



InfoAg 2015

www.adapt-n.com

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About us

Greg Levow

Co-founder

Agronomic Technology Corp

greg@agronomic.com

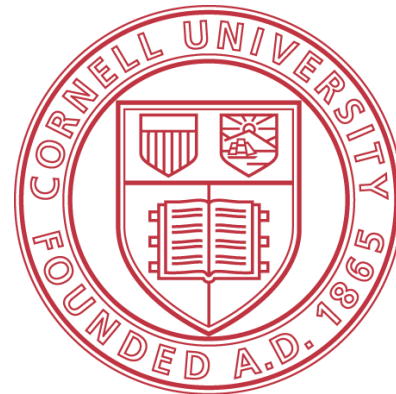


Dr. Harold van Es

Cornell University Professor

Soil Science & Water Management

hmv1@cornell.edu



Nitrogen: Elusive and complex



Nitrogen:

- How much N did I lose from Tuesday's 2" rainfall?
- It's been cold, how much N has my soil mineralized?
- How much less N will I lose if I add a stabilizer?
- What impact will switching to no-till have on my N needs?
- What happens if the rest of the season is dry? Wet?
- Will I need less N if I switch from fall to spring pre-plant?
- Should I apply variable rate nitrogen?



Adapt-N answers these questions
for agronomists and growers, and
creates win-win performance
improvements



Objectives today

- Adapt-N overview and why it's different
- Research methodology, results, and key learnings
- Agronomic inputs and recommendations in detail
- N modeling in a precision ag approach
- Data privacy



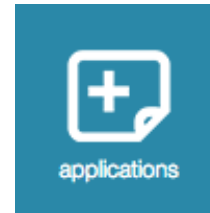
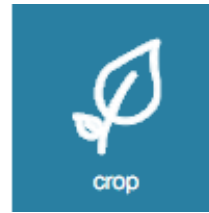
Adapt-N

- Set the standard for nitrogen modeling
- Built on 10+ years of land-grant research
- Demonstrated to improve grower profit while reducing N loss
- 100% independent, unbiased, and transparent
- Designed for agronomists, recognized by the industry



Robust Nitrogen Modeling

User
Inputs:



Adapt-N
Simulations:

High-Resolution Climate Data
(Precip, Temp, Solar Radiation)

13 Interrelated Software Models

- Crop growth, N uptake, N loss, manure, etc.
- 2,000+ proprietary soil dictionary records



Results for
every field:



RECOMMENDATION

- Daily recommendations
- PDF reports
- Shapefile + agX export
- Interactive graphs
- N-Alerts
- Prior-season analysis



Nitrogen Recommendation

Grower: Smith Farming

Farm: Corey's Farm

Field: Skunk River East

Zone: Main Zone

Nitrogen recommendation for July 30, 2014:

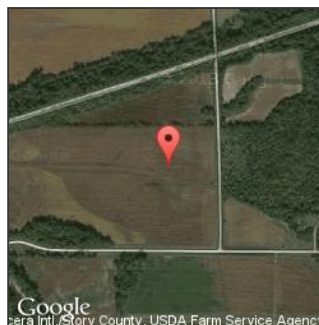
160 lbs N/Acre N recommendation	143-179 N recommendation range
------------------------------------	-----------------------------------

Recommendation based on supporting estimates and assumptions:

205 lbs N/Acre Expected N in crop at harvest	74 lbs N/Acre N mineralization so far	117 lbs N/Acre N loss so far
0 lbs N/Acre Partial credit from prior crop	52 lbs N/Acre N in crop now	23 lbs N/Acre Expected future loss
2 lbs N/Acre Expected future mineralization	6 lbs N/Acre N in soil now	13.6" / 28.0" Rainfall since planting / Rainfall since 01/01/14

Field information

Soil: Webster
Maturity Class: Grains: 107 day corn
Planted: 06/01/14
Expected Yield: 200.0 bu/acre
Harvest Population: 30,000
Organic Matter %: 3.5
Previous Crop: Grain Corn
N fertilizer already applied: 100 lbs N/Acre
Irrigation Applied: None
Manure Applied: No
Adapt-N Zone ID: 8758



Adapt-N:

Functionality and Field Testing



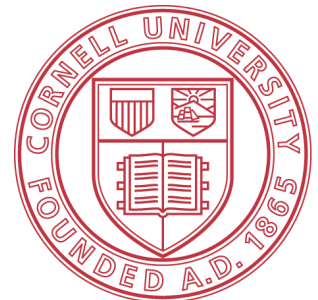
Disclosure

According to Cornell University policy, I am disclosing that I have an equity interest in Agronomic Technology Corp, which has received a license for the use and further development of the Adapt-N tool.

This tool was developed as part of my Cornell research program, and Agronomic Technology Corp is providing some support to my program for the further development of this technology.



agronomic
TECHNOLOGY



Many sources of variation in N availability

→ generalized recommendations are too simplistic!

- Organic amendments (manure, compost, etc.)
- Crop rotations
- Soil type differences (at multiple scales)
- Soil organic matter contents
- Soil and crop management (tillage, planting date, etc.)
- **Weather:**
 - Temperature
 - **Precipitation!**



Interactions are complex and nonlinear

Map of the United States showing the percentage change in the number of people aged 65 and older by region. The map uses a color scale from light blue (low increase) to dark blue (high increase).

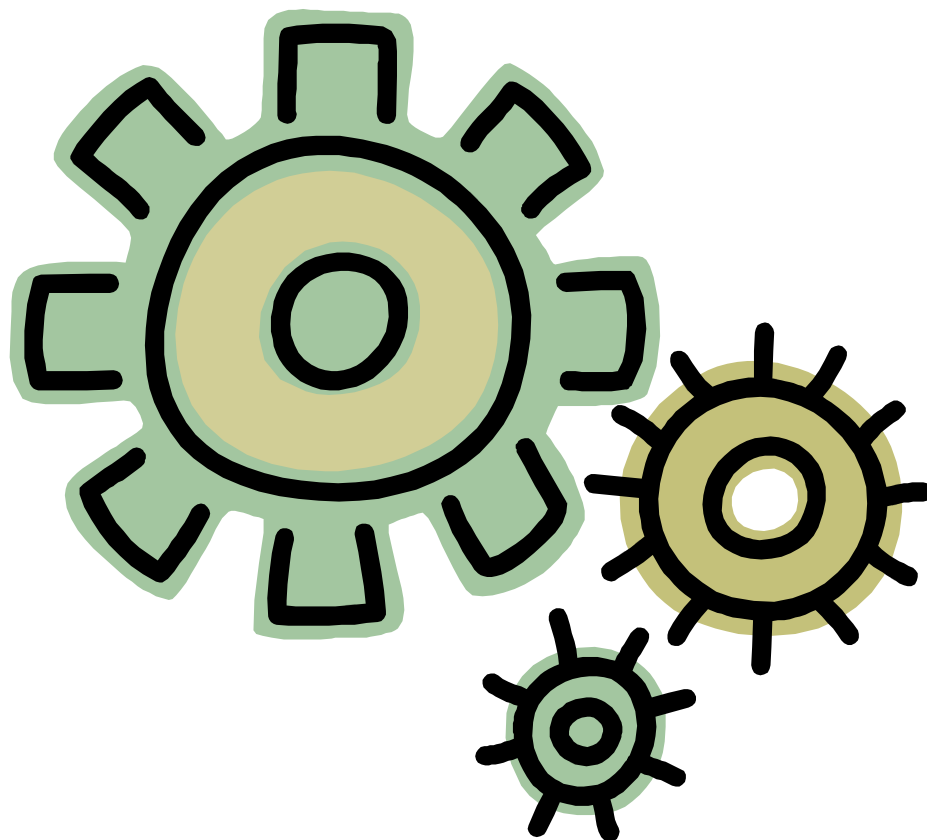
Region	Change (%)
Alaska	11%
Washington	12%
Montana	16%
California	5%
Nevada	5%
Arizona	5%
New Mexico	5%
Texas	16%
North Dakota	16%
South Dakota	16%
Nebraska	16%
Kansas	16%
Oklahoma	16%
Minnesota	37%
Wisconsin	37%
Illinois	37%
Indiana	37%
Michigan	37%
Ohio	37%
Pennsylvania	37%
New York	71%
Connecticut	71%
Massachusetts	71%
Rhode Island	71%
Delaware	71%
Maryland	71%
District of Columbia	71%
Virginia	27%
North Carolina	27%
South Carolina	27%
Georgia	27%
Florida	27%
Alabama	27%
Mississippi	27%
Louisiana	27%
Arkansas	27%
Missouri	27%
Iowa	27%
Illinois	27%
Indiana	27%
Michigan	27%
Wisconsin	27%
Minnesota	27%
Nebraska	27%
Kansas	27%
Oklahoma	27%
Texas	27%
Montana	27%
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Idaho	27%
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Arizona	27%
New Mexico	27%
Colorado	27%
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Idaho	27%
Utah	27%
Nev	



Globalchange.gov

Inner Workings of Adapt-N

(in short)



PNM model: The core of the *Adapt-N* tool

13 interconnected soil and crop models:

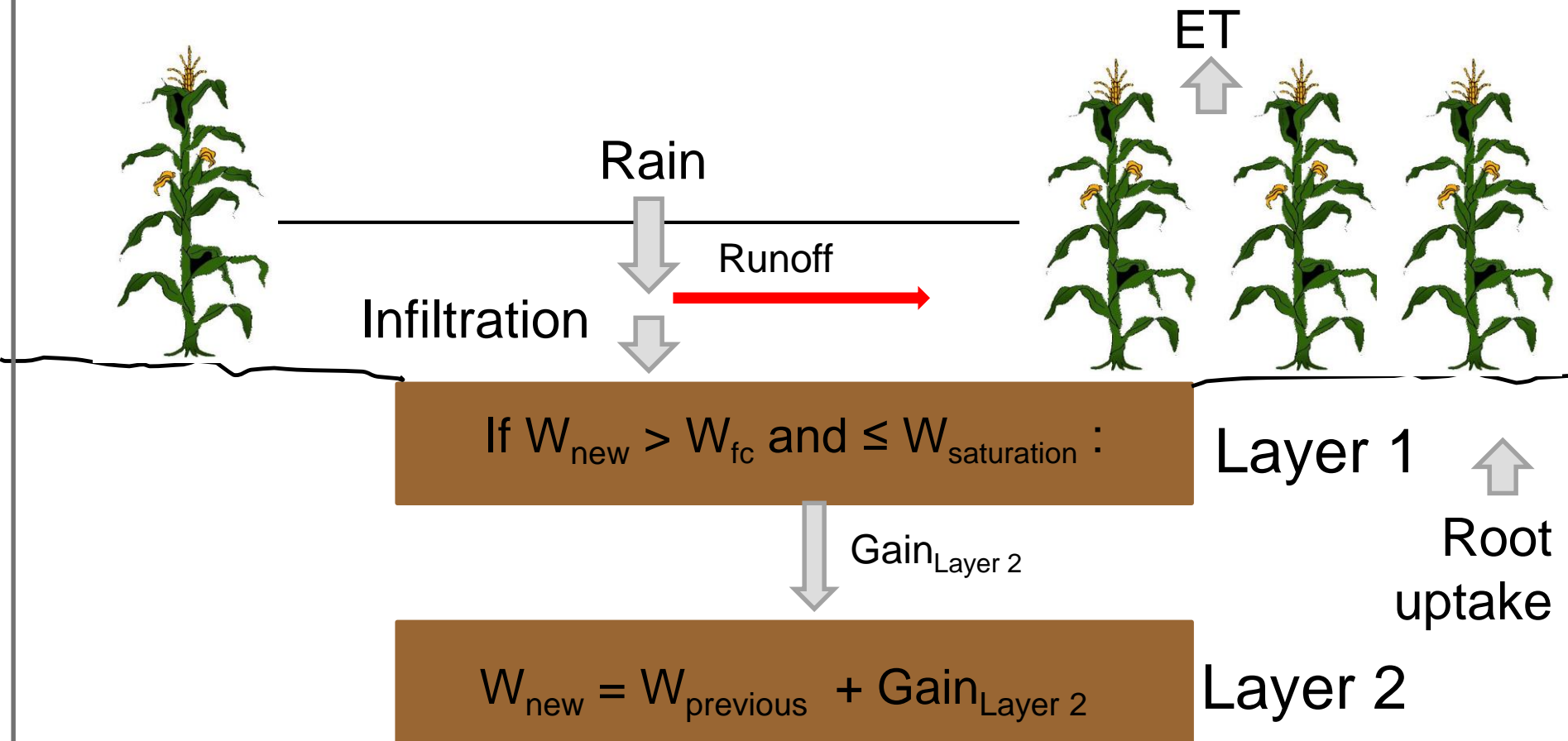
- Based on long-term modeling efforts at leading international institutions going back to the 1980's
- Includes comprehensive literature knowledge
- Calibrated and tested with extensive field studies
- Accesses high-resolution weather data and extensive soil databases

Hutson, J.L., R.J. Wagenet, and M.E. Niederhofer. 2003. Leaching Estimation And Chemistry Model: a process-based model of water and solute movement, transformations, plant uptake, and chemical reactions in the unsaturated zone. Version 4. Dept of Crop and Soil Sciences. Research Series No. R03-1. Cornell University, Ithaca, NY, USA.

Sinclair, T.R., and R.C. Muchow. 1995. Effect of nitrogen supply on maize yield: I. modeling physiological responses. *Agronomy Journal* 87:632-641.

