EXTENSION

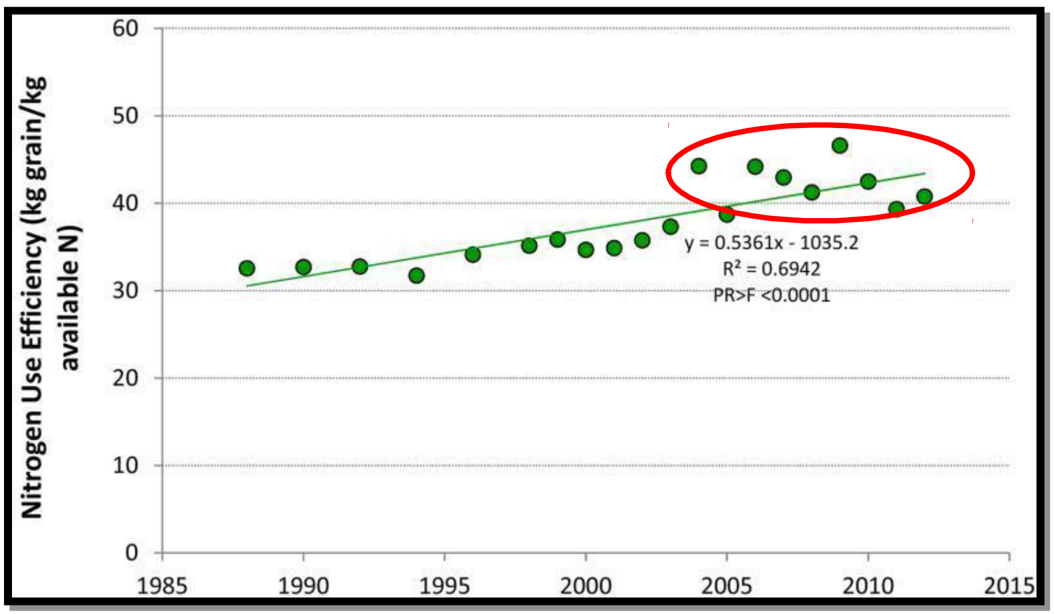
Project SENSE—On-Farm Trials to Evaluate Sensor-Based N Management

20th Annual Kansas Agricultural Technologies Conference

January 19, 2017

Background

- High groundwater nitrate is an issue in Nebraska
- NUE has not increased in the past 10 years
- Current practices may be reaching a plateau in NUE
- Sensor-based N recommendation systems are one tool with the potential to better manage spatial variability



Ferguson, R.B. 2015. Groundwater quality and nitrogen use efficiency in Nebraska's Central Platte River Valley. J. Environ. Qual. 44:449-459.

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Project SENSE Goals

Sensors for Efficient Nitrogen Use and Stewardship of the Environment

- Promote adoption of in-season N fertilization for corn
- Increase grower familiarity with the use of crop canopy sensors
- Provide data to refine current canopy sensor algorithms

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Funding Sources

Nebraska's Natural Resources Districts
www.nrdnet.org
Protecting Lives • Protecting Property • Protecting the Future

Nebraska CornBoard

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

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Project SENSE Team

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Implementing Project SENSE

- Goal of 20 on-farm trials per year over a 3-year period
  - 2015: 17 sites
  - 2016: 19 sites
- Cooperator requirements:
  - 30-inch row spacing
  - Irrigated by center pivot
  - Yield monitor in combine

Experimental Design

- Two treatments:
  - Grower’s normal N management
  - Sensor-based N application
- High-N reference (non-limiting N rate)
- Randomized complete block design
  - 6 replications
- Treatment strip width depended on grower’s equipment
  - 16, 12, and 8 rows
- Total study area: 20-30 acres

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SYSTEM INTEGRATION

Fertilizer Applicator

- Hagie DTS 10
  - Front-boom setup made sensor mounting easier
    - Sensor system can operate on multiple applicators
  - 5 boom sections allowed for multiple strip widths
  - No endorsement of any company or equipment is implied

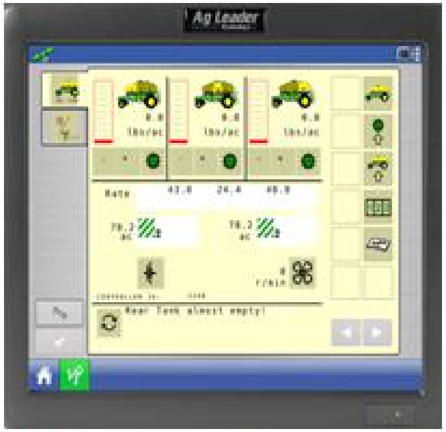
System Integration

- What is needed?
  - Ag Leader® Integra or Insight in-cab monitor
  - Sensors (2 minimum) with mounting brackets (1 per 20' of boom recommended)
  - Sensor cables (specific to # of se

desired)

Sensors may be mounted ahead of the applicator boom. Nozzle drops required for liquid N application.

Two sensors (minimum) are required for OptRx® system operation.



The Ag Leader® monitor receives OptRx® sensor data with ground speed and provides target N (lb/ac) to rate controller using a Sufficiency Index algorithm.

System Integration

- What is needed?
  - Master module (communicates sensor data to monitor)
  - Application rate module (communicates target rate from Ag Leader® monitor to rate controller
  - GPS receiver for ground speed and as-applied mapping

The master module enables connection between the OptRx® sensors and Ag Leader® in-cab monitor.

The application rate module communicates with the rate controller via serial interface.

GPS may be required for applicator ground speed, but not for sensing. GPS is necessary to generate as-applied maps.

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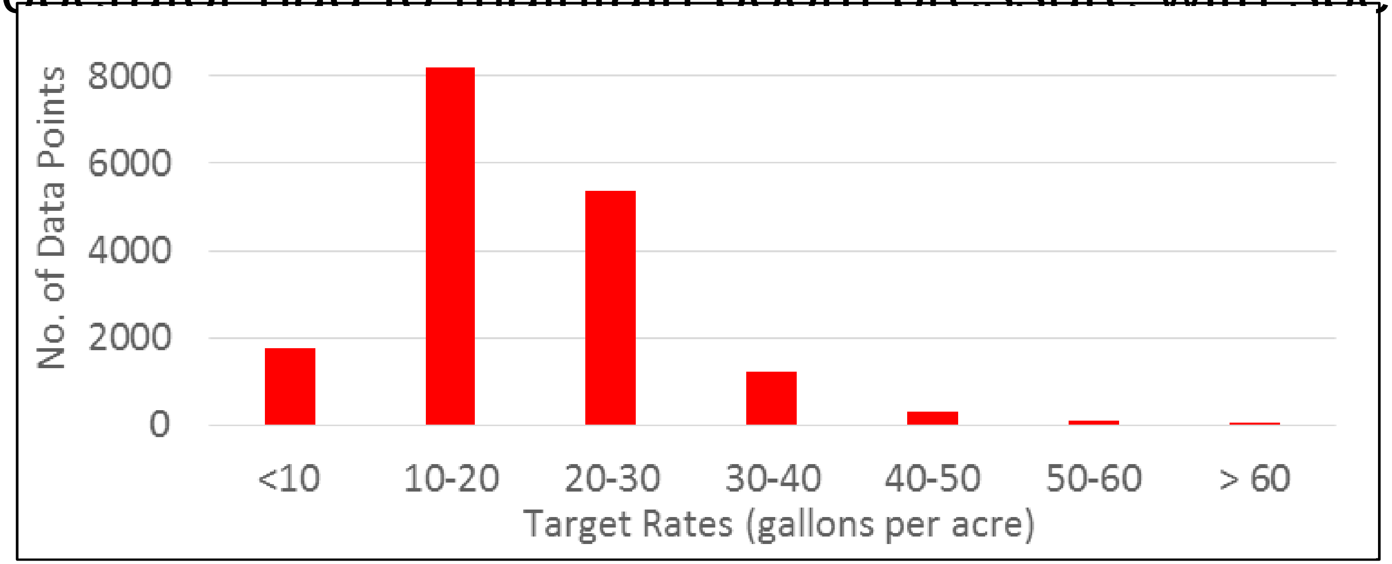
Nozzle/Control System Considerations

