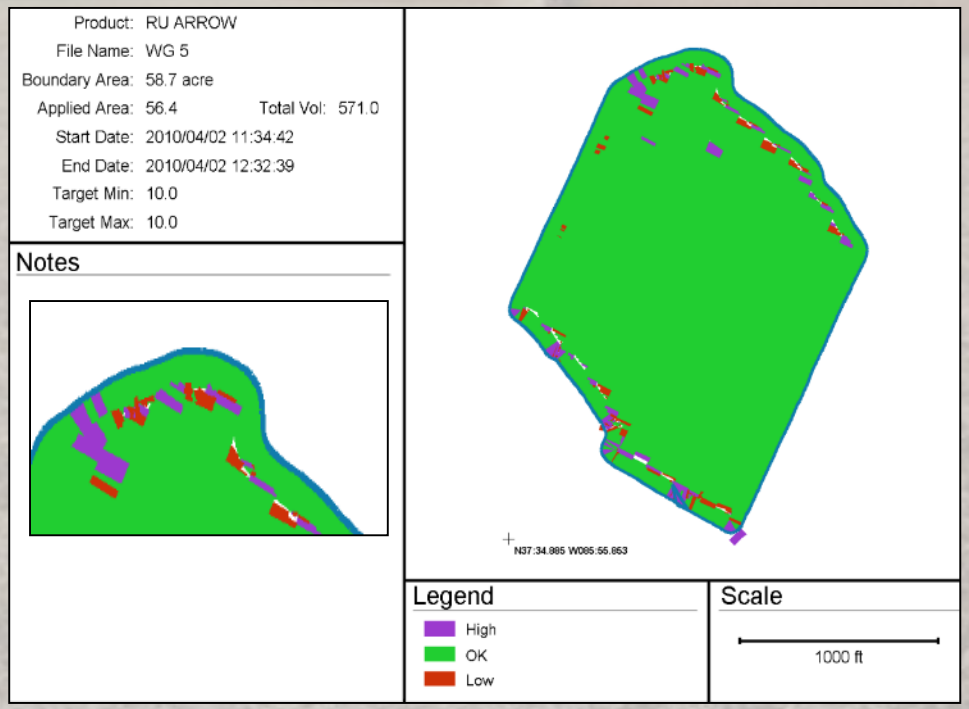
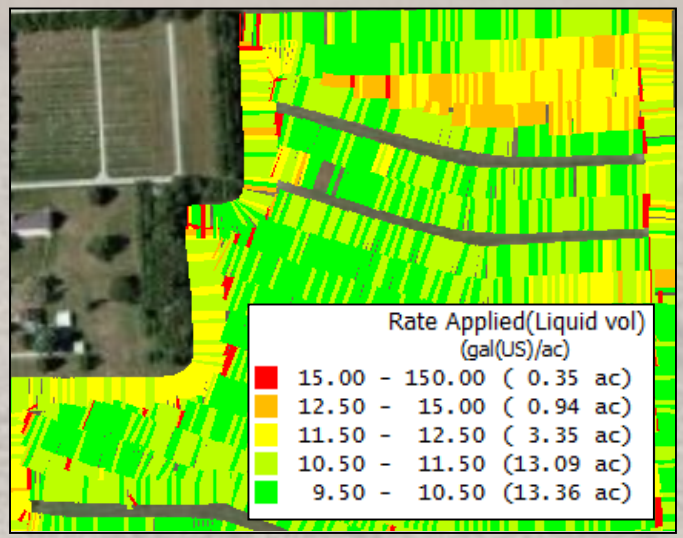
Opportunities for Operator Improvement

- We first need to ask an important question:
- What feedback is provided to operators regarding their effectiveness?
- Is this enough information to really be effective?
- In many cases, it comes down to what the real goal was