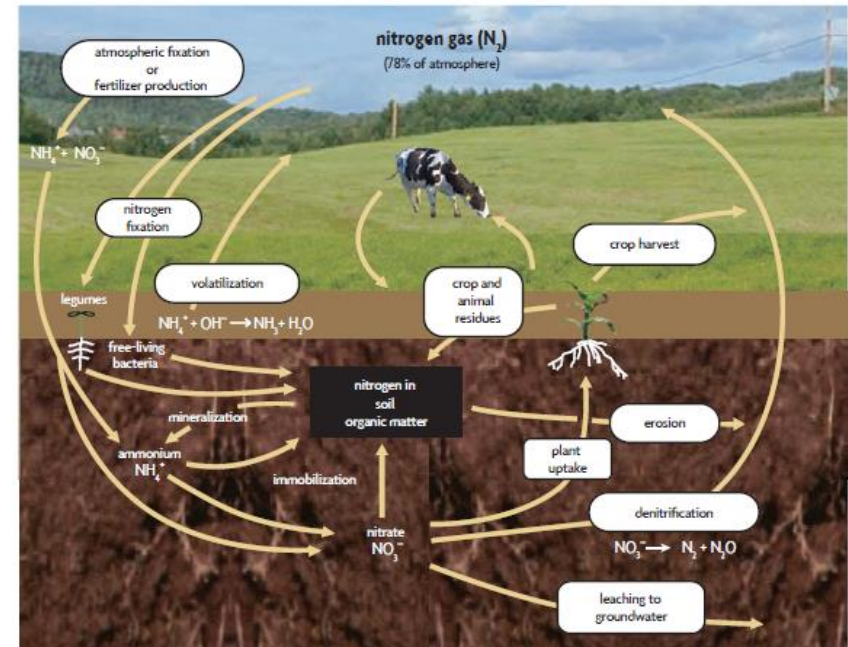
Soil Water Dynamics

- Simulates soil water conditions throughout profile (20 layers)
- Parameterized using soil dictionaries
- Accounts for soil and management conditions



Major N Processes in Adapt-N Model

- Net additions:
 - Mineralization - immobilization
 - Urea hydrolysis
- Transformations
 - Nitrification
- Losses
 - Denitrification (nitrification)
 - Ammonia volatilization
 - Leaching
 - Plant N uptake



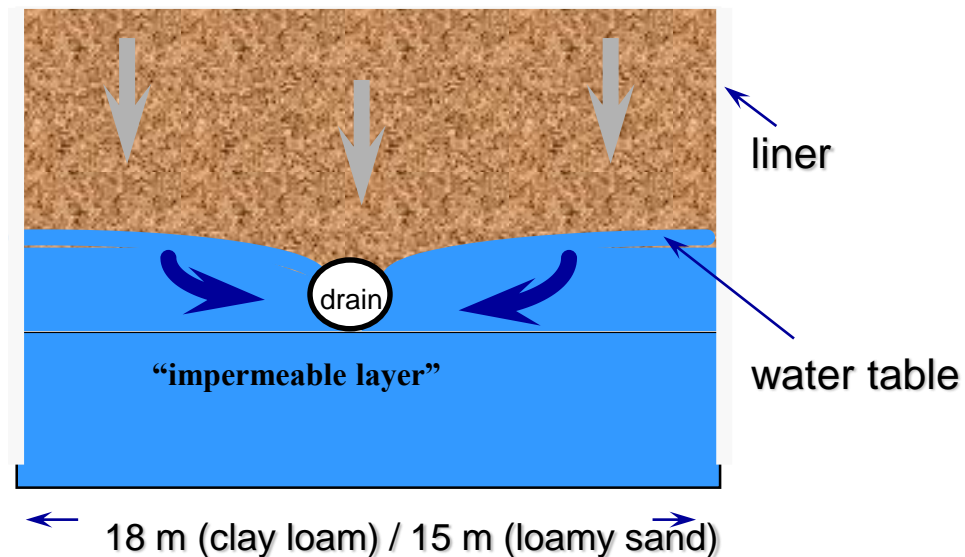
➤ Modifications for Enhanced Efficiency Compounds

$$\Delta q_{(NO_3-N, NH_4-N, \text{etc})} = q_0^*[1 - \exp(-kt)]$$

Making the models work

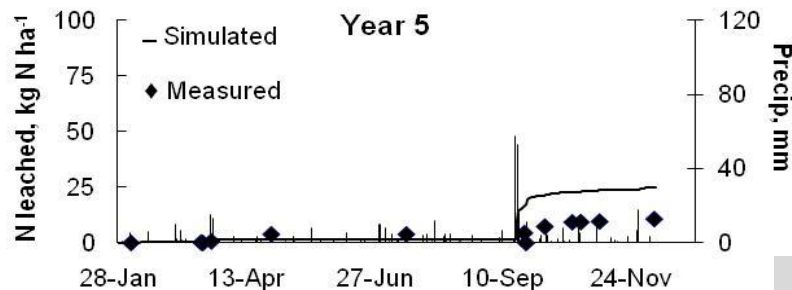
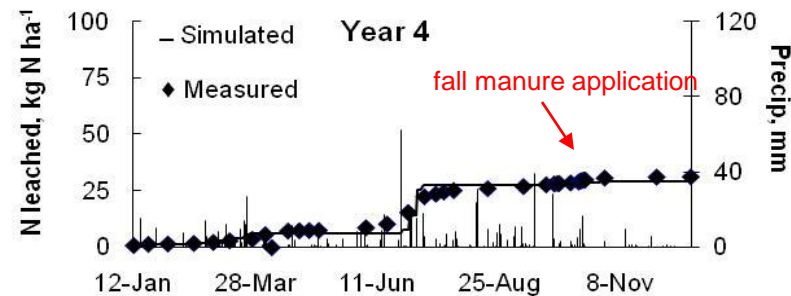
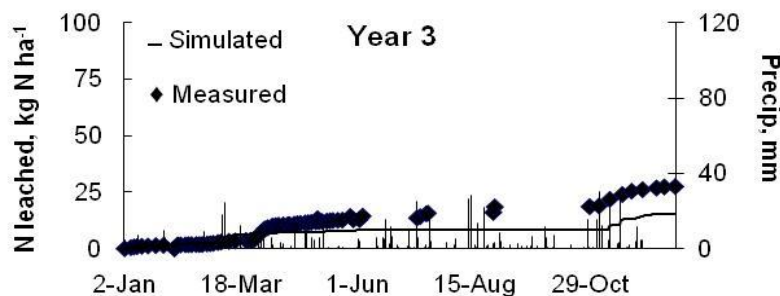
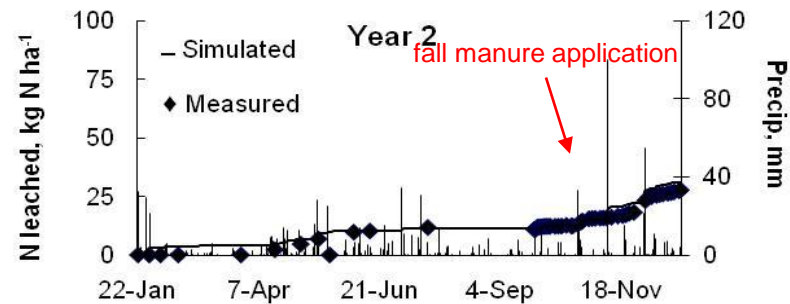
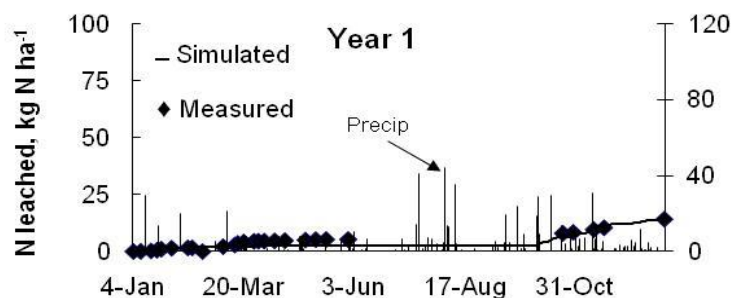
Lysimeter Experiments

- New York and Minnesota
- N fertilizer and manure (rate and timing)
- N losses measured
- Results used for model calibration



Independent Model Evaluation

Nitrate-N Leaching



Adapt-N-Recommendation Methodology

N Rate =

Expected N in Crop



Input: Expected Yield

- N in Crop Now - N in Soil Now



Simulation based on
actual real-time weather

- Prior Crop Credit



Partial simulation, partial
fixed credit

- Net N Future N Losses and Gains



Probabilistic
simulations based on
historical weather

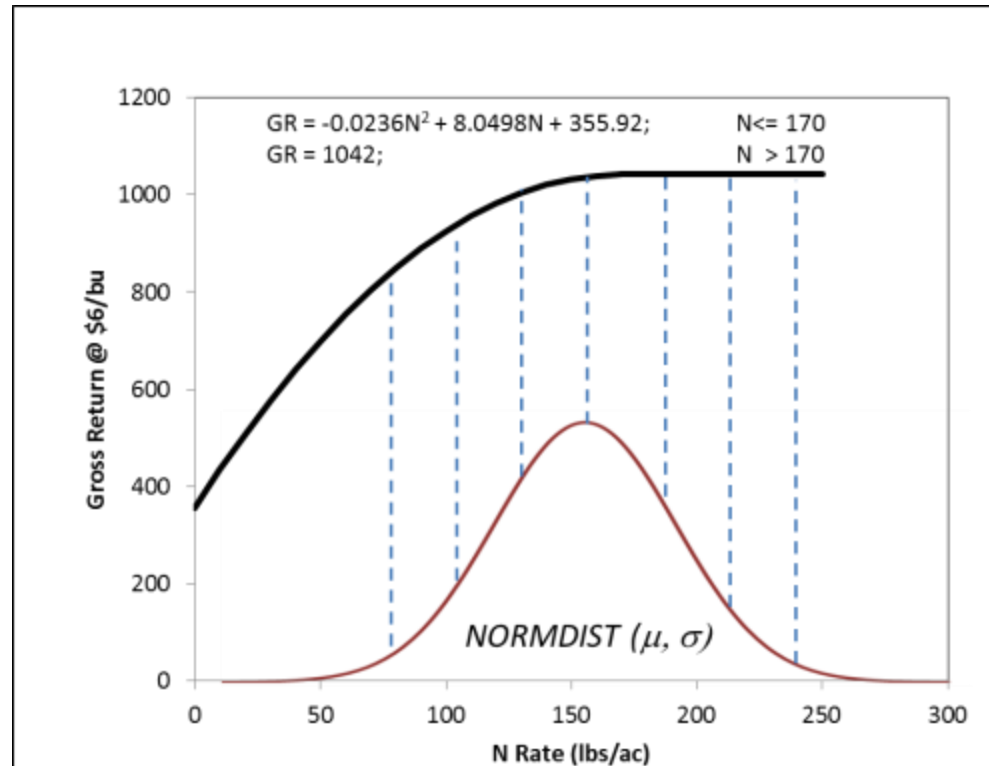
- Price-Profit-Risk Factor



Probability-uncertainty
simulations

Risk Components

Differential Impact of Under and Over-Fertilization due to Nonlinear-Asymmetrical Yield Response to N



Stochastic Gross Returns:
$$\left(\int_{-\infty}^{\infty} \left(\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} * GR \right) \right)$$

Adapt-N Strip Trials

Validating and Improving the Tool



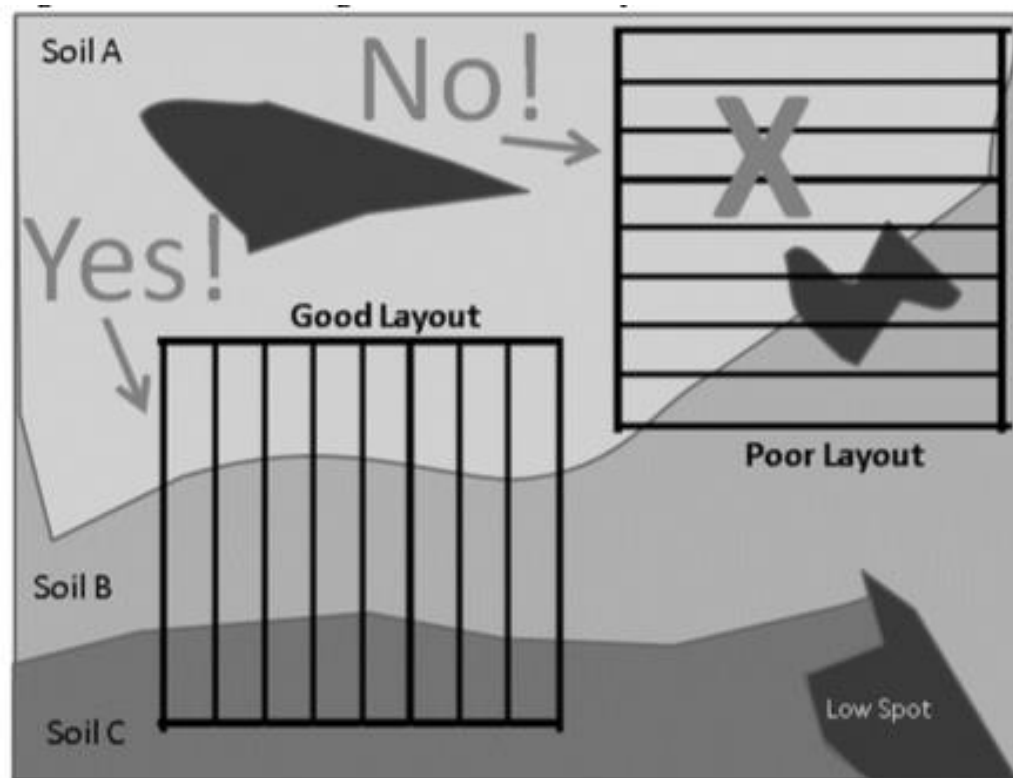
Adapt-N Model Calibration and Testing

- 200+ Cornell University-coordinated replicated strip trials in 10 states (Midwest, Northeast, Mid-Atlantic, Southeast)
- In collaboration with researchers and consultants
- Adapt-N vs. Grower rates or Multi-rate N response trials
- Additional “informal” testing
- Funded by many organizations