- Analysis of 2015 application data indicated a need for turndown ratios exceeding 4:1 (maximum to minimum)
- 95% of flow rates desired were between 8.5 GPA and 36 GPA
- Average desired rate was 20 GPA
- Fixed-orifice nozzles can only provide 2:1 turndown, operator had to maintain boom pressure with speed



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Nozzle/Control System Considerations

- More advanced nozzle/control systems will likely be required to minimize the need for speed changes
- Variable-flow nozzles can extend turndown ratios from 4:1 to 8:1 across typical operating pressures
- Pulse Width Modulation (PWM) control of nozzle solenoid valves are another new technology, extending turndown ratios greater than 6:1
- Both options will require additional expenses, but maintaining target speeds will help provide adequate field efficiency during application

The TurboDrop nozzle (left) may extend flow rates up to 4:1 while the VeriFlow nozzle (right) may extend flow rates up to 8:1 across the range of operating pressures.

The Capstan Ag PWM nozzle control system may extend flow rates over 6:1 across the range of typical operating pressures.

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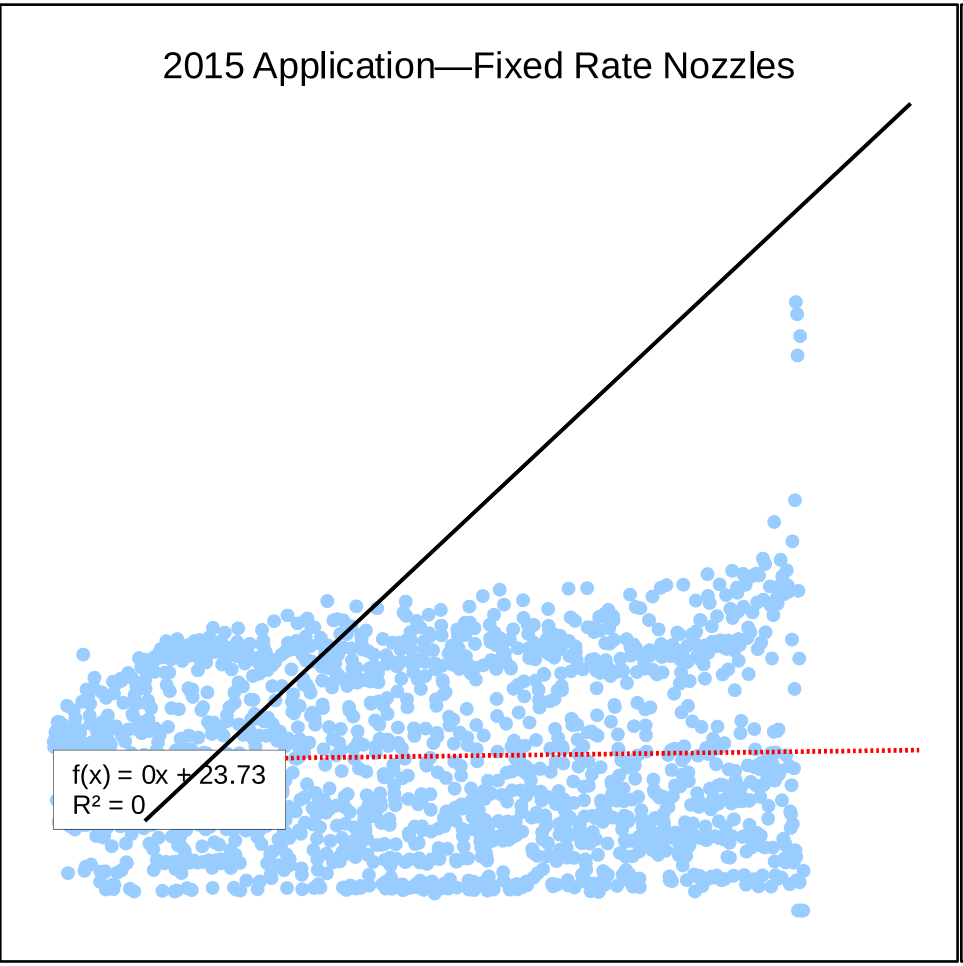
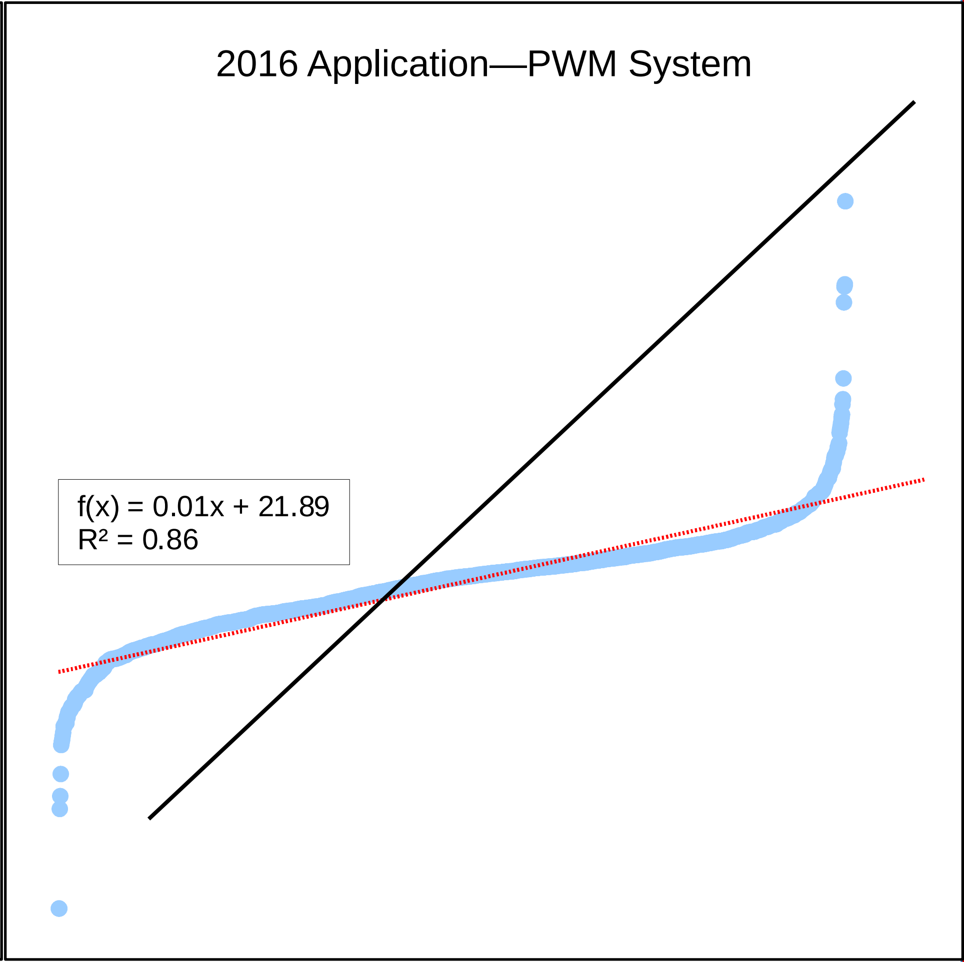
Comparing Fixed Rate vs. PWM System