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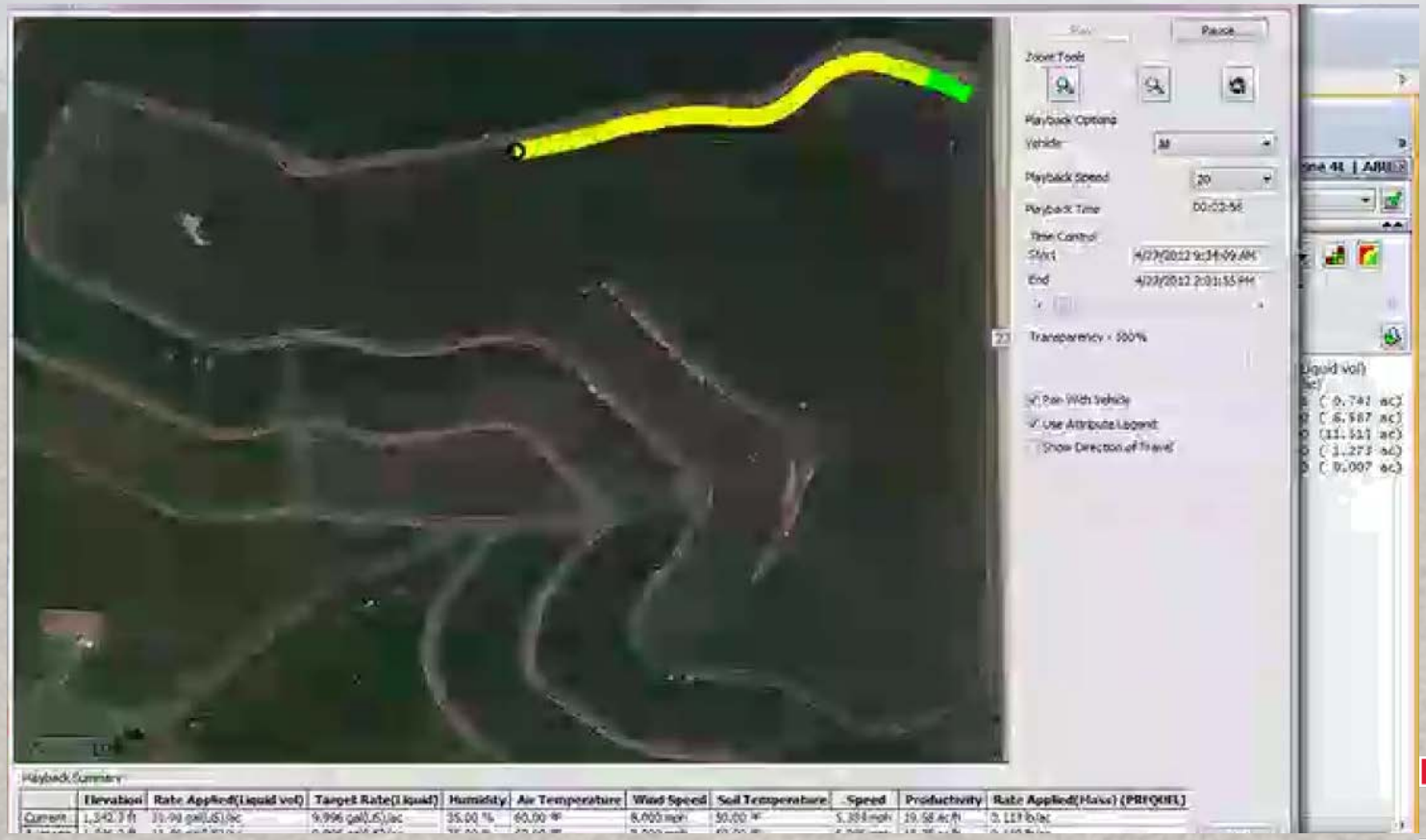
Opportunities for Operator Improvement

- Dataset playback is an FMIS feature that allows us to review what occurred during field application



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Case Study: Increasing Map Resolution?

- As boom widths increase, the question becomes how accurate are the traditional maps we have access to?
- All fields are not created equal…what effect does turning really have on application accuracy?
- Sprayer GPS tracking
- Nozzle pressure sensing
- Boom section status monitoring