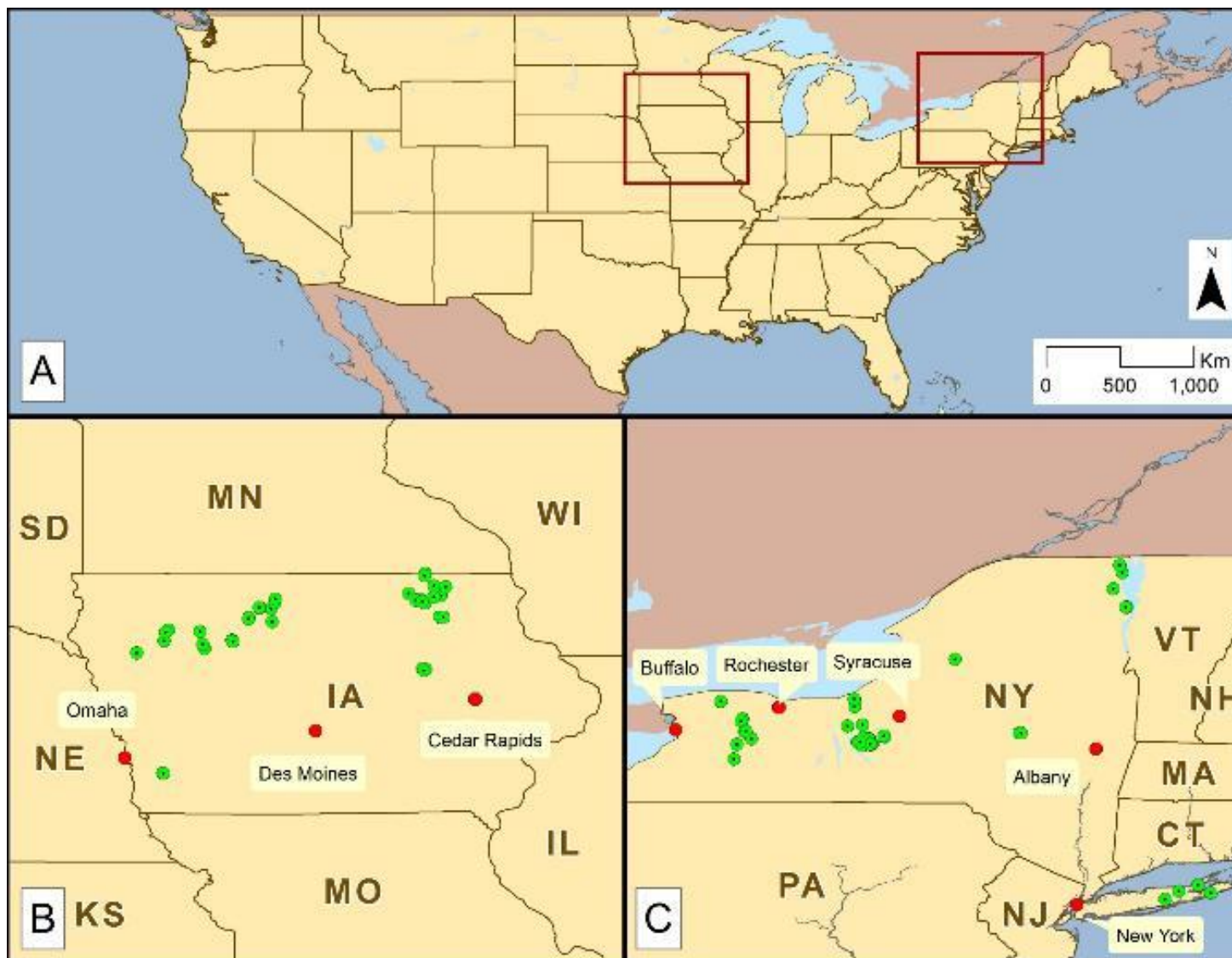
Strip Trial Design

- Spatially balanced designs with at least 4 replications
- Trials include:
 - Soil sampling, before/during/after the season. Stalk sampling
 - Soil health evaluation
 - Multiple N rates to compute the retrospective economic optimum rate
 - Comparisons with standard recommendations (MRTN, etc.)
 - Trial design with in-field variability



2011-14 Grower vs Adapt-N Strip Trials

Iowa and New York (n=126)

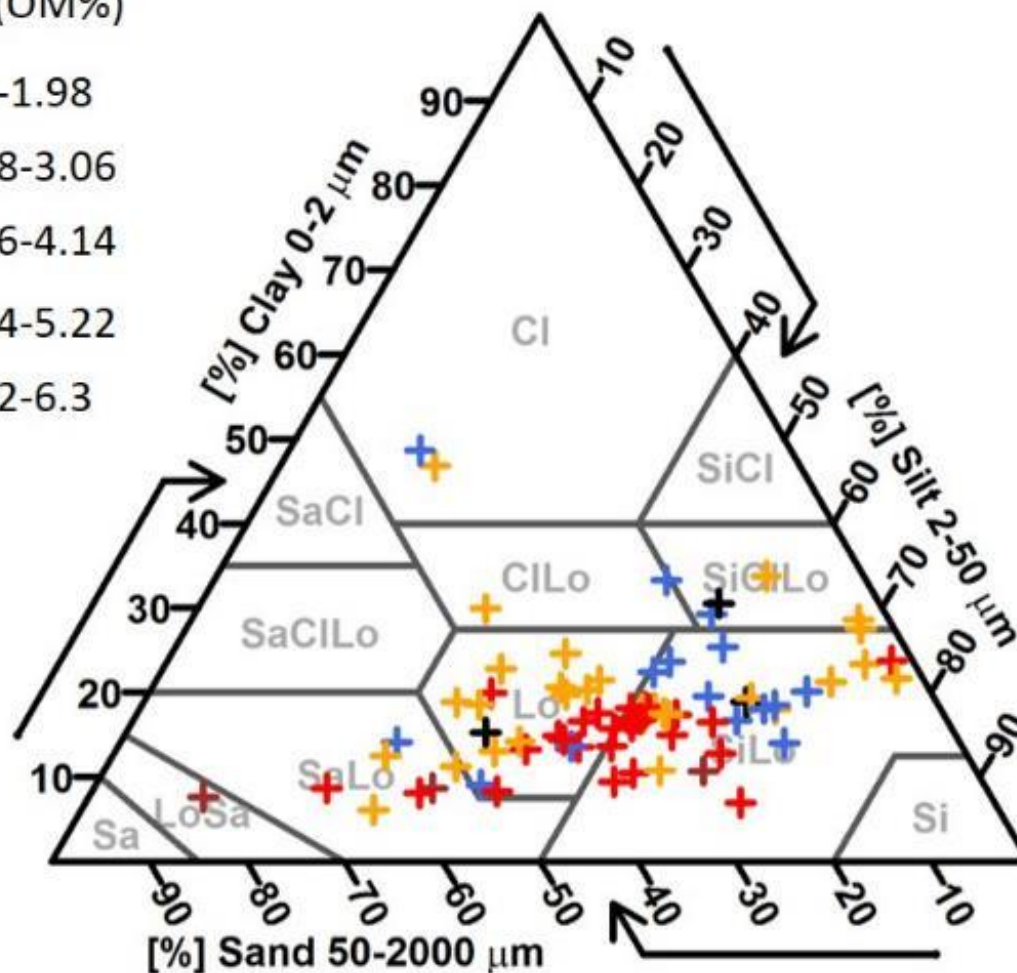


2011-14 Grower vs Adapt-N Strip Trials

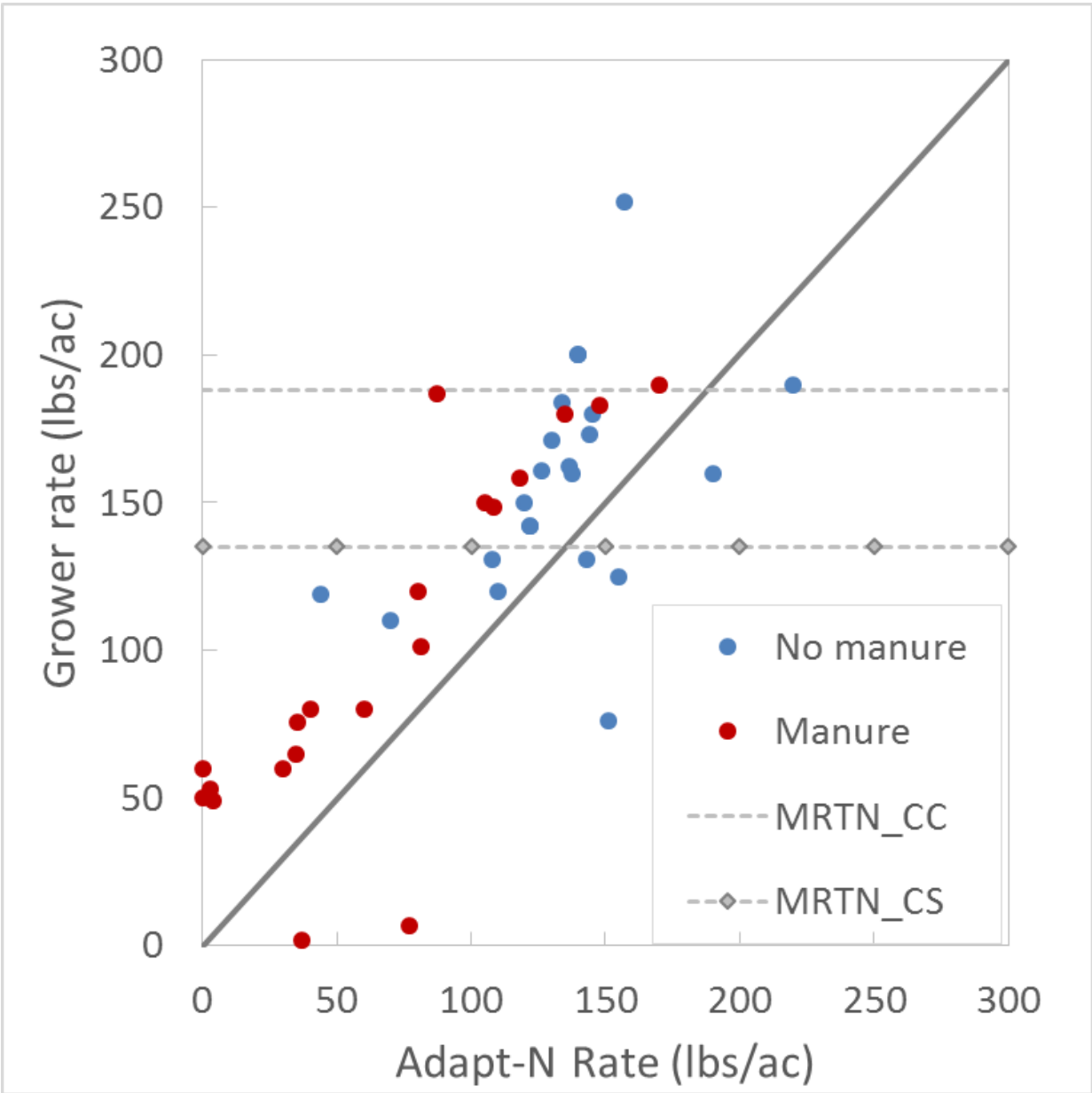
Soil Texture and Organic Matter Content

Legend (OM%)

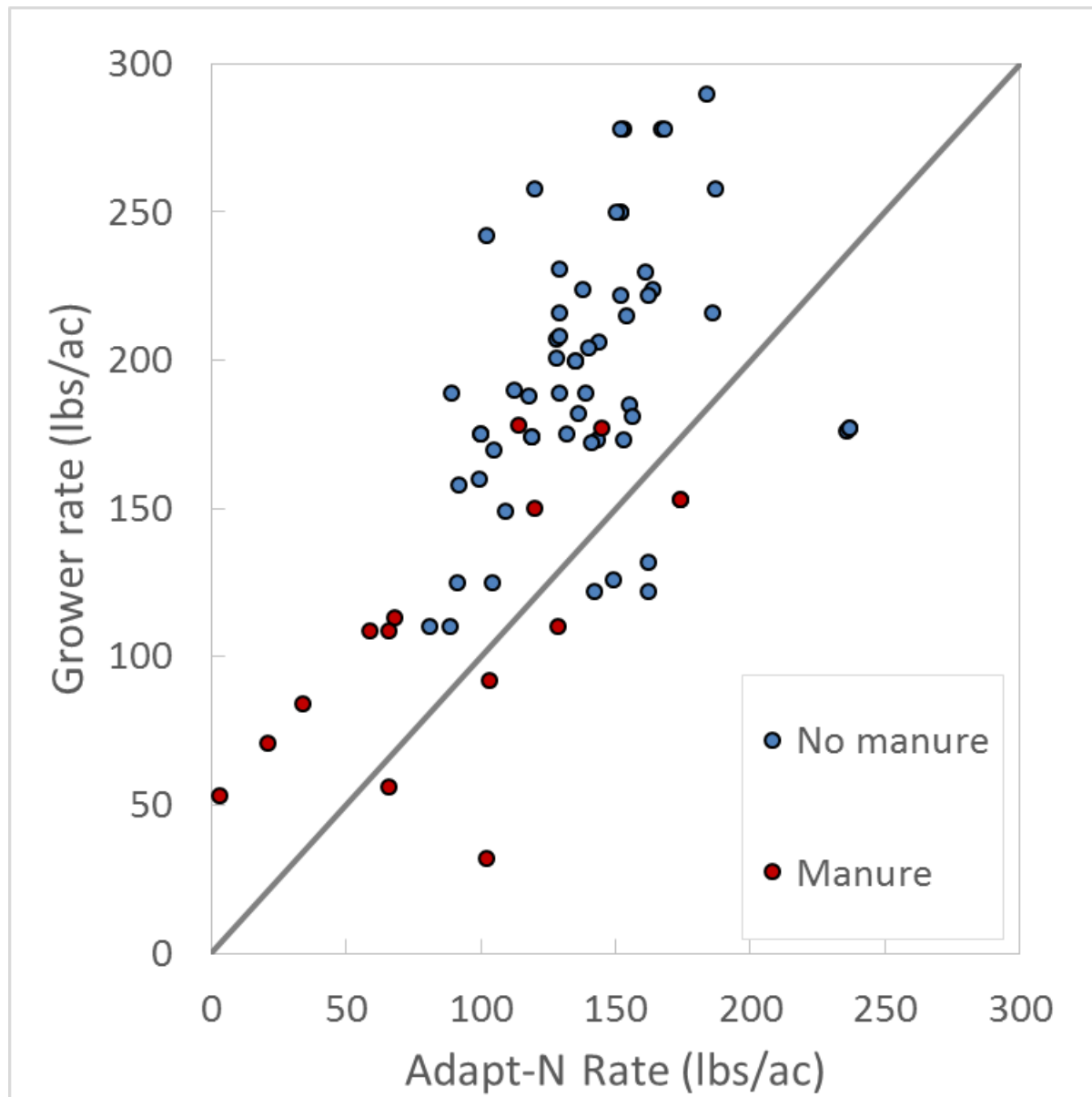
- + 0.9-1.98
- + 1.98-3.06
- + 3.06-4.14
- + 4.14-5.22
- + 5.22-6.3