16.5% of as-applied values are within +/-10% of the target rate

75.5% of as-applied values are within +/-10% of the target rate

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SYSTEM Operation

Sensor Basics

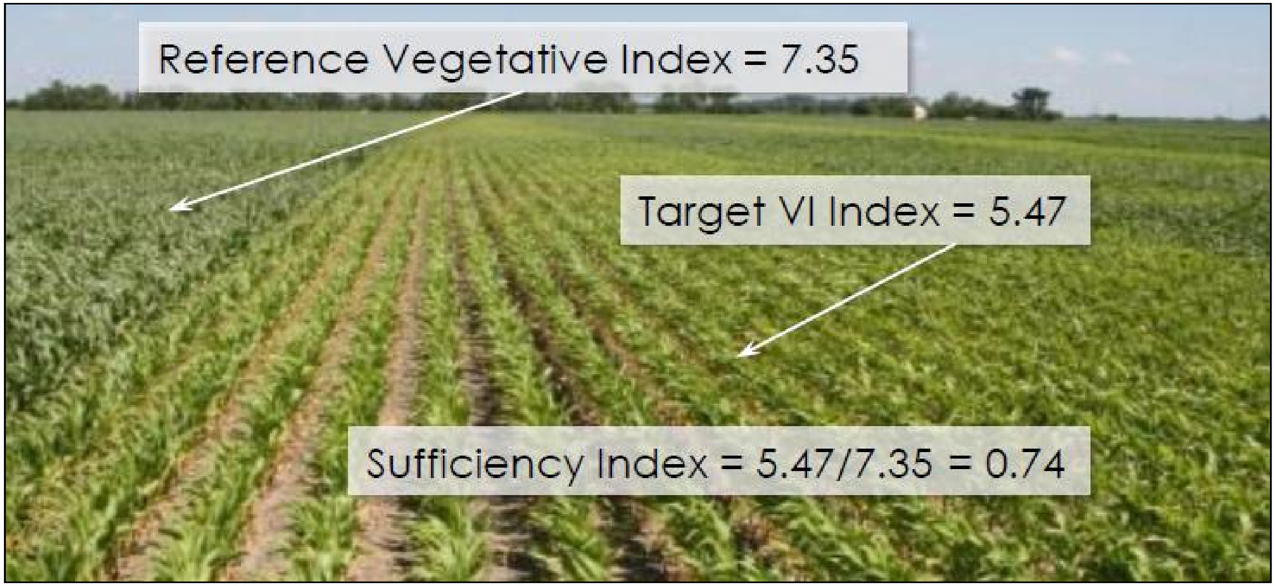
- Active crop canopy sensors emit their own light source and measure the reflectance in specific wavelengths:
  - Red, Red Edge, NIR
- Vegetation indices are then calculated:

$$NDRE = \frac{NIR \; - \; Red\,Edge}{NIR \; + \; Red\,Edge}$$

Sufficiency Index

- The Sufficiency Index (SI) relates the target corn to a reference—the NDRE value of the corn when N is not limiting:

$$SI = \frac{NDRE_{Target}}{NDRE_{Reference}}$$



Virtual Reference

- Some sensor algorithms call for a physical “N-rich strip”, where N is not limiting
- The Ag Leader® OptRx® system uses a virtual reference method:
  - The applicator is driven through the field for 5 minutes (without applying fertilizer)
  - The sensors should see a wide range of crop conditions
  - The reference value selected is the 95th percentile value of the entire distribution of NDRE values

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OptRx® Algorithm

- The Sufficiency Index is incorporated into an algorithm
- The applicator senses and applies fertilizer in real-time
- Ag Leader® monitor calls

for other inputs:

  - Optimal N Rate
  - N already applied
  - N Credits
  - Min/Max N rates

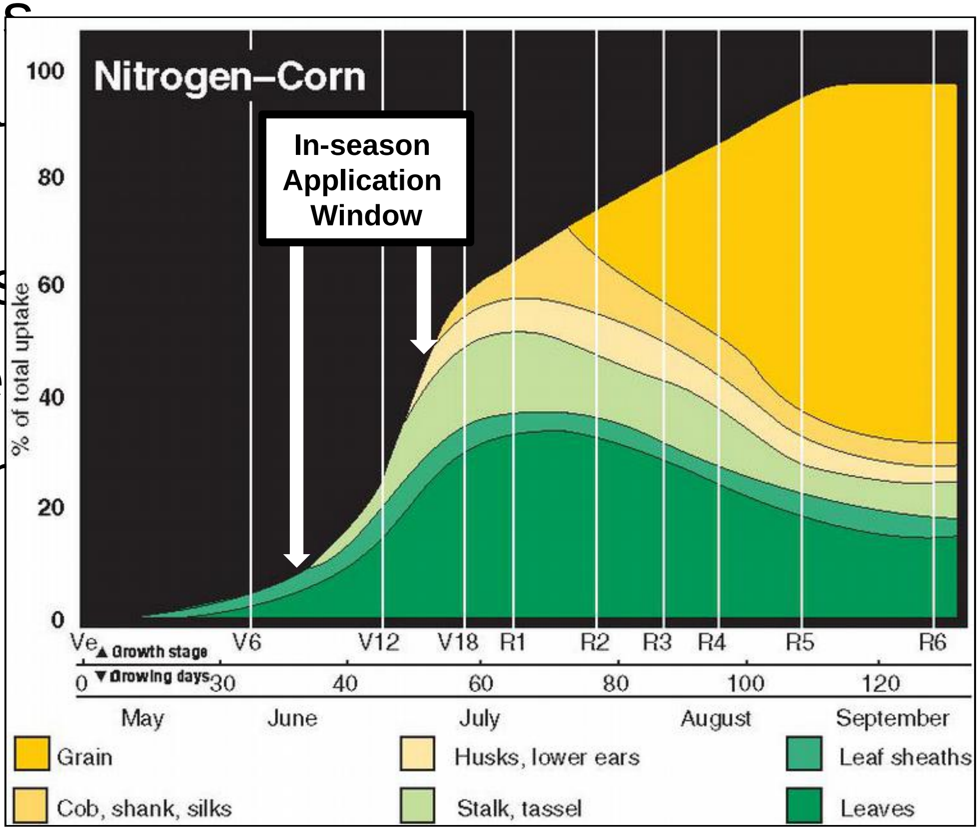
Application Timing

- In-season application is recommended between the V8 and V14 crop growth stages
  - Period of rapid N upta
- Base rate
  - Growers applied a bas

    rate of 75 lbs N/acre

    the SENSE treatmen

    strips



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300
250
bushels/acre
200
15
0