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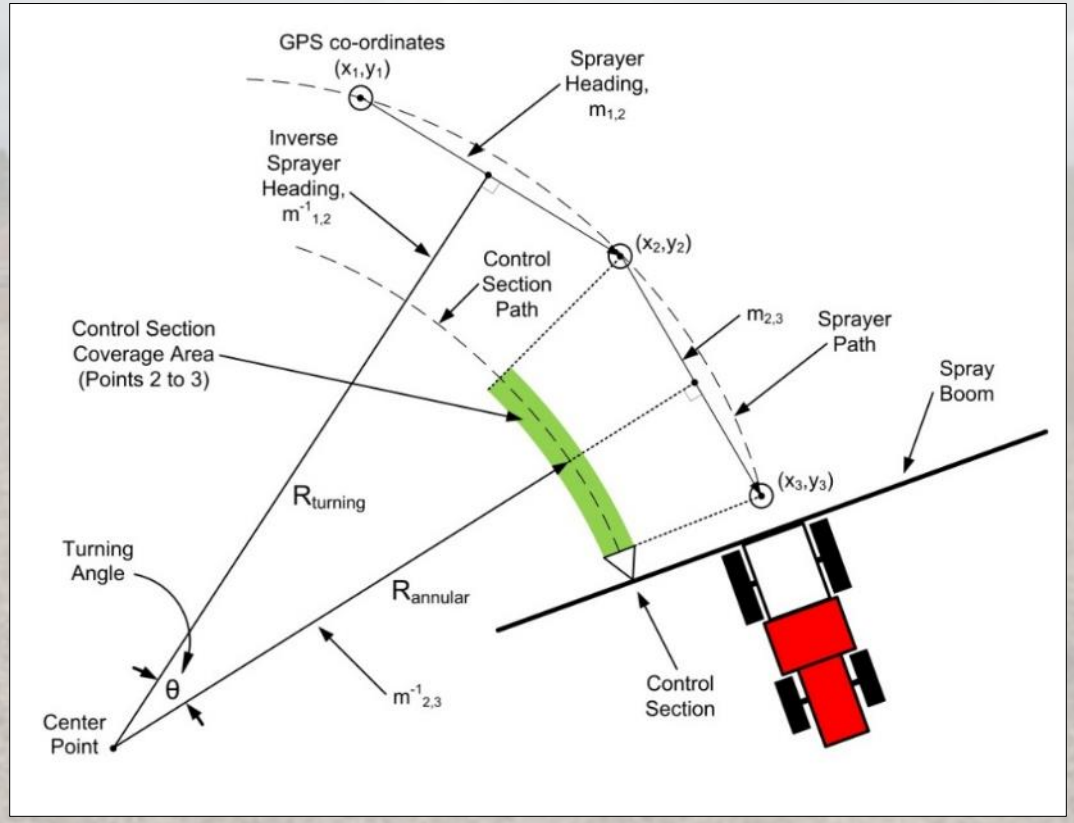
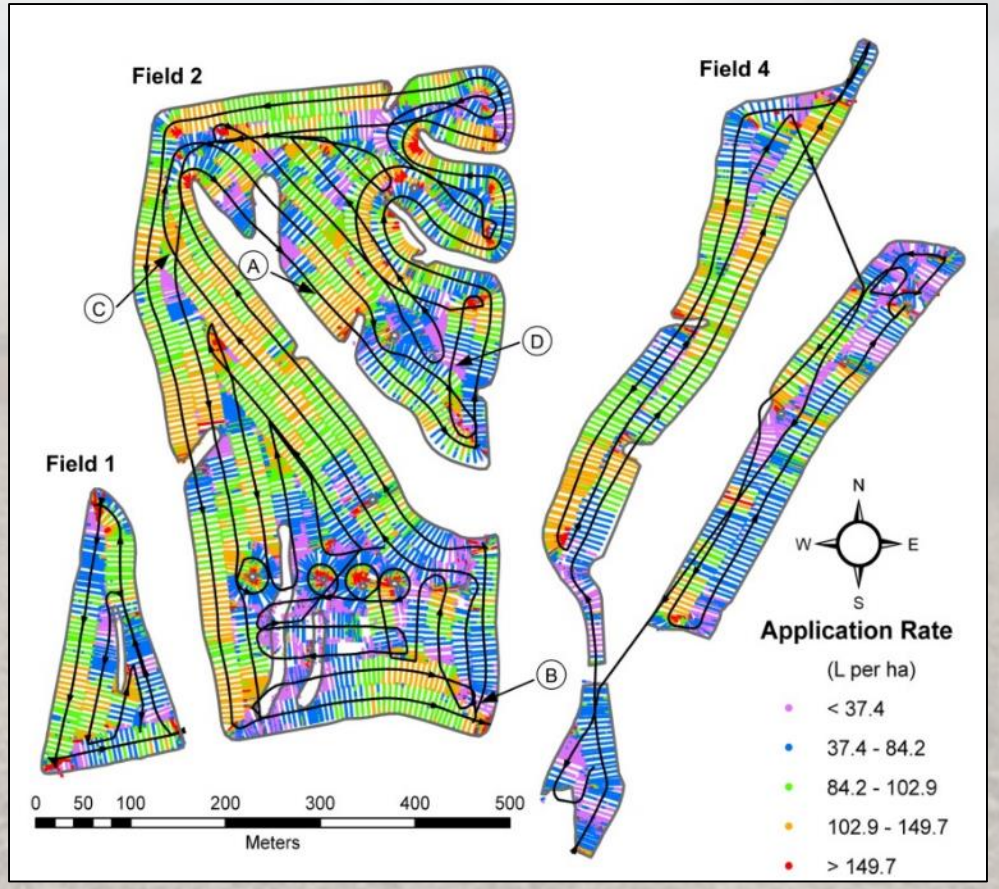
Case Study: Increasing Map Resolution?

- The data were merged with a sub-boom coverage area modeling tool:
- Coverage areas estimated for individual control sections
- Nozzle flow rates estimated from nozzle pressure
- Applications rates were then estimated for three fields



Case Study: Increasing Map Resolution?

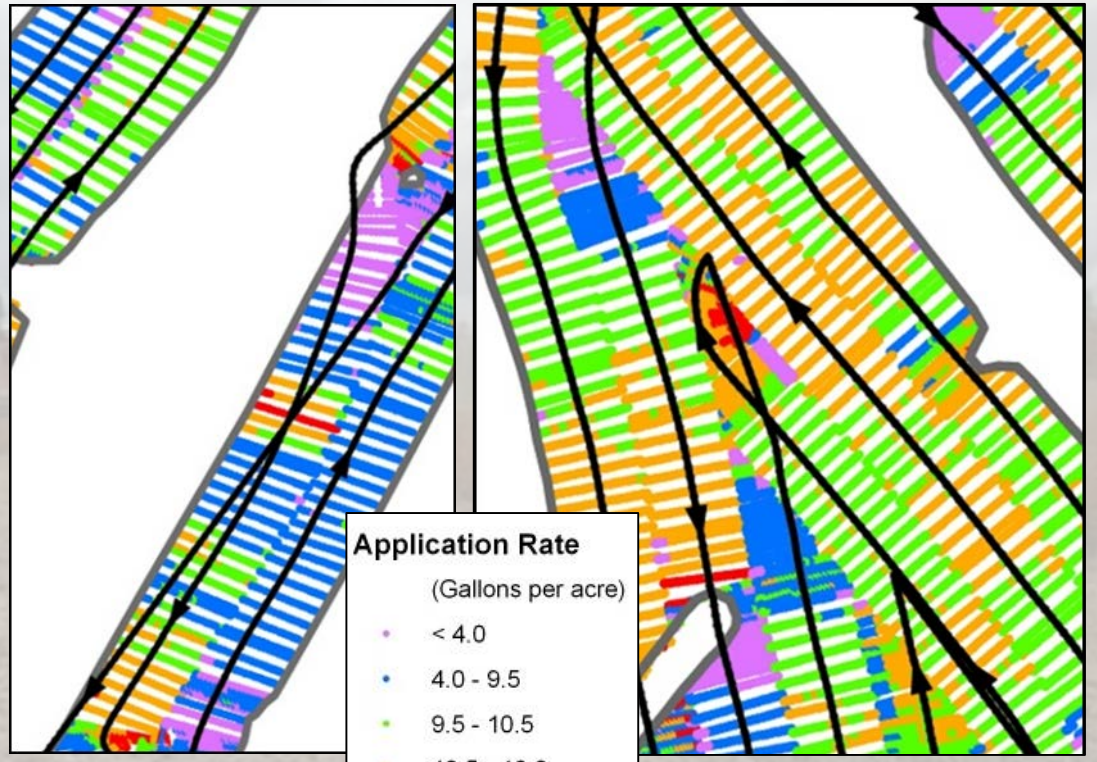
- As-applied estimated application rate maps provided a more revealing look at potential application errors:
- Turning with the 100 ft boom was a major contributor in one field
- Controller response to acceleration was a problem
- System limitations for pressure and flow