Grower vs Adapt-N Rates - Iowa

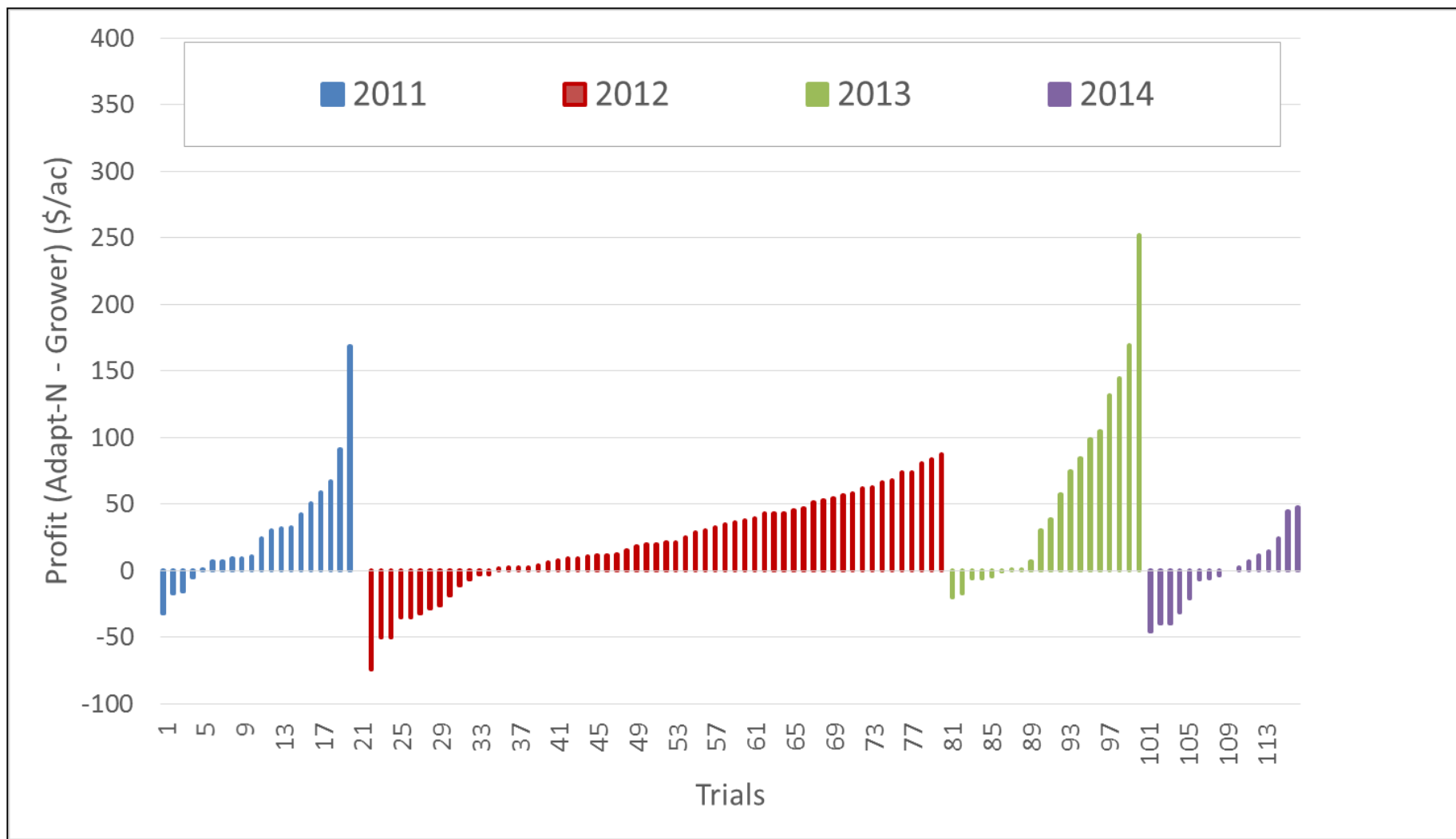


Grower vs Adapt-N Rates – New York



Profit differences for 2011-2014 strip trials in NY and IA

Comparing Adapt-N rate recommendations with Grower rates



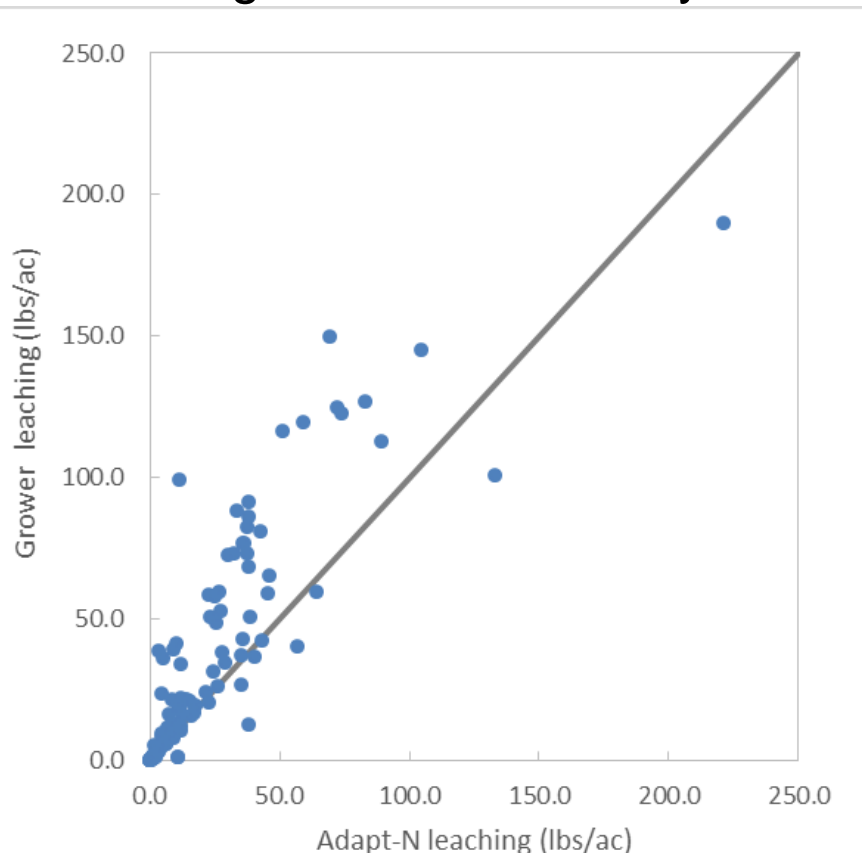
Comparison of Adapt-N and Grower N rates

2011-14 on-farm strip trials in Iowa and New York

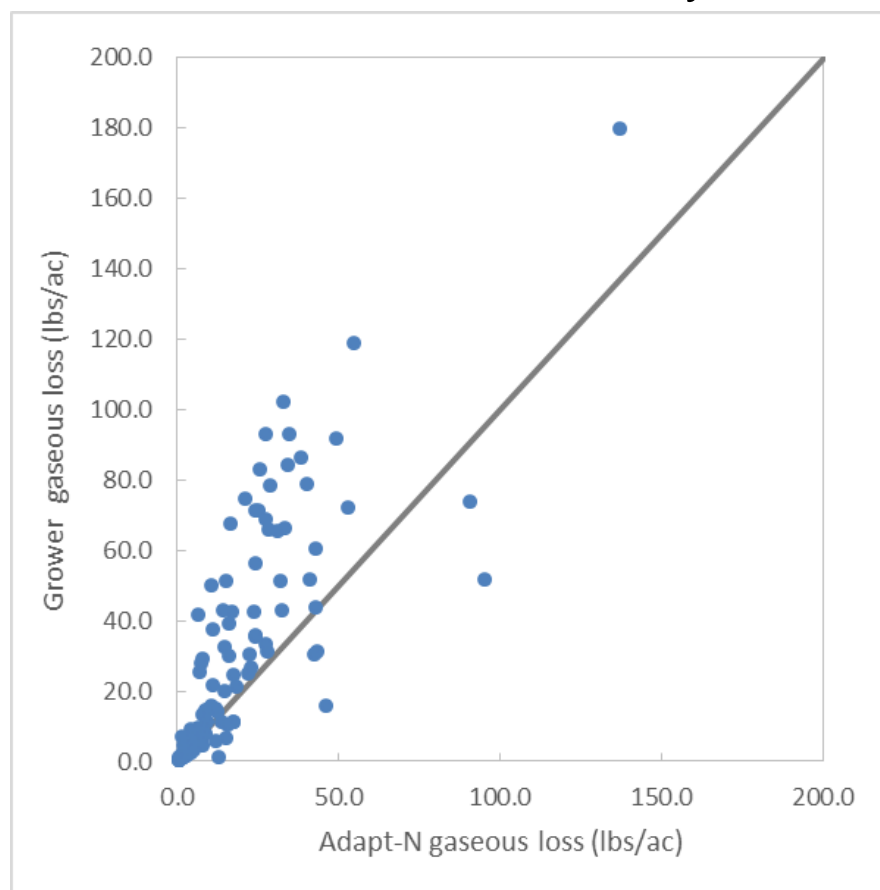
State-Year	NY2011	NY2012	NY2013	NY2014	IA2011	IA2012	IA2013	Mean
N input diff (lbs/ac)	-62.7	-66	19.1	-32.6	-16.7	-27.6	-19.3	-29.4
Yield diff (bu/ac)	-0.05	-1.85	20.60	-3.20	1.90	-0.45	0.50	2.49
Profit diff (\$/ac)	\$34.1	\$23.93	\$93.63	\$0.95	\$21.6	\$14.35	\$12.2	\$28.68

Comparison of Adapt-N and Grower N rates: Simulated environmental losses Iowa and New York Trials 2011-14

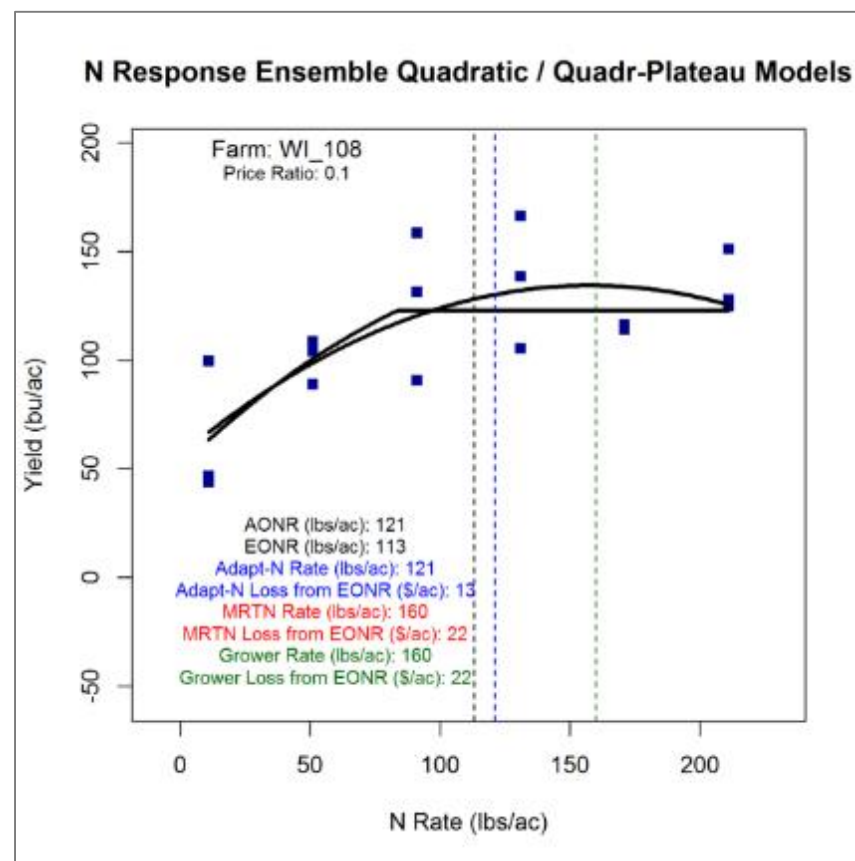
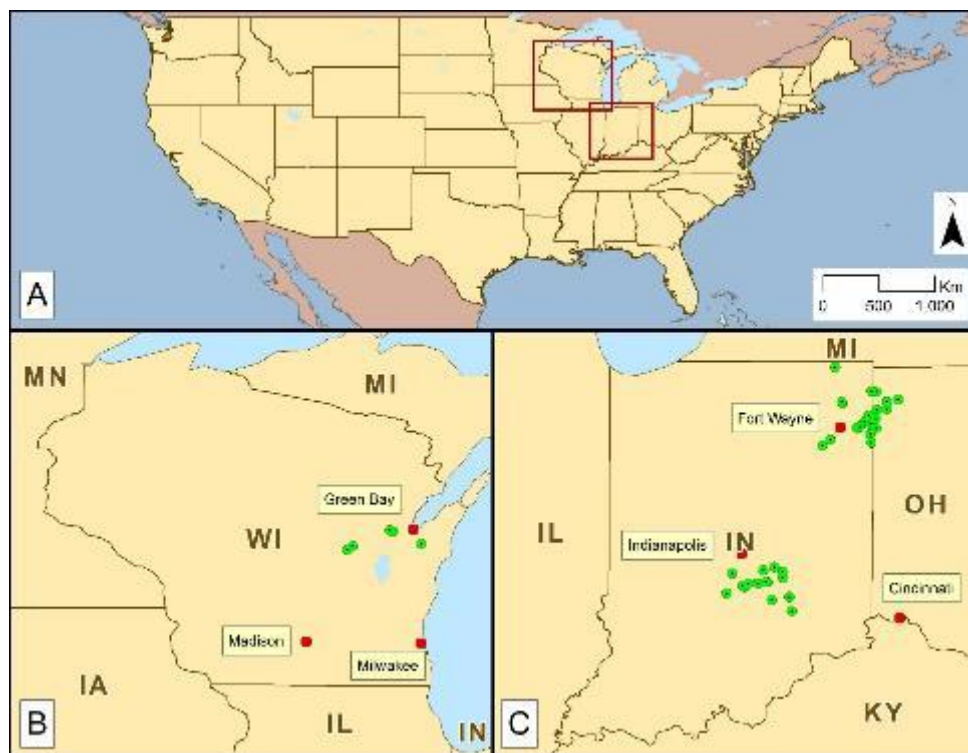
Leaching losses reduced by 35%