135
115
95
75
lbs of N/acre
55
35
15

0.40
0.35
NDRE
0.30
0.25

SENSE Yield
Grower Yield
N Rate

Reference
NDRE

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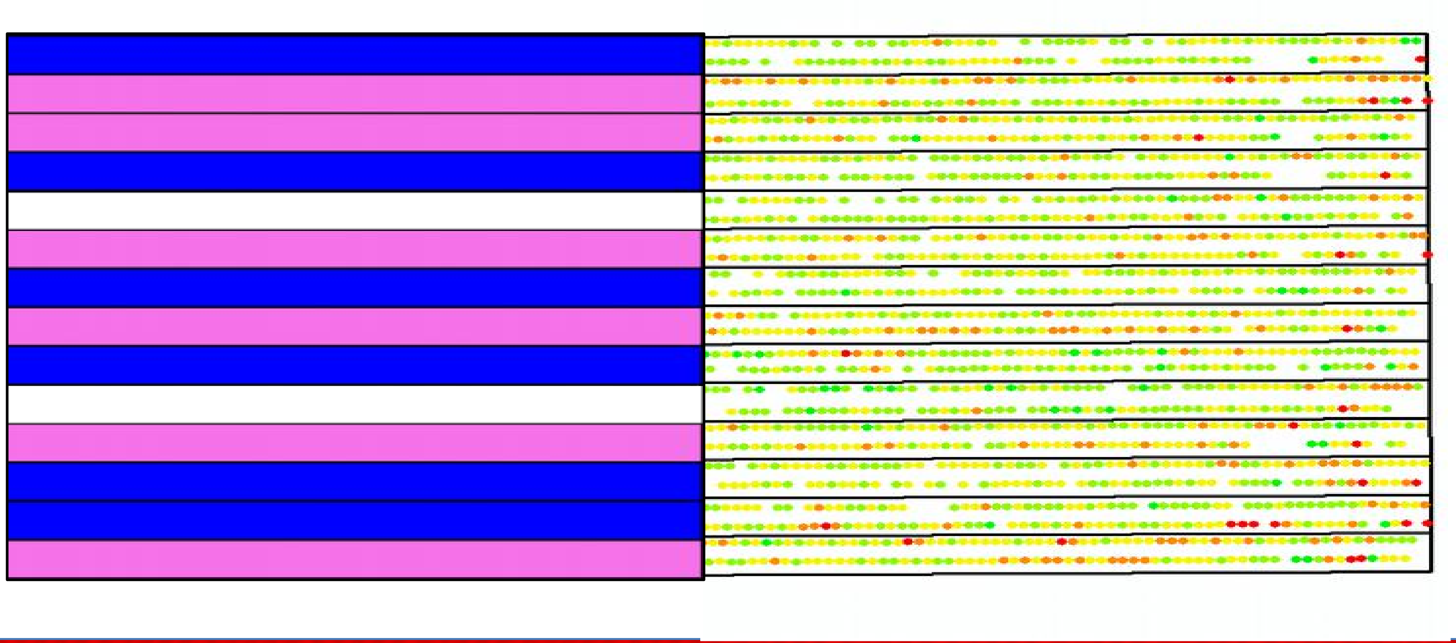
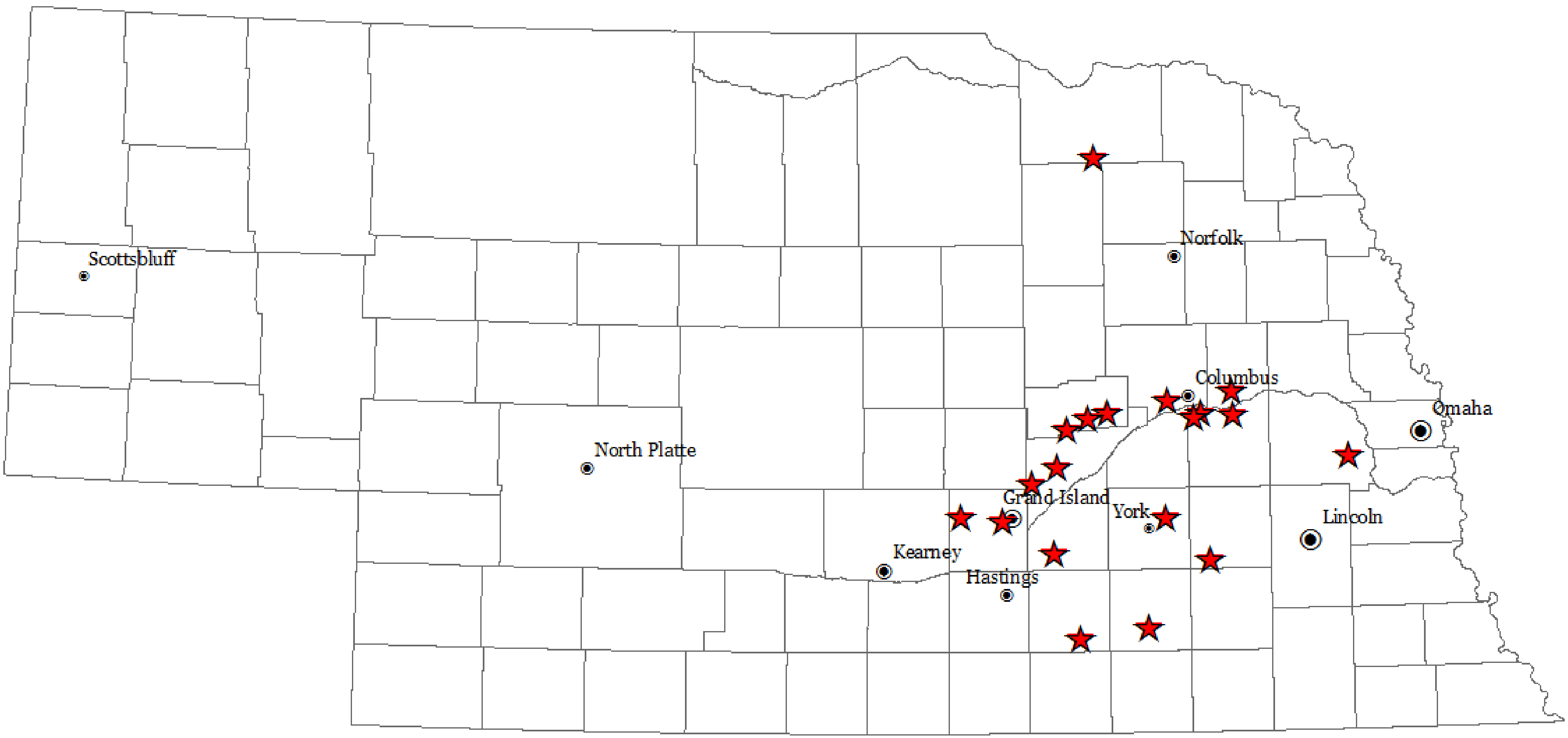
2015-2016 results