EXTENSION

Case Study: Increasing Map Resolution?

- Data visualization:



	PSI	DROP SIZE	CAPACITY ONE NOZZLE IN GPM	CAPACITY ONE NOZZLE IN OZ./MIN.	GPA (20")								GALLONS PER 1000 SQ. FT.			
					4 MPH	5 MPH	6 MPH	8 MPH	10 MPH	12 MPH	15 MPH	20 MPH	2 MPH	3 MPH	4 MPH	5 MPH
TT11005 (50)	15	XC	0.31	40	23	18.4	15.3	11.	9.2	7.7	6.1	4.6	1.1	0.70	0.53	0.42
	20	VC	0.35	45	26	21	17.3	13.	10.4	8.7	6.9	5.2	1.2	0.79	0.60	0.48
	30	VC	0.43	55	32	26	21	16.	12.8	10.7	8.5	6.4	1.5	0.97	0.73	0.58
	40	C	0.50	64	37	30	25	18.6	14.9	12.4	9.9	7.4	1.7	1.1	0.85	0.68
	50	C	0.56	72	42	33	28	21	16.6	13.9	11.1	8.3	1.9	1.3	0.95	0.76
	60	C	0.61	78	45	36	30	23	18.1	15.1	12.1	9.1	2.1	1.4	1.0	0.83
	75	C	0.68	87	50	40	34	25	20	16.8	13.4	10.1	2.3	1.5	1.2	0.92
	90	M	0.75	96	56	45	37	28	22	18.6	14.9	11.1	2.6	1.7	1.3	1.0