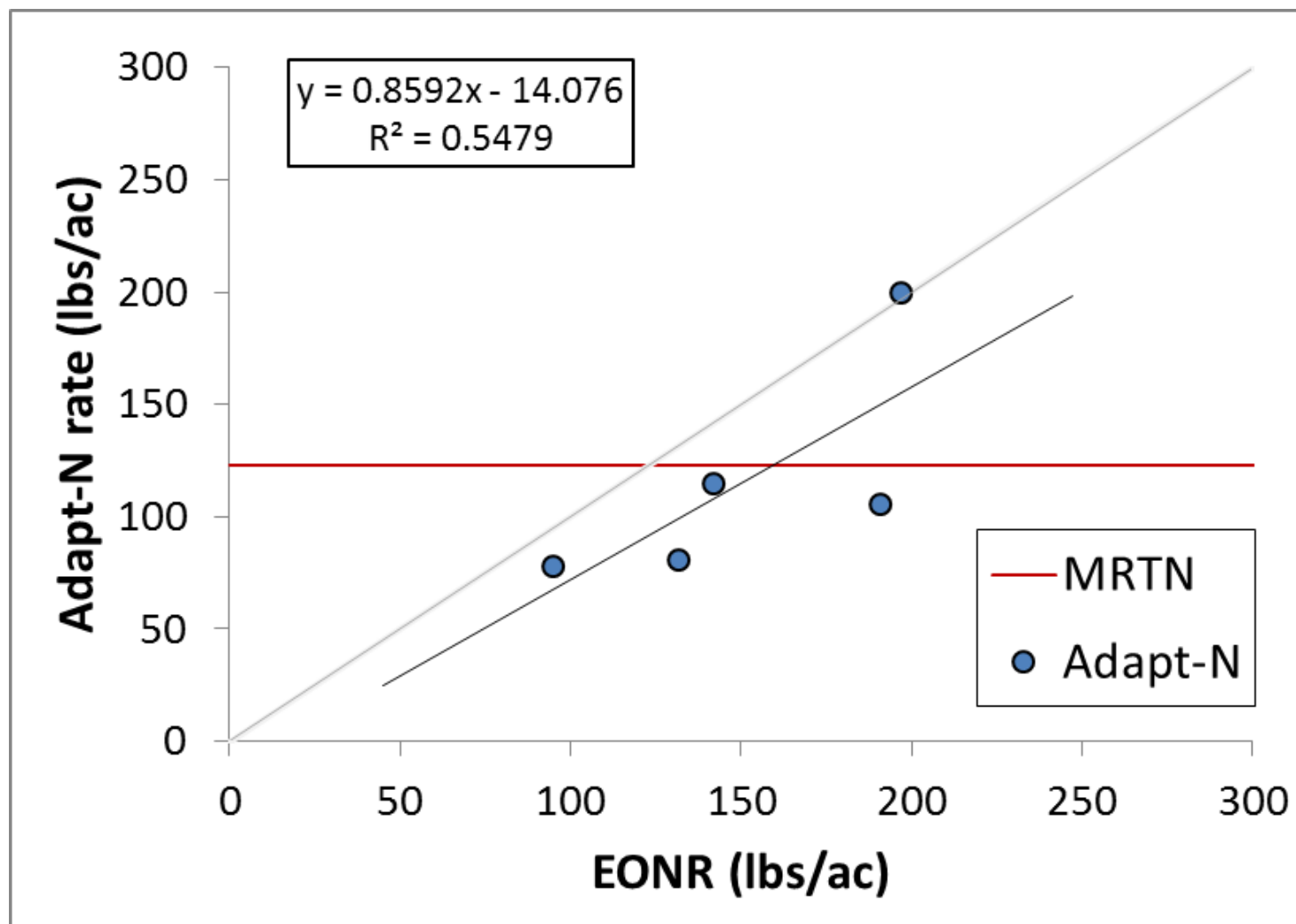
Gaseous losses reduced by 40%



2013-14 Multi-Rate Trials: Wisconsin, Indiana, Ohio (n=42)

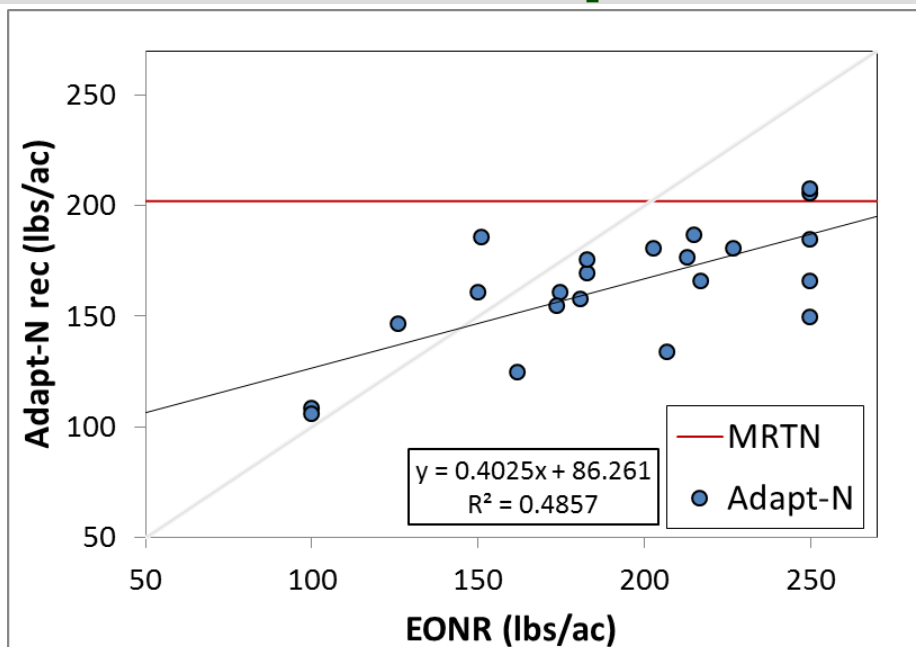


Wisconsin 2013 EONR vs Adapt-N

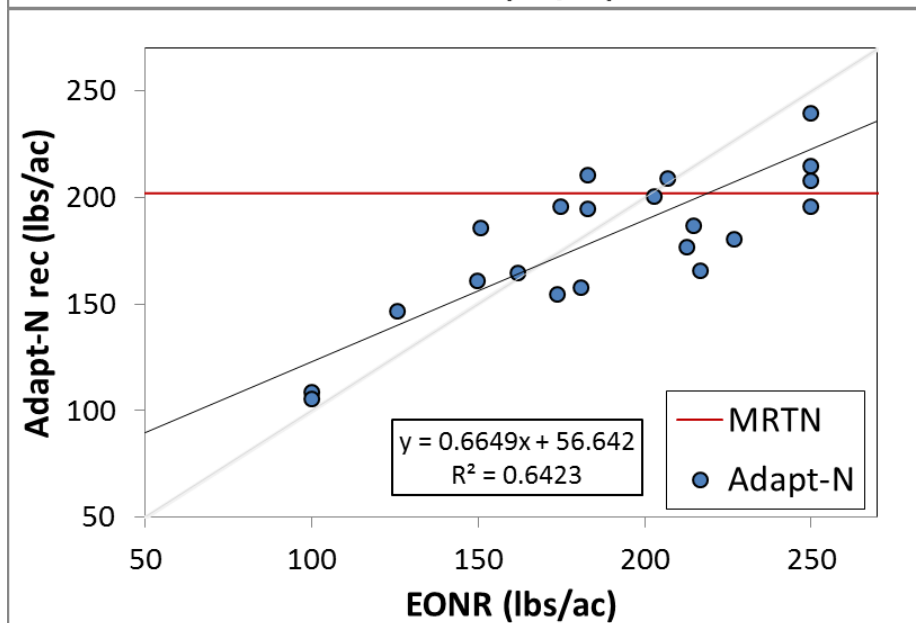


Indiana-Ohio 2014 EONR vs Adapt-N

Early Sidedress



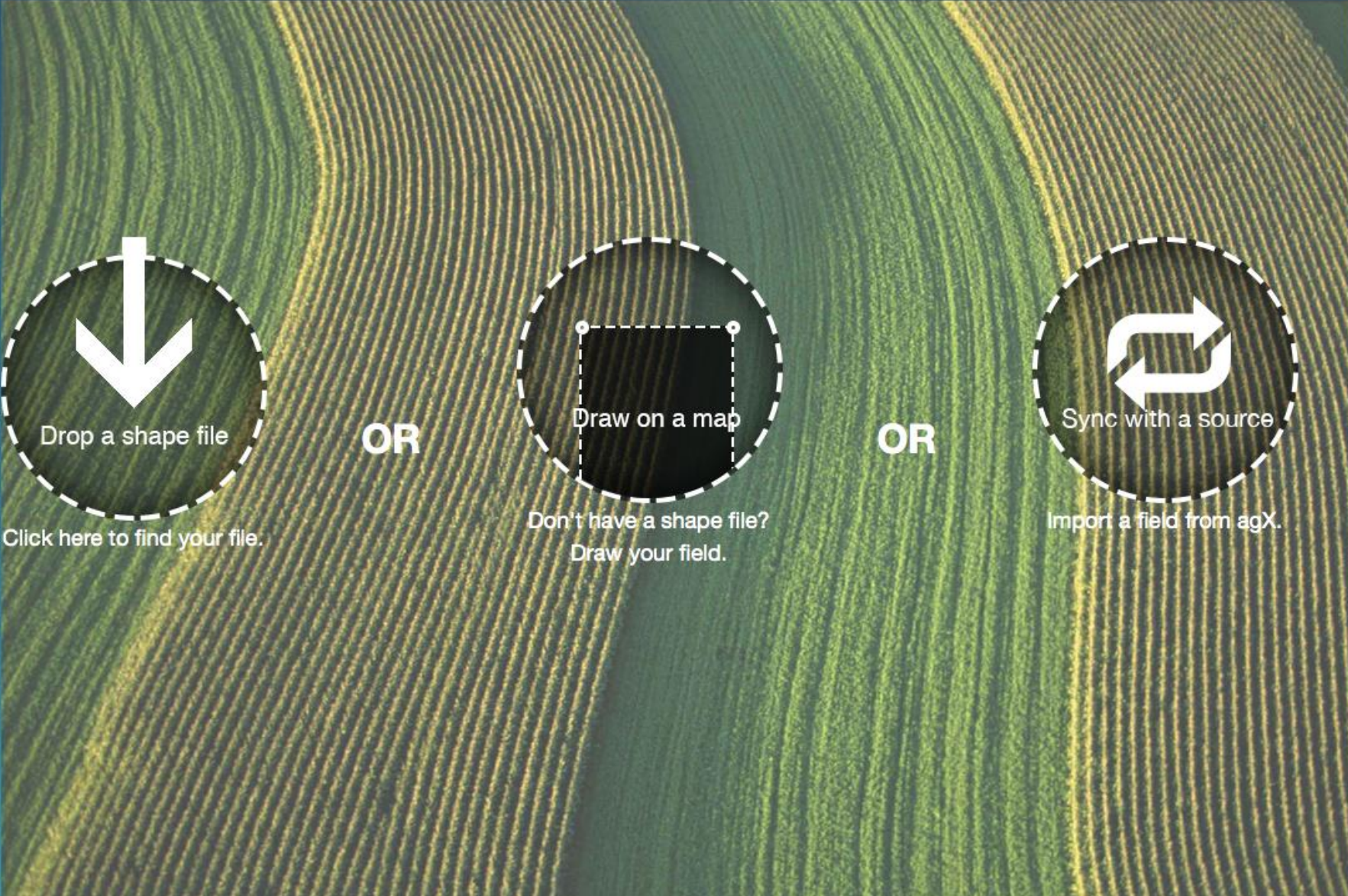
2nd Sidedress



- Adapt-N offers win-win solutions
- Importance of good input data to achieve precise recommendations
- Recent upgrades have improved recommendations
- Complex models are needed to deal with diversity of conditions

Creating recommendations

Loading field data



Hi, Greg

summary

land

soil

crop

applications

settings

logout

Drop a shape file

Click here to find your file.

OR

Draw on a map

Don't have a shape file?
Draw your field.

OR

Sync with a source

Import a field from agX.

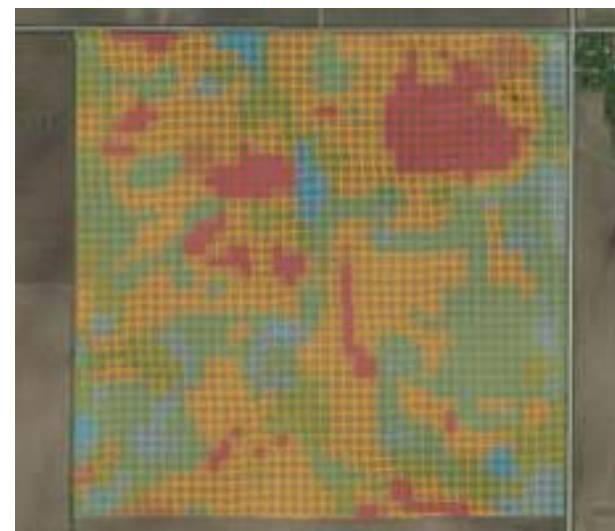
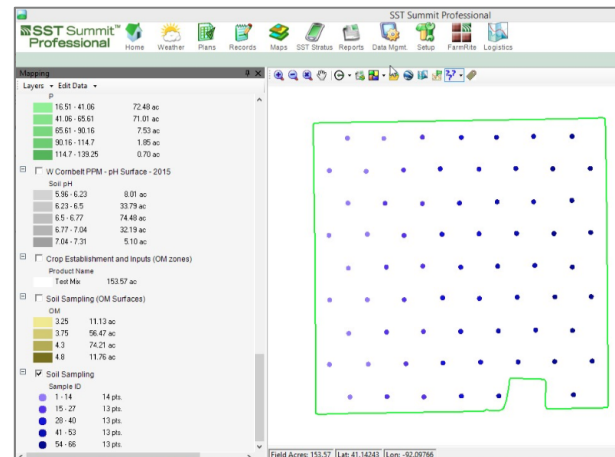
Fundamental objective: minimize time