Data Analysis Methods

- For each plot strip, we averaged:
  - Grower's target N rates
  - OptRx® system as-applied N rates
  - Yield monitor data
    - Cleaned with Yield Editor (USDA-ARS, Columbia, MO)



Project SENSE Sites 2015-2016



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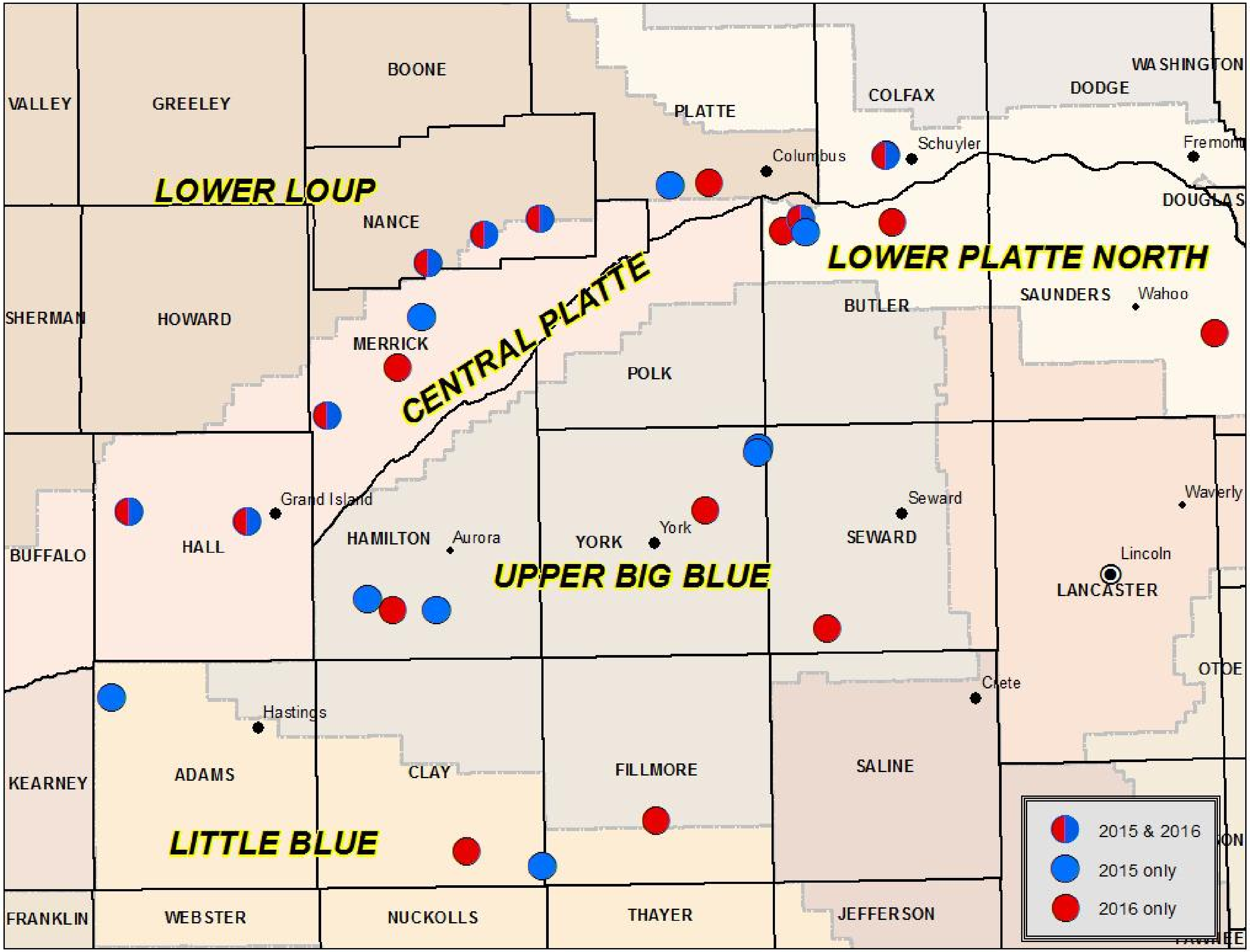
Project SENSE Sites 2015-2016



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Results

- We compared the grower N rates and yields to that of the OptRx system:
  - $Difference = Grower - SENSE$
  - SENSE outperformed Grower = **green**
  - Grower outperformed SENSE = **red**
- PFP_N — Pounds Grain per Pound N
- Pounds N per Bushel Grain
- Profit = (Yield * Corn Price) – (N Rate * N Price)
  - Corn Price: $3.05/bushel
  - N Price: $0.45/lb N
- Differences were statistically analyzed using PROC GLIMMIX in SAS 9.4 (SAS Institute, Cary, NC)

Results for All Sites 2015

Total N Rate (lb/ac)	195 A*	155 B	40
Yield (bu/ac)†	227 A	222 B	5
PFPN (lb grain/lb N)	65 B	80 A	-15
Lb N/bu Grain	0.86 A	0.70 B	0.16
Marginal Net Return	$701.80 B	$709.55 A	-$7.75

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

*Values with the same letter are not significantly different at a 95% confidence level.

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Results for All Sites 2016

Total N Rate (lb/ac)	186 A*	155 B	-31
Yield (bu/ac)†	202 A	199 B	3
PFPN (lb grain/lb N)	64 B	75 A	-11
Lb N/bu Grain	0.94 A	0.79 B	-0.14
Marginal Net Return	$535.47 B	$541.33 A	-$5.86

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

*Values with the same letter are not significantly different at a 95% confidence level.

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Results By NRD 2016

NRD	Yield† (bu/acre)	Total N (lbs/acre)	PFPN	lbs N applied/bu	Profit
Central Platte	-3*	-23*	-6*	0.15*	-$18.27*
Little Blue	5*	-14	-7*	0.04*	$7.57
Lower Loup	3	-35*	-14*	0.18*	-$7.16
Lower Platte North	3	-33*	-12*	0.13*	-$6.18
Upper Big Blue	8*	-56*	-23*	0.24*	-$0.61

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

*Values with an asterisk are significantly different at a 95% confidence level.