20 psi

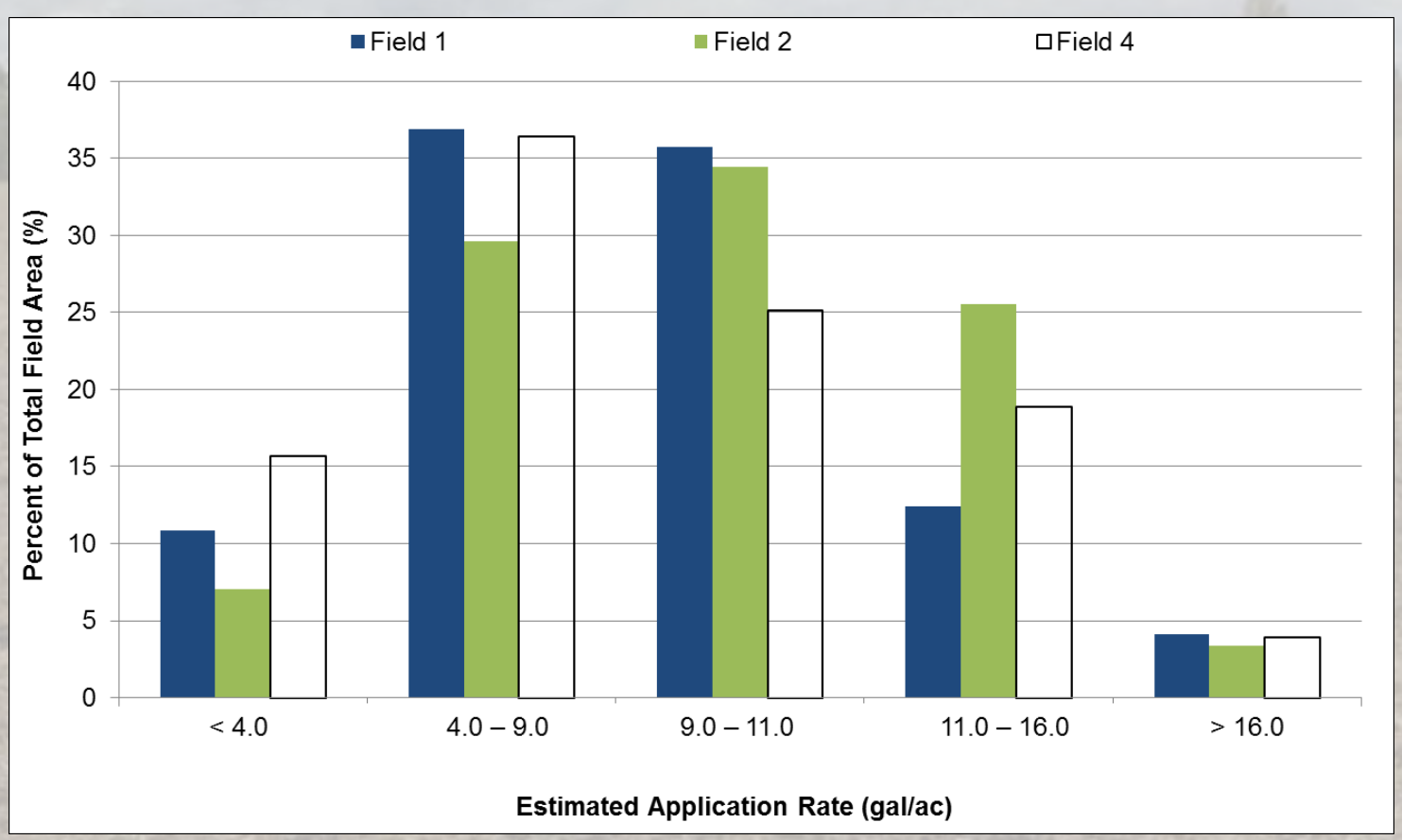
40 psi

75 psi

To increase nozzle flow rates 2x, boom pressure must increase 4x!!!

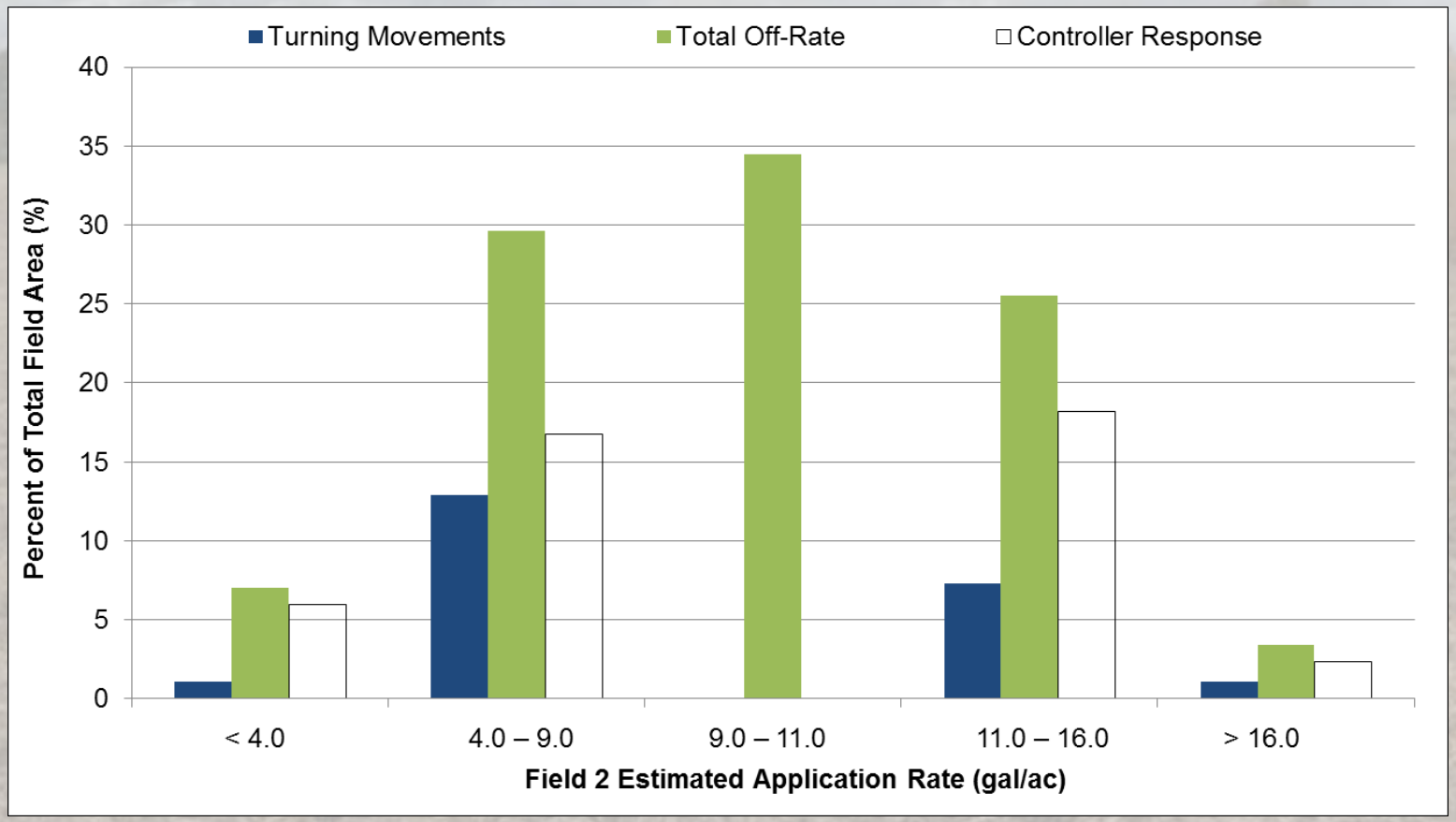
Case Study: Increasing Map Resolution?