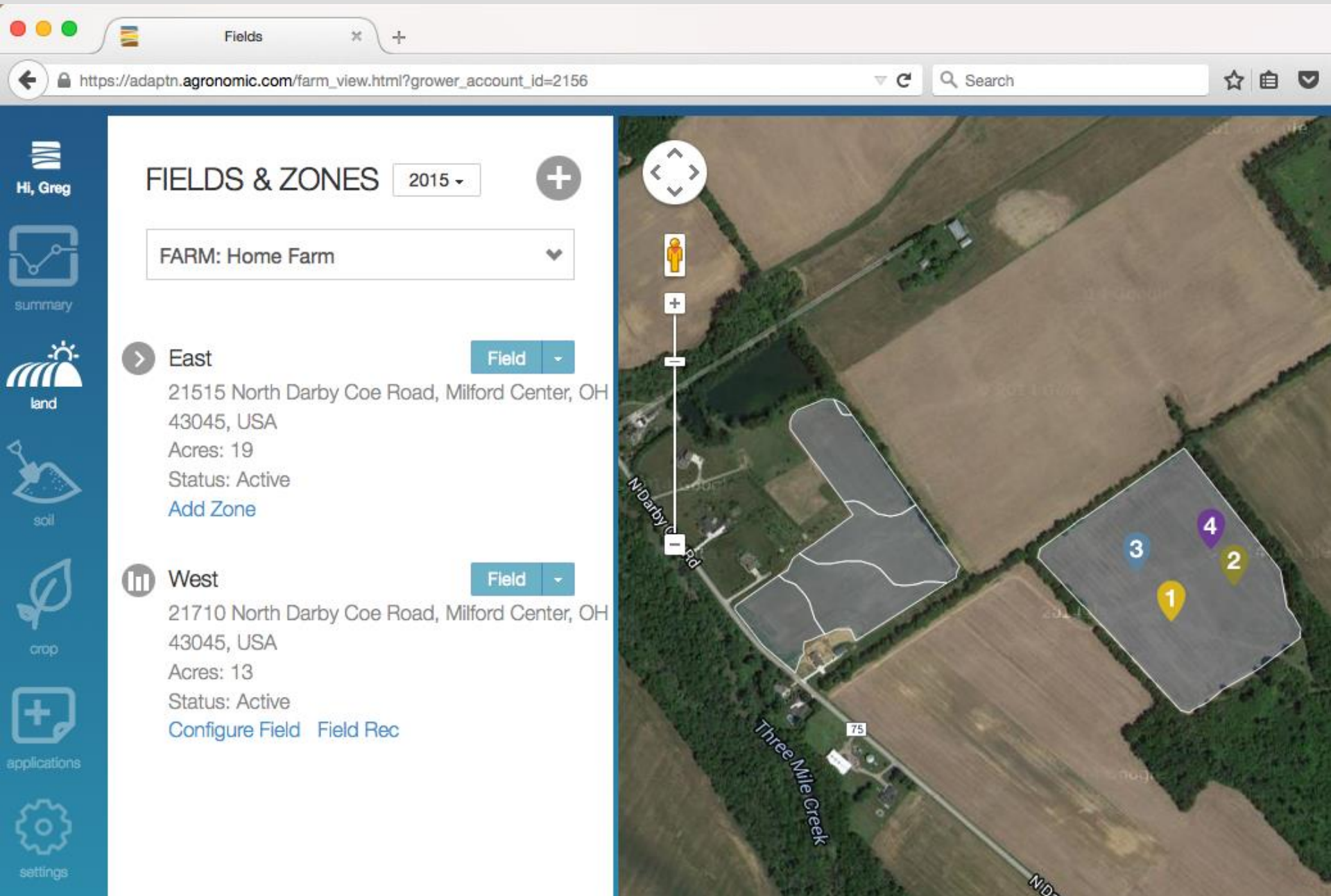
- Make use of data where it already exists
- Agree on and use a data standard
- Streamline workflows

 **SST Software**
Manage Data. Harvest Information.

 **agX**®
The language of agriculture.


adapt-N





The screenshot displays a web browser window with the URL `https://adaptn.agronomic.com/farm_view.html?grower_account_id=2156`. The interface is divided into a left sidebar, a central panel, and a right map area.

Left Sidebar: Contains navigation icons and labels: "Hi, Greg", "summary", "land", "soil", "crop", "applications", and "settings".

Central Panel: Titled "FIELDS & ZONES" with a "2015" dropdown and a "+" button. It lists two fields:

- East:** 21515 North Darby Coe Road, Milford Center, OH 43045, USA. Acres: 19. Status: Active. Includes an "Add Zone" link and a "Field" dropdown.
- West:** 21710 North Darby Coe Road, Milford Center, OH 43045, USA. Acres: 13. Status: Active. Includes "Configure Field" and "Field Rec" links, and a "Field" dropdown.

Right Map Area: An aerial map showing two outlined fields. The field on the right contains four numbered zones: 1 (yellow), 2 (green), 3 (blue), and 4 (purple). Map controls like a compass, person icon, and zoom buttons are visible on the left side of the map.

Flexible zone creation options

Single zone



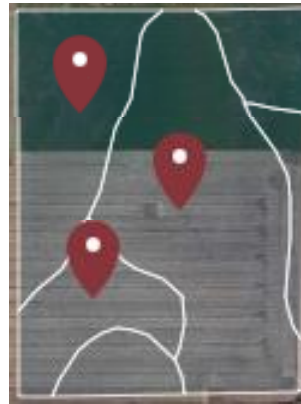
Multi-zone



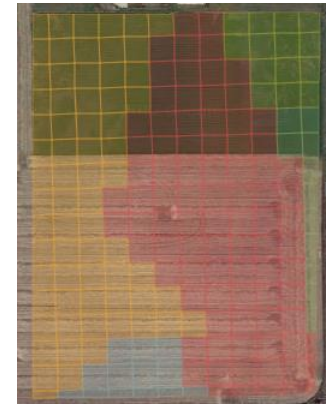
Full field
variable rate



N rec for flat rate
application or basic
nitrogen analysis



Simple VRT, or analysis
by soil type, yield goal,
organic matter, etc.



Powerful multi-variable VRT
prescriptions, exportable to
other systems

Agronomic inputs

- Soil Type/Texture
- Slope
- Soil Organic Matter
- Prior crop info
- Planting info, expected yield
- Tillage method and details
- Existing and expected applications:
 - Nitrogen rate, type, placement, date, stabilizer
 - Manure type, rate, incorporation, and analysis
 - Irrigation

We go where the data is

Soil Organic Matter

Last Updated by Greg Test on June 23rd, 2015 11:04 AM ET



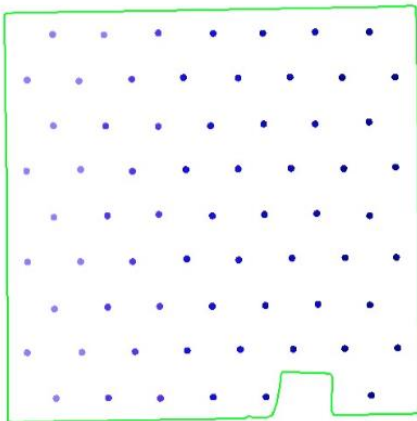
Upload a shapefile



Sync with a source



Enter a constant value



Example: Using Shapefiles to load soil organic matter data in grid-sampled or zone-sampled format.

We go where the data is

Soil Organic Matter

Last Updated by Greg Test on June 23rd, 2015 11:04 AM ET



Upload a shapefile



Sync with a source



Enter a constant value



Example: Syncing soil test data from another system



We go where the data is

[Soil Organic Matter](#)

Last Updated by Greg Levow (Adapt-N Staff) on July 15th, 2015 05:55 PM ET



Soil Test Sample Depth (Inches)

Constant Soil Organic Matter %

Submit

Users always have the option to enter data manually.

Modeling includes complex dynamics

APP

Grower: FIPS 19 - Iowa

Farm: FIPS 125 - Marion

Knoxville: vrt288

Application Date

2015-07-08

2015

Incorporate

Incorporate

Amount

3500

Manure

Dairy

APPLY IRRIGATION 2015

Grower: FIPS 19 - Iowa

Farm: FIPS 125 - Marion

Knoxville: vrt288

Application Date

2015-07-08

Inches

1.5

Add

PAST APPLICATIONS

DATE APPLIED	AMOUNT IN INCHES	DELETE	EDIT
2015-07-01	1.5		

PAST APPLICATIONS

DATE APPLIED	APPLICATION	FERTILIZER TYPE
05/05/15	Starter	Urea

Plus:

- Tillage method, % cover, etc.
- Planting info, expected yield
- Crop rotation
- Down the road: cover crops, soil health component, and more...



Hi, Greg



summary



land



soil



crop



applications



settings

logout

FIELD RECOMMENDATION

YYYY-MM-DD

Go

Recommendation for 07/28/2015

0 / 41 / 95 / 1,378

lbs N/acre (min/avg/max/total)

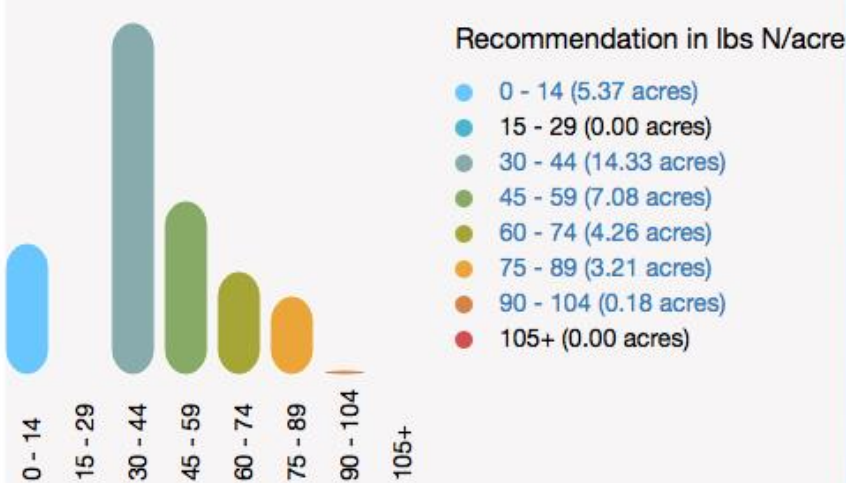
Grower FIPS 19 - Iowa
Farm FIPS 125 - Marion
Field Knoxville
Acres 34

[Export Recommendation](#)

FIELD CONFIGURATION

Planting Date 05/05/2015
Maturity Class Grains: 99 day corn
Previous Crop Grain Corn
Tillage Method Conservation Tillage
Rainfall Since Planting 19.1"
Estimated Growth Stage V18

	min	avg	max
Organic Matter (%)	1.20	2.35	3.70
Harvest Population	27,500	28,153	35,000
Yield Target (bu/acre)	160	165	220





Hi, Greg



summary



land



soil



crop



applications



settings

logout

FIELD RECOMMENDATION

YYYY-MM-DD

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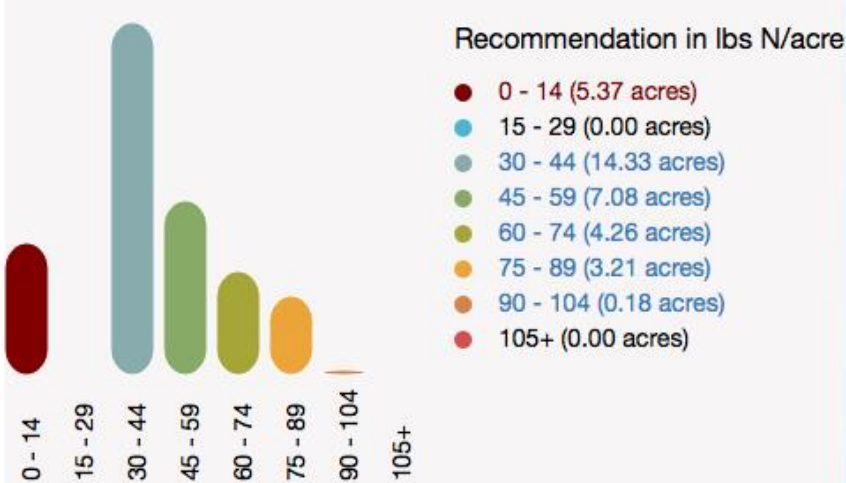
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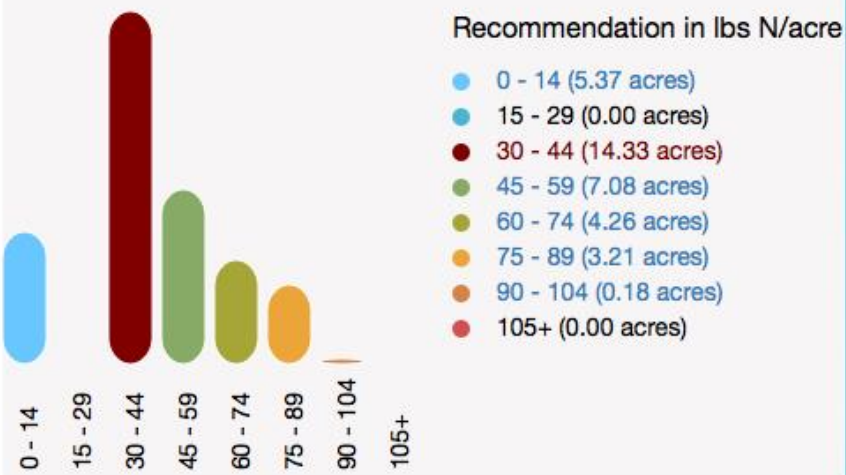
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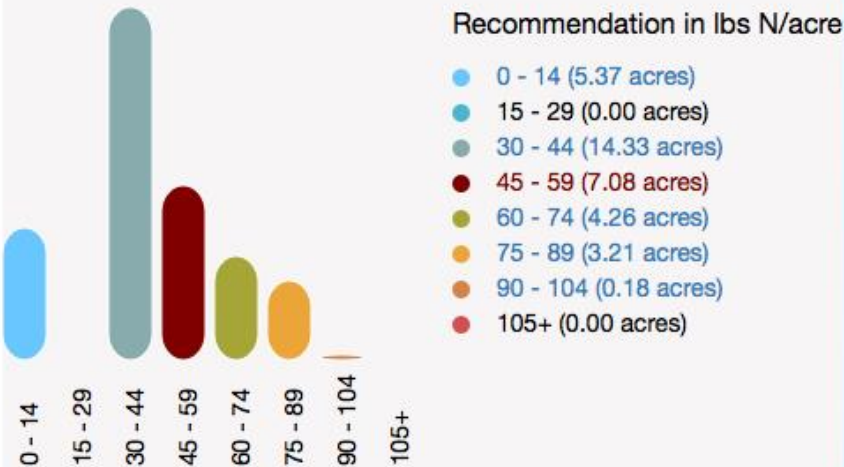
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FIELD RECOMMENDATION

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Recommendation for 07/28/2015

0 / 41 / 95 / 1,378

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Grower FIPS 19 - Iowa

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Field Knoxville

Acres 34

Export Recommendation

FIELD CONFIGURATION

Planting Date 05/05/2015

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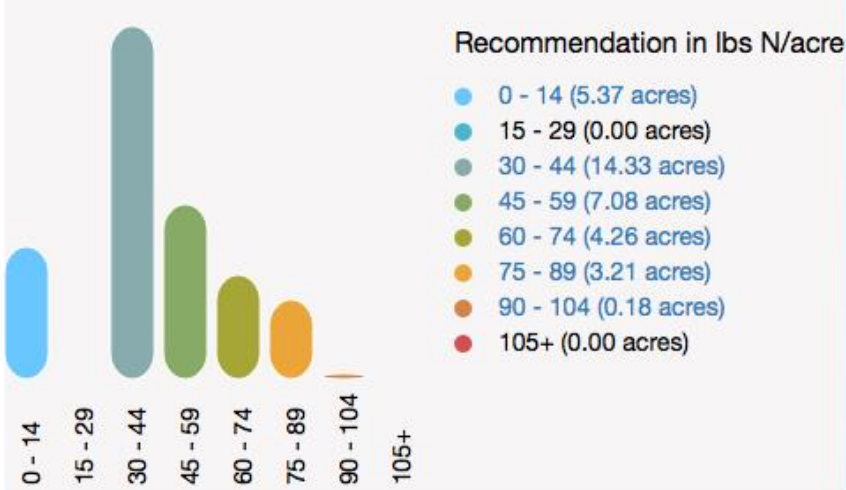
Previous Crop Grain Corn

Tillage Method Conservation Tillage

Rainfall Since Planting 19.1"

Estimated Growth Stage V18

	min	avg	max
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Yield Target (bu/acre)	160	165	220



Supporting estimates



RECOMMENDATION

YYYY-MM-DD

Go

Created for 2015-Jul-28.