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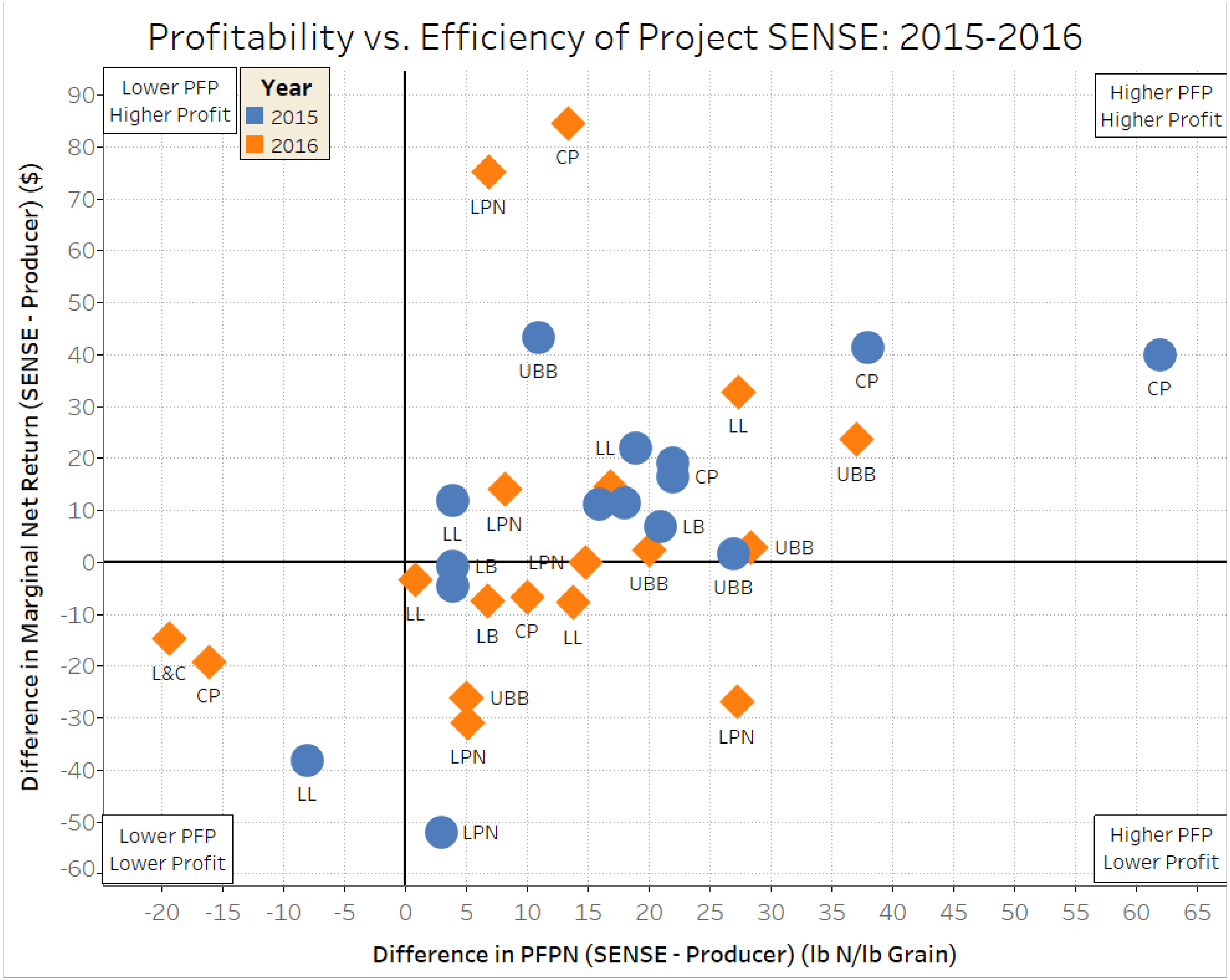

Profitability vs. Efficiency of Project SENSE: 2015-2016
Lower PFP
Higher Profit
Year
2015
2016
Higher PFP
Higher Profit
Lower PFP
Lower Profit
Higher PFP
Lower Profit
CP
LPN
UBB
CP
CP
LL
UBB
LL
CP
LL
LPN
LB
UBB
LB
LPN
LL
LB
CP
LL
UBB
UBB
L&C
CP
UBB
LPN
LPN
LL
LPN
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Difference in Marginal Net Return (SENSE - Producer) ($)
Difference in PFPN (SENSE - Producer) (lb N/lb Grain)

Economics

- Breakeven acreage was calculated using average N and yield differences (all plots)
  - N = $0.45/lb
  - Corn = $3.05/bu
  - Equipment = $15,000 for standard
  - 10% resale value
- Three nozzle types were used:
  - Fixed Rate Nozzles
  - Variable Orifice Nozzles (+$3,600)
  - PWM System (+$15,000)