- An post-analysis showed very poor application efficacy across all three fields
- Target rate +/- 10% was achieved up to 35% of the time:



How did different factors affect accuracy?

- For the larger Field (No. 2), turning did contribute to overall errors, but controller response to operator demands may have been a bigger issue:



Automatic Boom Height Control

- Maintaining proper boom-to-target height is critical and can affect:
- Application uniformity (low clearance)
- Off-target movement of spray particles (excessive clearance)
- Mechanical and non-contact sensors are available
- Sensors control boom hydraulics to maintain height

EXTENSION

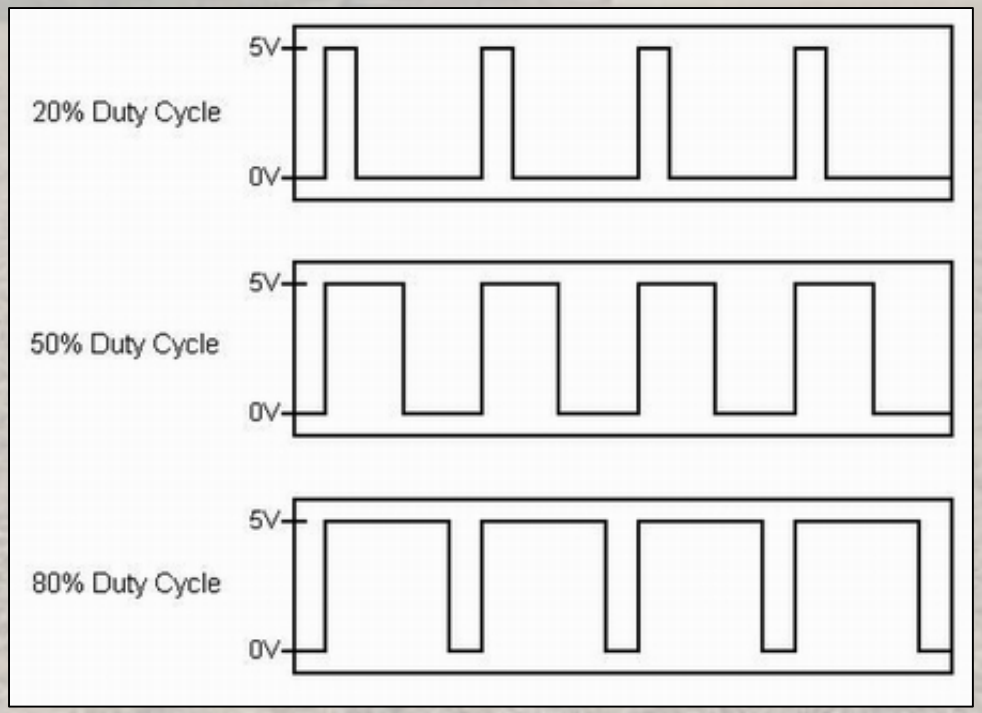
Pulse Width Modulation

- PWM systems have been commercially available for 5 to 10 years
- These systems control nozzle flow rates by quickly actuating solenoid valves at each nozzle
- A major benefit of PWM systems is the ability to compensate for turning movements while spraying
- Standard rate control is possible to compensate for speed changes

EXTENSION

Pulse Width Modulation

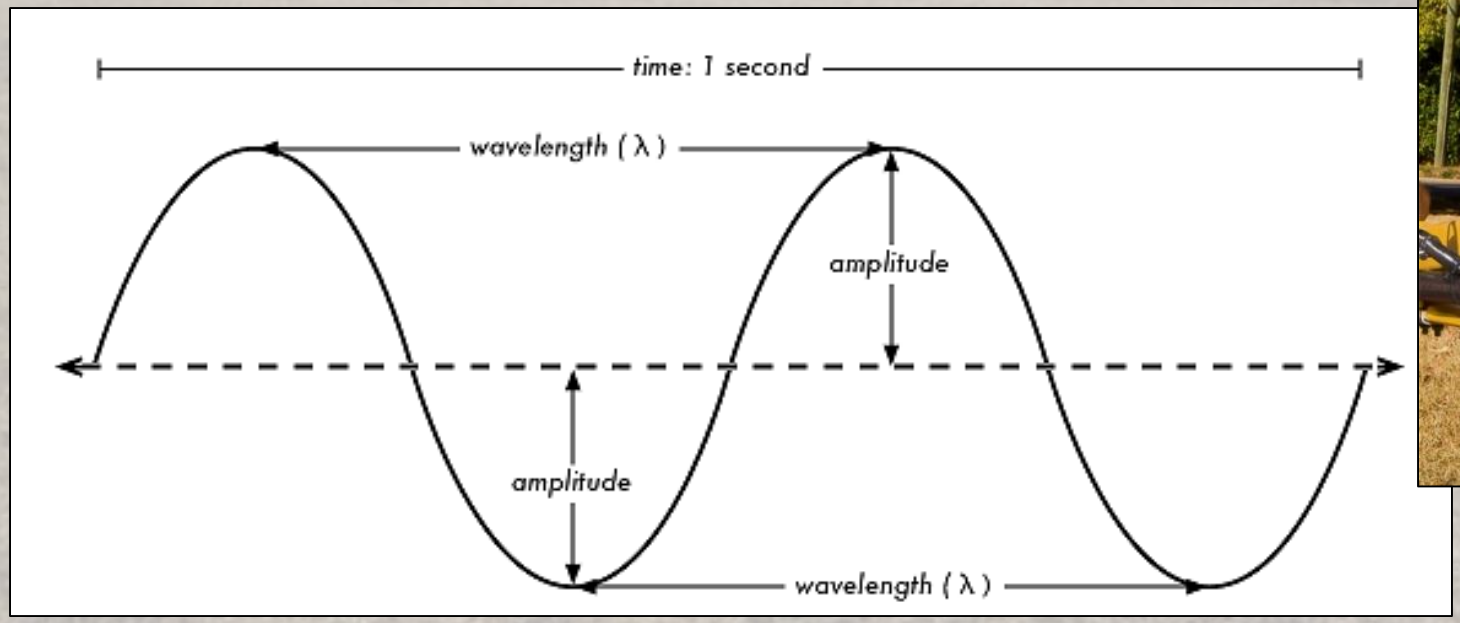
- PWM systems may also operate across a range of pressures
- Turn compensation, section control, and drift reduction are possible benefits
- % duty cycle refers to the time a valve is “on”