60 lbs N/Acre
Sidedress N Recommendation

58 - 65
Rec Range (lbs N/Acre)

30 lbs N/Acre
N Fertilizer Already Applied

Recommendation based on 2015's configuration and the simulation year's supporting estimates, and assumptions:

164 lbs N/Acre
Expected N in crop at harvest

24 lbs N/Acre
N mineralization so far

36 lbs N/Acre
N loss so far

0 lbs N/Acre
Partial credit from soybeans

86 lbs N/Acre
N in crop now

2 lbs N/Acre
Expected Future Fertilizer Loss

9 lbs N/Acre
Future Net N Credits

4 lbs N/Acre
N in soil now

19.1"/24.5"
Rainfall since planting / since 01/01/15

1 lbs N/Acre
Current Nitrate N top 12"
Virtual PSNT: 0.3 ppm

6.6"/6.6"
Water in root zone / field capacity

4 lbs N/Acre
Root zone inorganic N

View as a [short](#) or [full](#) PDF. View [Graphs](#). Get [help](#) with these values.

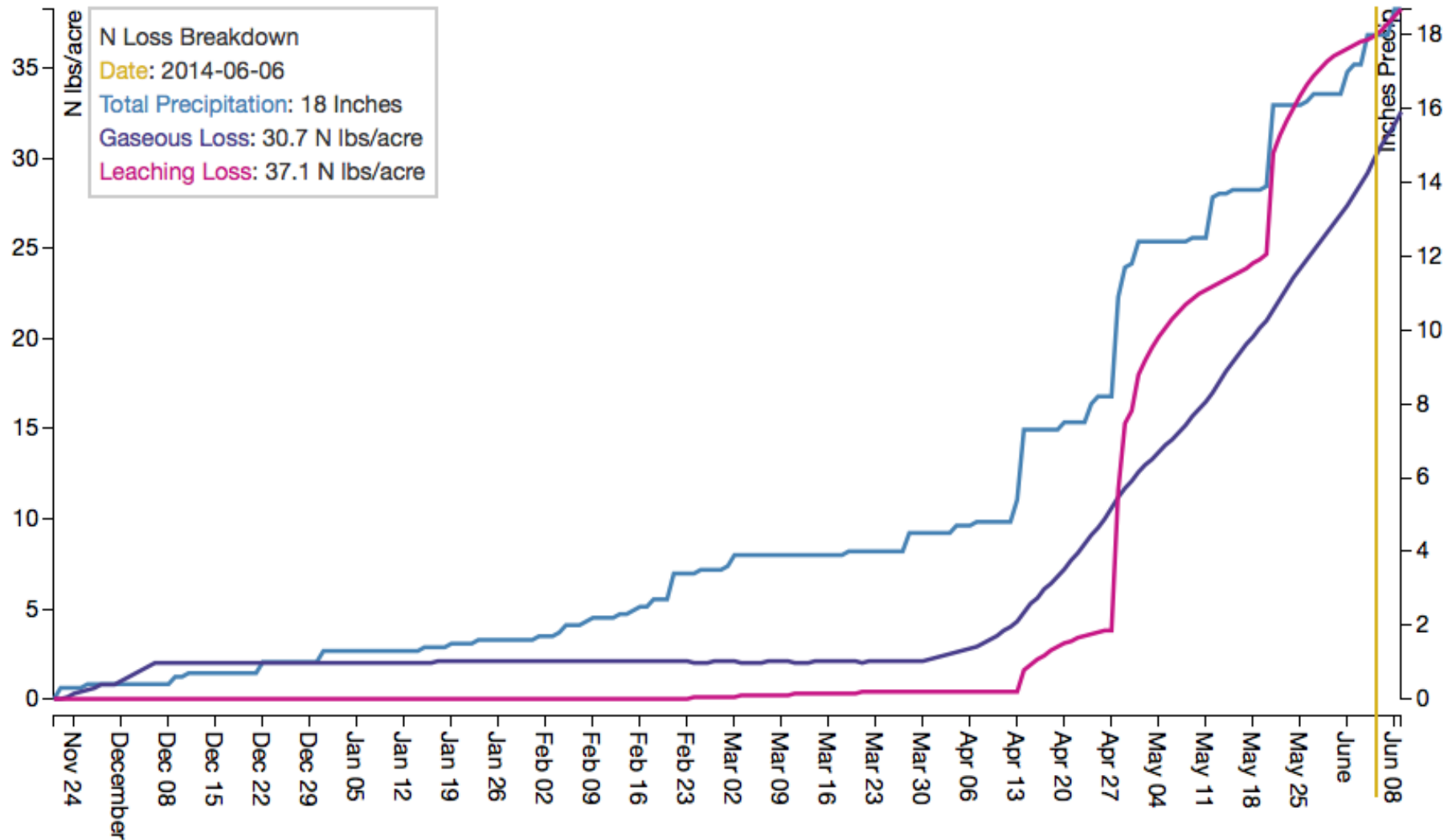
Data was last updated 2015-Jul-28 18:26:07 ET.

Detailed support for all recommendations gives users key insights into our modeling results so ground observations and other tools can be used in complement.

Graphs provide detailed insight

Grower: Ian's Farm (IA) Farm: Ian's Farm (IA) Field: Skunk River West Zone: Whole Field

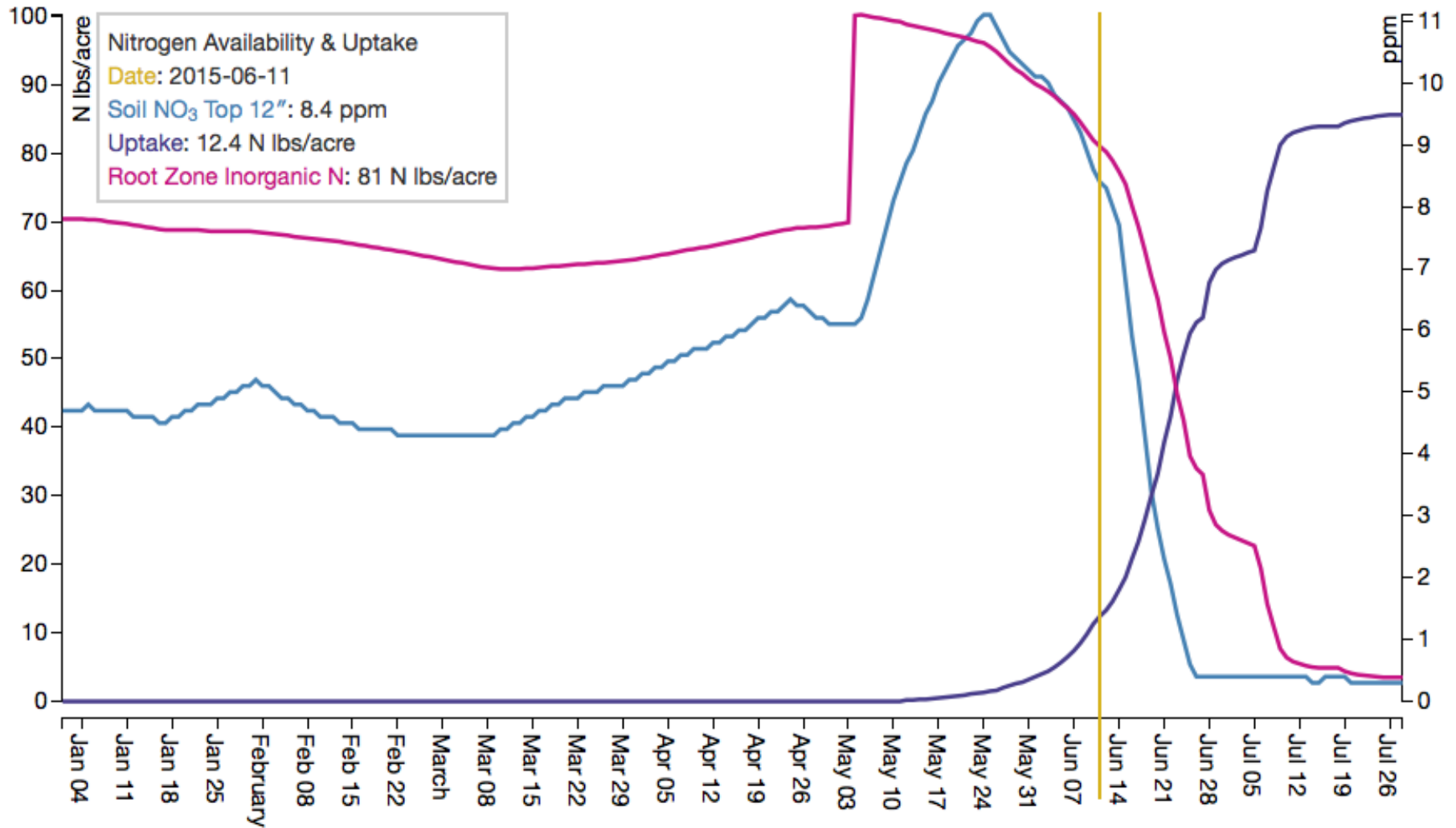
Total N Loss & Precipitation - N Loss Breakdown - Mineralized N & Temperature - Nitrogen Availability & Uptake - Crop Growth & N Uptake



Graphs provide detailed insight

Grower: FIPS 19 - Iowa Farm: FIPS 125 - Marion Field: Knoxville Zone: vrt196

Total N Loss & Precipitation - N Loss Breakdown - Mineralized N & Temperature - Nitrogen Availability & Uptake - Crop Growth & N Uptake



Multi-year analysis

1

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FIELD RECOMMENDATION

YYYY-MM-DD

Go

«

July 2015

»

Su	Mo	Tu	We	Th	Fr	Sa
28	29	30	1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	1
2	3	4	5	6	7	8

Recommendation for 07/28

0 / 41 / 95 / 1,000

lbs N/acre (min/avg/max/total)

Grower FIPS 19 - Iowa

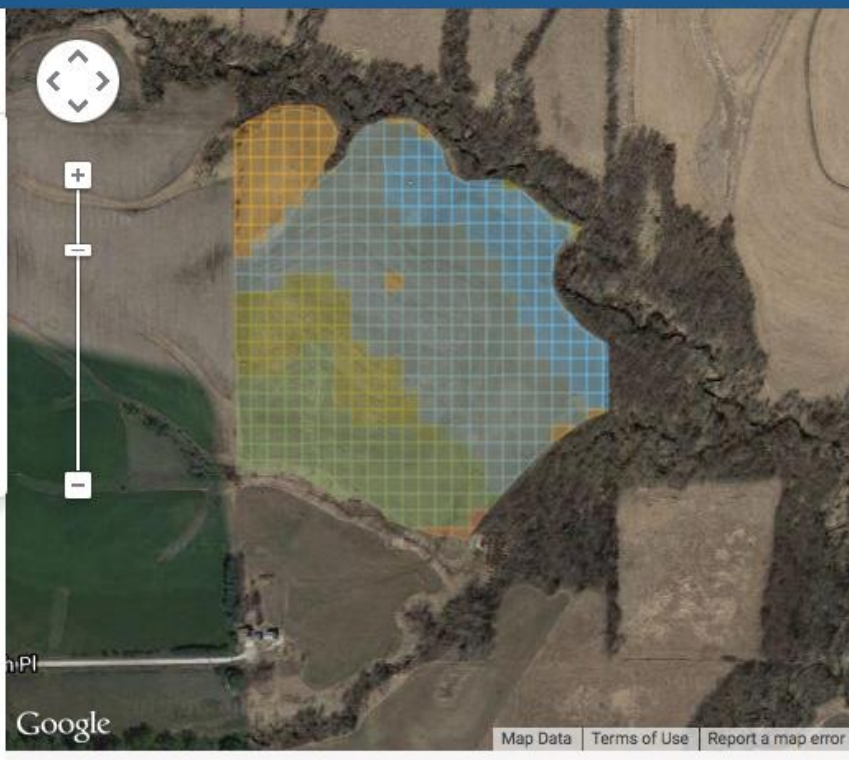
Farm FIPS 125 - Marion

Field Knoxville

Acres 34

FIELD CONFIGURATION

Planting Date 05/05/2015



+

-

hPI

Google

Map Data Terms of Use Report a map error

Select from historical weather years to compare recommendations under different scenarios

2015 vs. 2012 (Iowa)

FIELD RECOMMENDATION

2015-07-28

Go

2015
19" rain

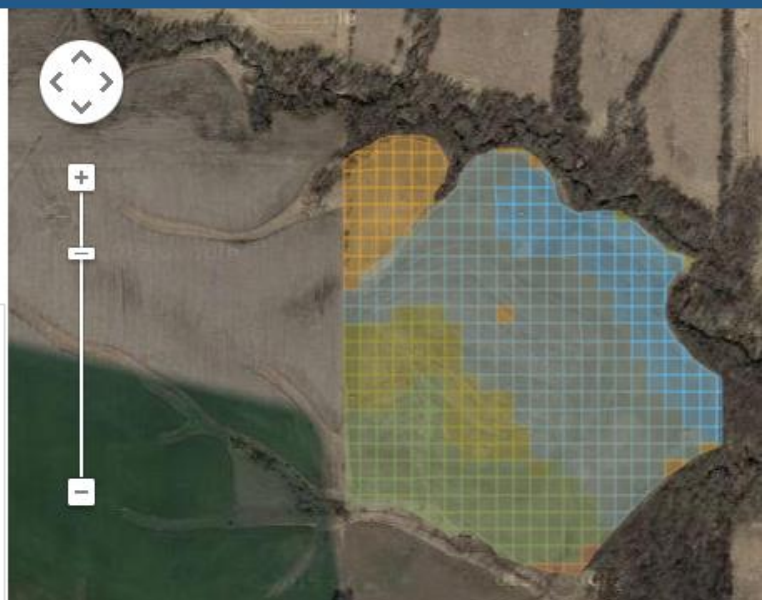
Recommendation for 07/28/2015

0 / 41 / 95 / 1,378



Recommendation in lbs N/acre

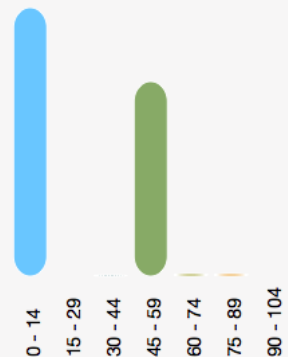
- 0 - 14 (5.37 acres)
- 15 - 29 (0.00 acres)
- 30 - 44 (14.33 acres)
- 45 - 59 (7.08 acres)
- 60 - 74 (4.26 acres)
- 75 - 89 (3.21 acres)
- 90 - 104 (0.18 acres)
- 105+ (0.00 acres)