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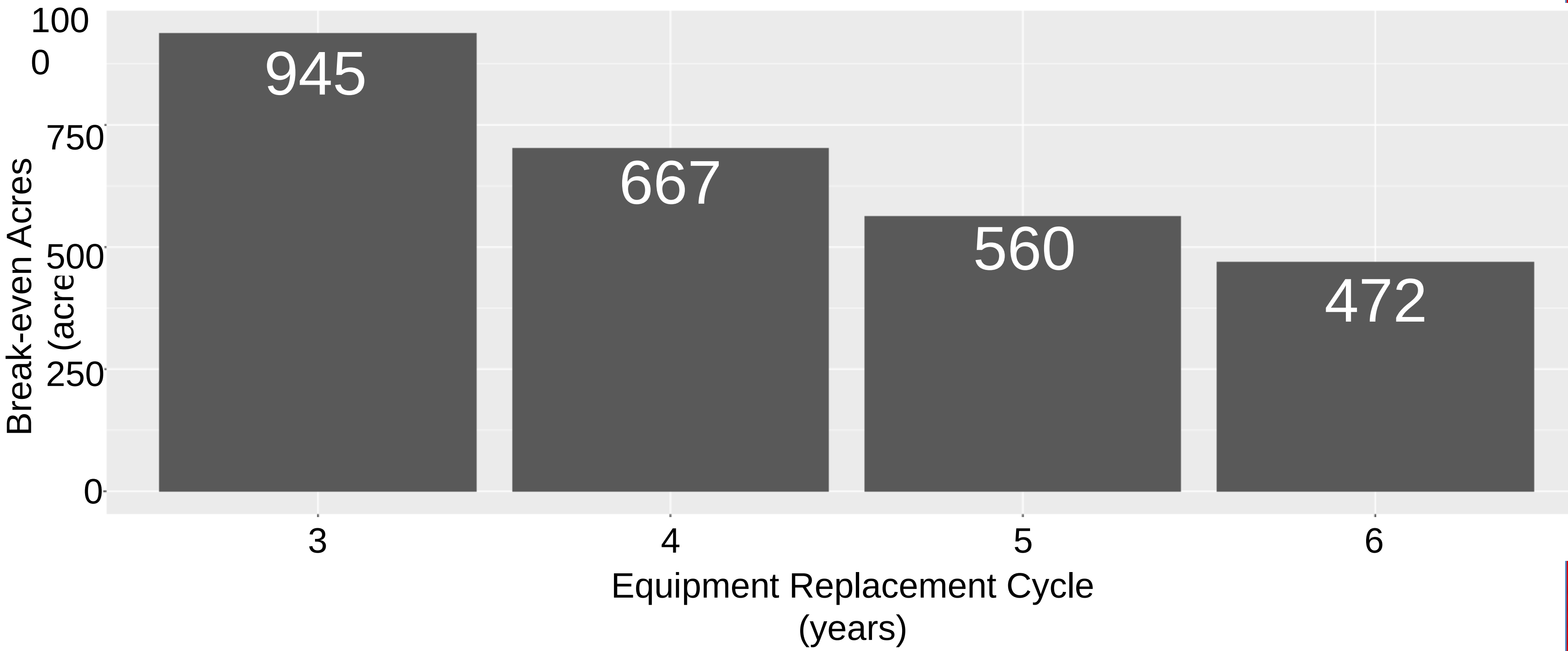
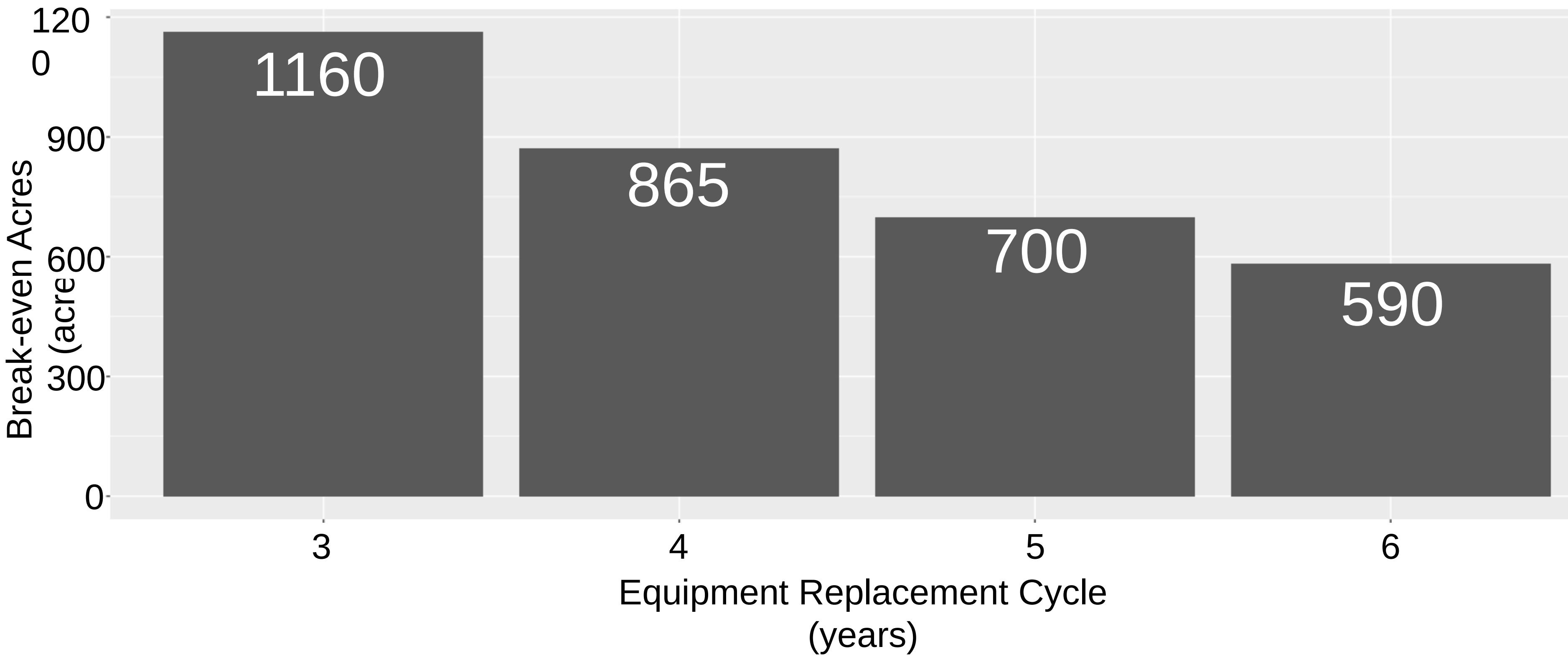
Break Even Acreage—Fixed Rate

- Fixed Rate Nozzles ($15,000)



Break Even Acreage—Variable Orifice

- Variable Orifice Nozzles ($18,600)



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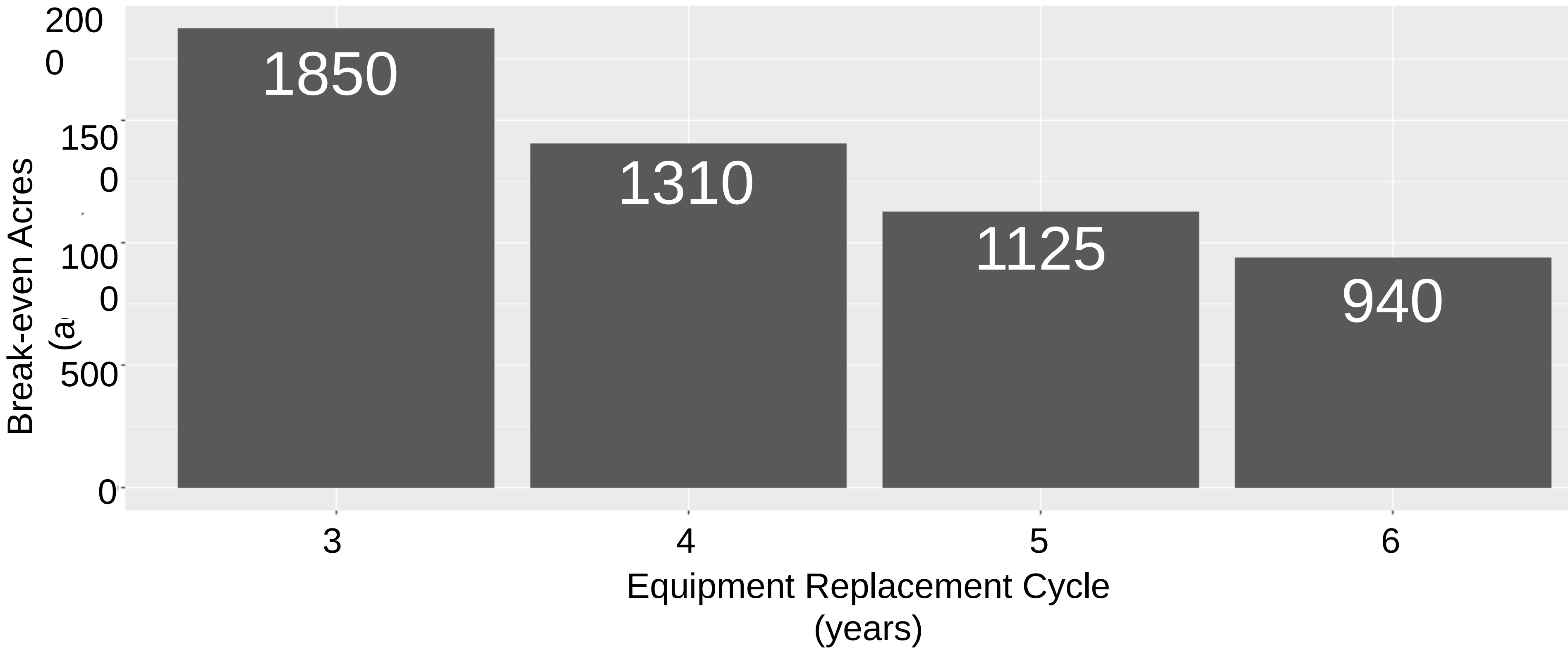
Break Even Acreage—PWM System

- PWM System ($30,000)



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Specific Examples

Site 1

Total N Rate (lb/ac)	160	133	27
Yield (bu/ac)†	234 A*	235 A	-1
PFPN (lb grain/lb N)	82 A	99 B	-17
Lb N/bu Grain	0.68 A	0.57 B	0.11
Marginal Net Return	$640.97 A	$655.53 B	-$14.56

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

*Values with the same letter are not significantly different at a 95% confidence level.