EXTENSION

Pulse Width Modulation

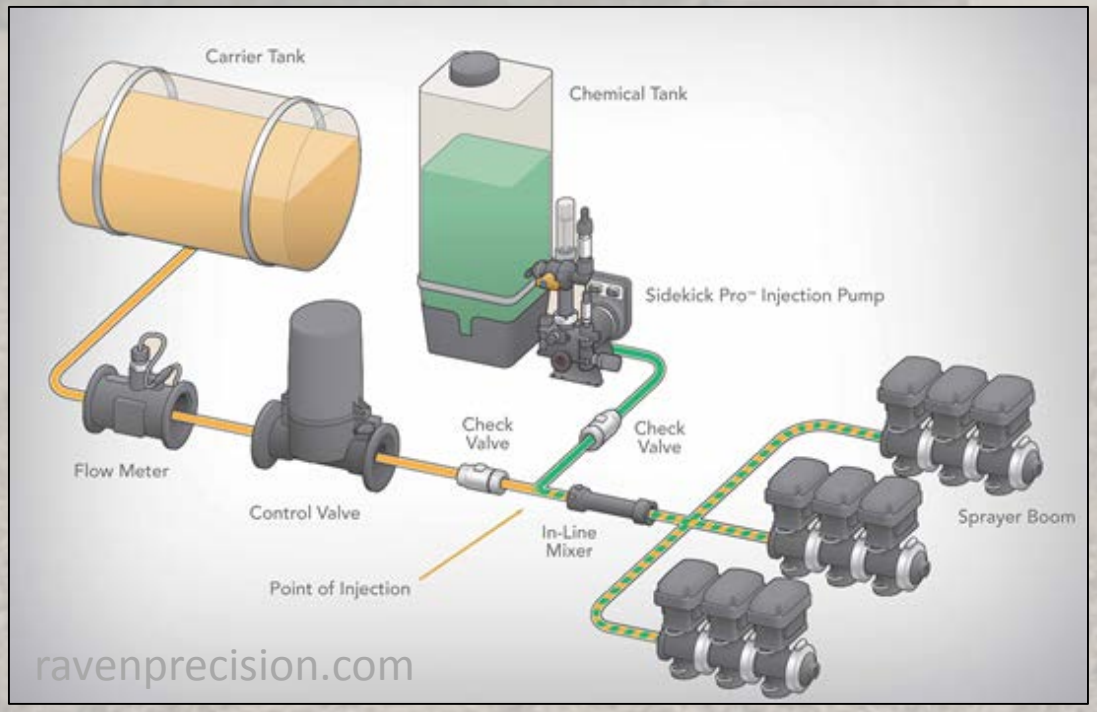
- Pulse frequency is also an important concept for PWM systems
- Imagine if a 50% duty cycle operated at a frequency of 1 pulse/sec (or 1 Hz)
- At 15 mph…the nozzle would be “off” for 11 feet!
- Thus, systems operate at higher frequencies



EXTENSION

Direct Injection Systems

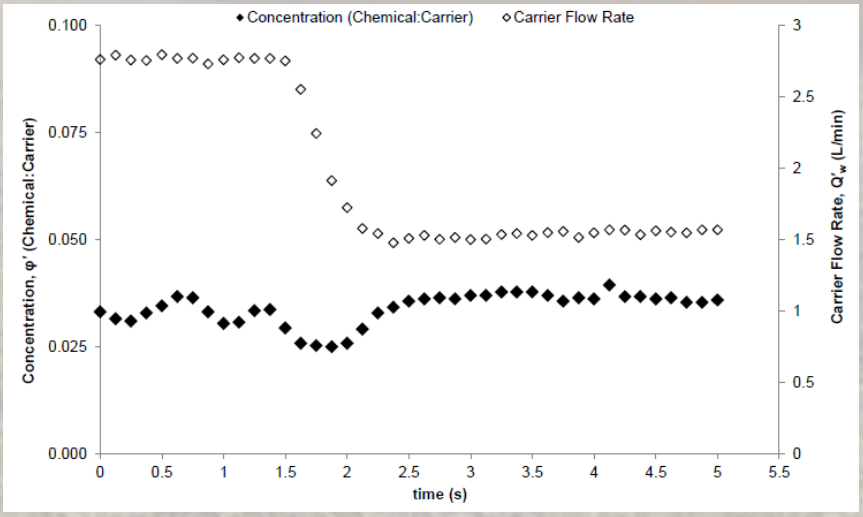
- DI systems allow for separate storage and metering of chemical into the carrier stream
- Operator exposure and cleanout procedures are improved
- Response (lag) times and mixing have been issues since they were initially developed