2012
7" rain

Recommendation for 08/28/2012

0 / 25 / 85 / 824



Recommendation in lbs N/acre

- 0 - 14 (19.70 acres)
- 15 - 29 (0.00 acres)
- 30 - 44 (0.07 acres)
- 45 - 59 (14.24 acres)
- 60 - 74 (0.24 acres)
- 75 - 89 (0.18 acres)
- 90 - 104 (0.00 acres)
- 105+ (0.00 acres)



Flexible export options

FIELD RECOMMENDATION EXPORT

Export Type

Shapefile ▼

Nitrogen Product

UAN (32-0-0) (Liquid) ▼

Percentage

100% ▼

Empty Area Treatment

Set to field avg ▼

Value

N/A

Set Floor Value (Min)

Select ▼

Value

N/A

Set Ceiling Value (Max)

Set to custom value ▼

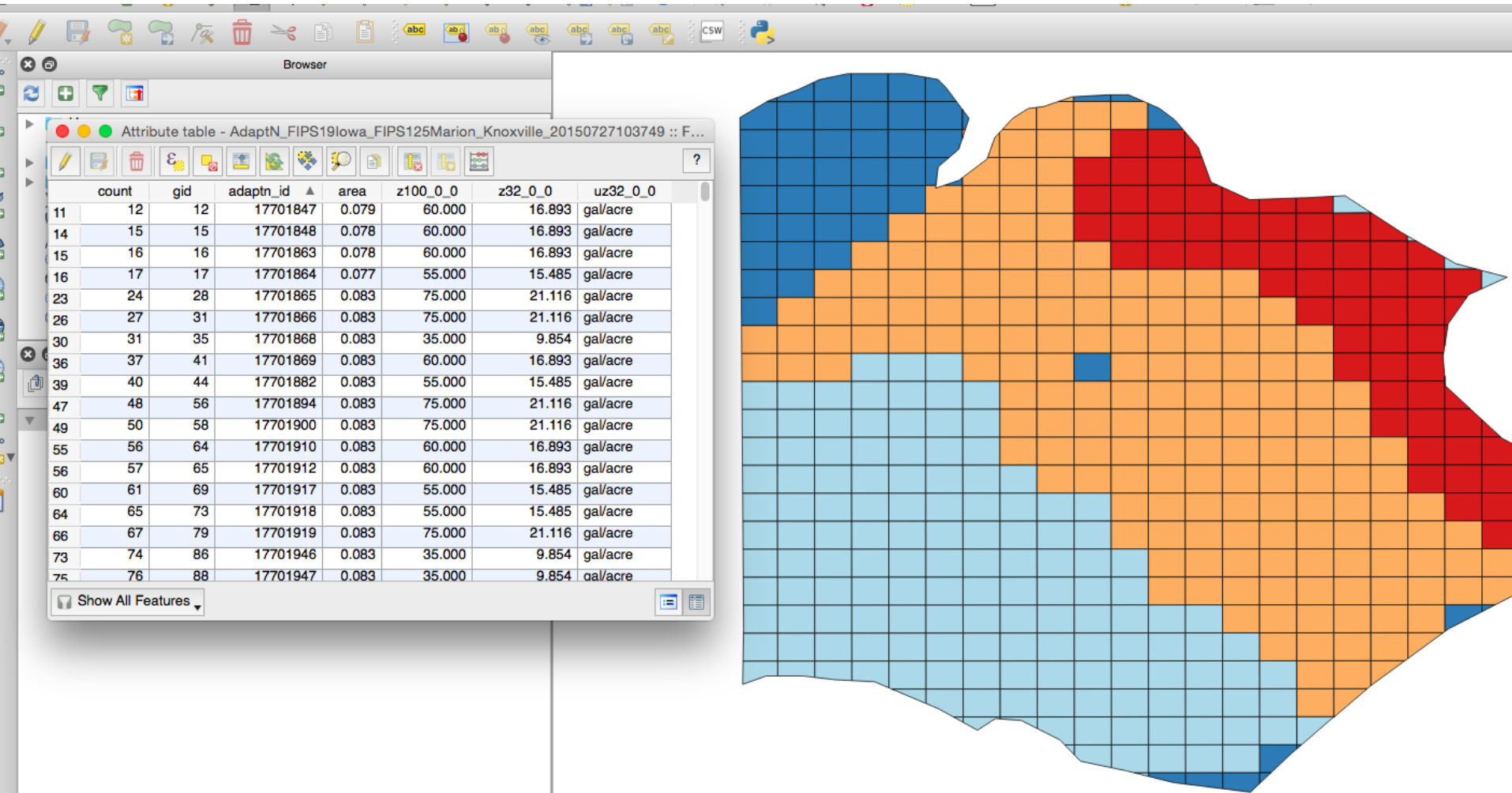
Value

90



Export as a Shapefile or to other systems in whatever form of nitrogen will be applied






Adapt-N rec as a Shapefile



Daily dashboards

GROWERS, FARMS & FIELDS

Viewing: **Active Fields** ▾

NAME	ACTIVE	ACRES	STAGE	RECOMMENDATION	PAST APPLIED	ACTION
Grower: Miller Farms (MN)	-	153	V0 - V18	+Nitrogen		
Farm/Field : Home Farm (MN) / Northeast Quarter	✓	146	V18 - V18	45 - 45 lbs/acre	60.0 - 60.0 lbs/acre	
Farm/Field : Waite Park / County Hwy 6	✓	7	V17 - V17	105 - 105 lbs/acre	120.0 - 120.0 lbs/acre	
Grower: Nyman Farms (NY)	-	22	V0 - V18	+Nitrogen		
Farm/Field : Home Farm / Middle Road 22	✓	22	V18 - V18	0 - 110 lbs/acre	0.0 - 100.0 lbs/acre	
Grower: Ohlson Farms (OH)	-	31	V0 - V18	+Nitrogen		
Farm/Field : Woodville Farm / Home 30	✓	31	V18 - V18	50 - 90 lbs/acre	0.0 - 35.0 lbs/acre	
Grower: Williams Farms (WI)	-	52	V0 - V19	+Nitrogen		
Farm/Field : Williams Dairy - Home Farm (WI) / Quarry 33	✓	33	V19 - V19	60 - 65 lbs/acre	0.0 - 0.0 lbs/acre	

Quickly view the N needs and status across all growers based on daily summary dashboards

Email/SMS alerts



The following fields and/or zones have recommended Nitrogen application values that exceed their alert threshold. Summary:

- 3 farms
- 3 fields
- 4 zones, max: 85, min: 65, avg: 73

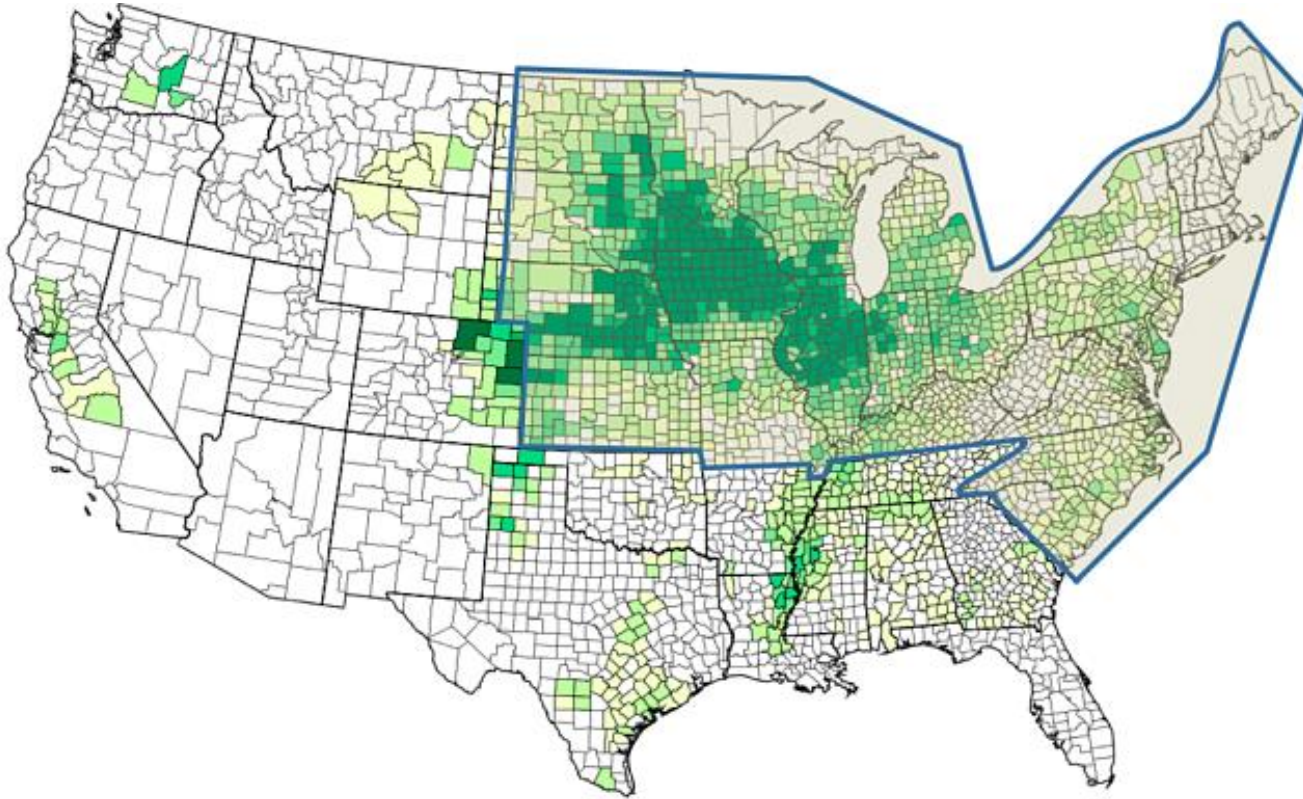
Alert Threshold: 40

Farm	Field	Zone	Stage	Rec
Jones	Jones	Main	V5	65
Reed	Reed	Main	V5	85
Reed	Reed	adapt N Trial	V5	75
Rons	Rons	adapt N Trial	V5	70

Recommendations generated at 2015-06-10 04:47:05 Eastern.



Widely deployed and growing


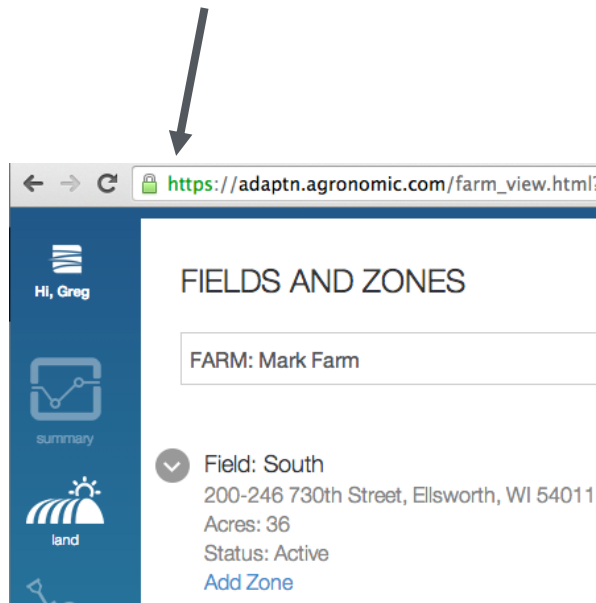


- 28 states and expanding
- Additional crops being added

- Enables sales agronomists to provide a consistent nitrogen recommendation service across the territory
- We don't market directly to growers, but enable your brand to provide scientifically-based N recs as a service
- Flexible account structure: dashboards, multi-user, alerts, reporting, and login access for your growers (if desired)
- Identify/enhance additional crop nutrition sales opportunities, while providing an environmentally responsible N management service
- Margin opportunities for your precision program

Data Privacy and Security

- Data intent
- Grower Bill of Rights
- HTTPS Encryption

Science Results Features Uses In Action ▾Sign Up Login

Grower Bill of Rights

Welcome to Agronomic Technology!

We are committed to Grower data security, control, and privacy, and the use of that data to help Growers improve their economic and environmental performance. In addition to "data policy" we believe in data that is independent, used only for intended reasons specified by the grower, and unbiased.

Grower Bill of Rights

- Data policy and use should be clear:
 - We will clearly explain what the data policies are. This includes who has access to data (who can see it, use it, or take control of it).
- Data belongs to the grower:
 - We will never rent or sell your data.
 - We will encourage adoption of data standards that are in the public trust.
- Data use should be used for its intended purpose:
 - By default, we will only use data in our system to provide results, improve our service and quality, and understand what features users desire down the road.
- Grower authorization for additional data use — including how they terminate that use — should be explicit:
 - For data uses other than those listed above, we will provide a clear and transparent explanation of the program and we will not proceed to use your data without your approval.
 - For any other program that you opt into, you will be able to end your participation through a process clearly outlined during the signup process.
 - An offer from a third party, including for research purposes, would be made only through us. Without an opt-in from the Grower no third party will receive any of your data as part of that communication.
- Any opt-in program will provide disclosure of:
 - What the program is and any benefit to you
 - How your participation in the program will affect your fees to us (for example, some programs may offset or eliminate your fees)
 - What data of yours will be used
 - How the data is anonymized and the level of aggregation of the results (when possible, we'll show a sample of what the consumers of the data will see)
 - To whom we are providing the results
 - What the process is around ending your participation in the program
- Our partners must be aligned with our Grower Bill of Rights
 - When we work with a partner, it is done on behalf of our Grower community. Our partners must understand and be aligned with the Grower Bill of Rights.

Thank you!

Greg Levow
greg@agronomic.com
866-208-FARM



Dr. Harold van Es
hmv1@cornell.edu