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Site 2 2015

Total N Rate (lb/ac)	175	108	67
Yield (bu/ac)†	283 A*	282 A	1
PFPN (lb grain/lb N)	91 B	153 A	-62
Lb N/bu Grain	0.61 A	0.38 B	0.23
Marginal Net Return	$919.20 B	$959.10 A	-$39.90

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
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Site 2 2016

Total N Rate (lb/ac)	140	171	-31
Yield (bu/ac)†	212 A*	211 A	1
PFPN (lb grain/lb N)	85 A	69 B	16
Lb N/bu Grain	0.66 A	0.88 B	-0.15
Marginal Net Return	$584.23 A	$565.03 B	$19.20

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

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Site 3

Site 3

Total N Rate (lb/ac)	210	176	34
Yield (bu/ac)†	183 A*	168 B	15
PFPN (lb grain/lb N)	49 A	54 A	-5
Lb N/bu Grain	0.87 A	0.96 A	-0.09
Marginal Net Return	$462.96 A	$432.03 B	$30.93

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

*Values with the same letter are not significantly different at a 95% confidence level.

Site 4

Total N Rate (lb/ac)	168	171	-3
Yield (bu/ac)†	184 A*	208 B	-24
PFPN (lb grain/lb N)	61 A	68 B	-7
Lb N/bu Grain	0.92 A	0.82 B	0.1
Marginal Net Return	$552.88 A	$627.92 B	-$75.04

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.
*Values with the same letter are not significantly different at a 95% confidence level.

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Site 5

Total N Rate (lb/ac)	206	127	79
Yield (bu/ac)†	229 A*	225 A	4
PFPN (lb grain/lb N)	62 A	99 B	-37
Lb N/bu Grain	0.90 A	0.56 B	0.34
Marginal Net Return	$604.29 A	$627.80 B	-$23.51

†Yield data from cleaned yield monitor data. Bushels per acre corrected to 15.5% moisture.

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Creating Successful On-Farm Trials

- Understand your cooperator
  - Varying levels of communication
- Keep organized
  - OneNote
  - Protocols for naming conventions and data analysis
  - Cloud storage with external backups
- Record everything
  - Every trip to field, calls/texts/emails from cooperators
  - GoPro video
  - Samsung 360 video

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Speed Bumps

- Application Timing
  - Difficult to get to all sites within application window
  - Weather factors

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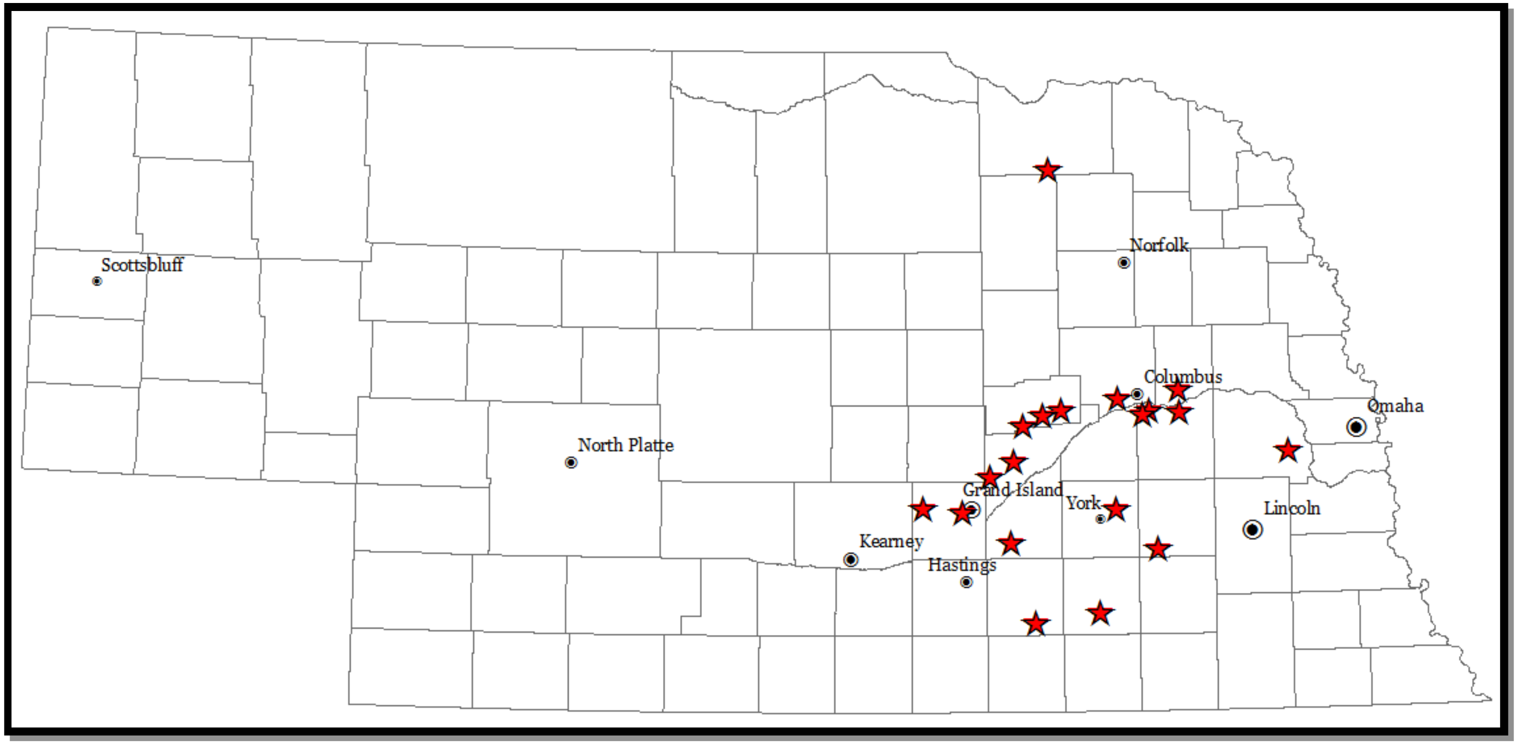
Speed Bumps

- Long Distances
  - Difficult to monitor rain gauges, soil moisture sensors
  - Long days
  - Over 25,000 miles traveled in 2016



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When in doubt, GUN IT!

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cropwatch.unl.edu/projectsense

YouTube: Nebraska On-Farm Research Network