EXTENSION

Direct Injection Systems

- Commercial availability is limited, few options exist
- These systems (when calibrated properly) can take the errors out of improper tank mixing which is an issue today
- Recent research (Luck, Shearer, et al.) has shown the potential to improve both mixing and response times by injecting directly ahead of the nozzle



EXTENSION

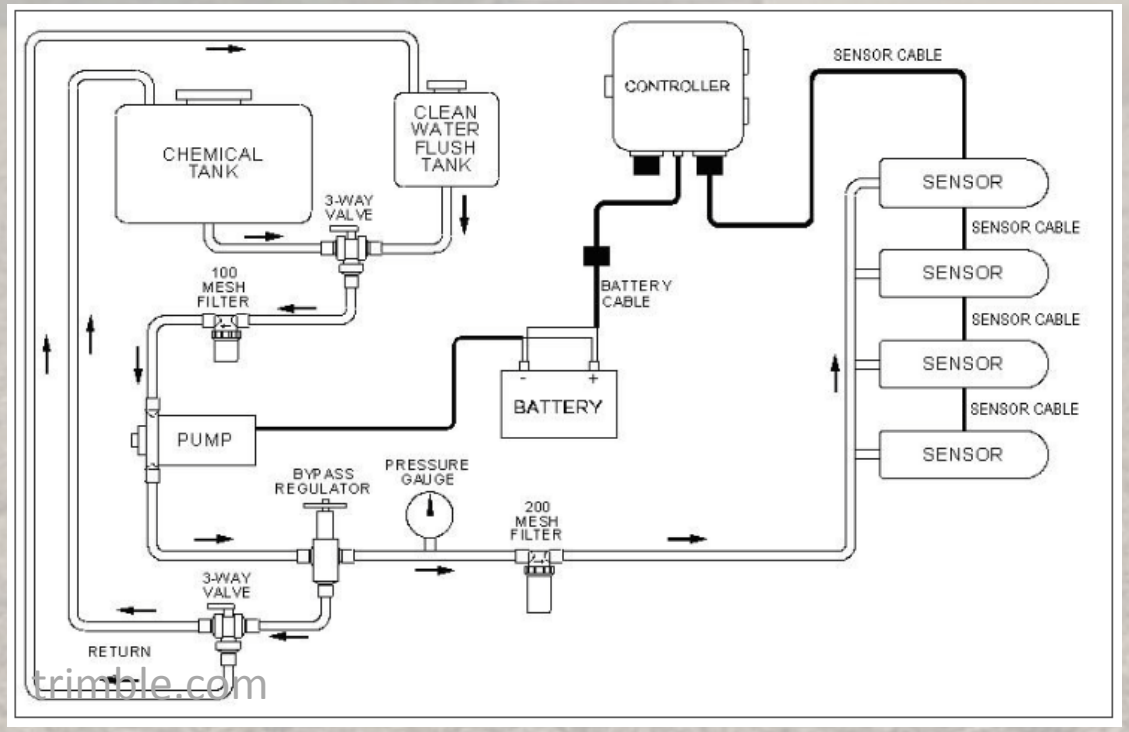
Weed Sensing Systems

- Reflectance-based systems work much like crop canopy sensors for detecting weeds
- Digital algorithms assess the presence of weeds and nozzle valves are actuated “on” or “off”
- Challenges to adoption continue to focus on Economics
- Payback depends on weed density in fields and acres in production

EXTENSION

Weed Sensing Systems

- WeedSeeker (Trimble) is one of few commercially available systems
- Nozzles control valves are integrated into the sensor body
- Remote solenoids can also be used
- System can be retrofit to existing sprayer systems



EXTENSION

Where do we go from here?

- I’ve focused on row crop production here, but…
- Innovations for specialty crop production have often advanced more quickly due to labor requirements
- Autonomous robotics may offer further developments:
  - Mechanical weeding
  - Spot spraying (UAVs?)
  - Flame application
  - Vegetable-based oil application
  - Automated chemical batching (DuPont)

EXTENSION

Where do we go from here?

- Technologies are improving at an ever-increasing pace in today's market
- Sprayer turning solutions, for example, are already being commercialized by companies
- Every technology has its limitations and that's where solid operator training and feedback is critical

Today.

Tomorrow?

EXTENSION

Where do we go from here?

- Most producers today are very thoughtful about the impact of their operations on the environment
- Off-target movement of pesticides is a primary concern, especially in areas where urbanization is moving into agricultural areas, weed resistance is another hot topic
- Technology can be costly for some and difficult to learn
- Effective training is necessary to help offset some of these issues

N EXTENSION

Thank you very much!

Please let us know if you have questions!

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