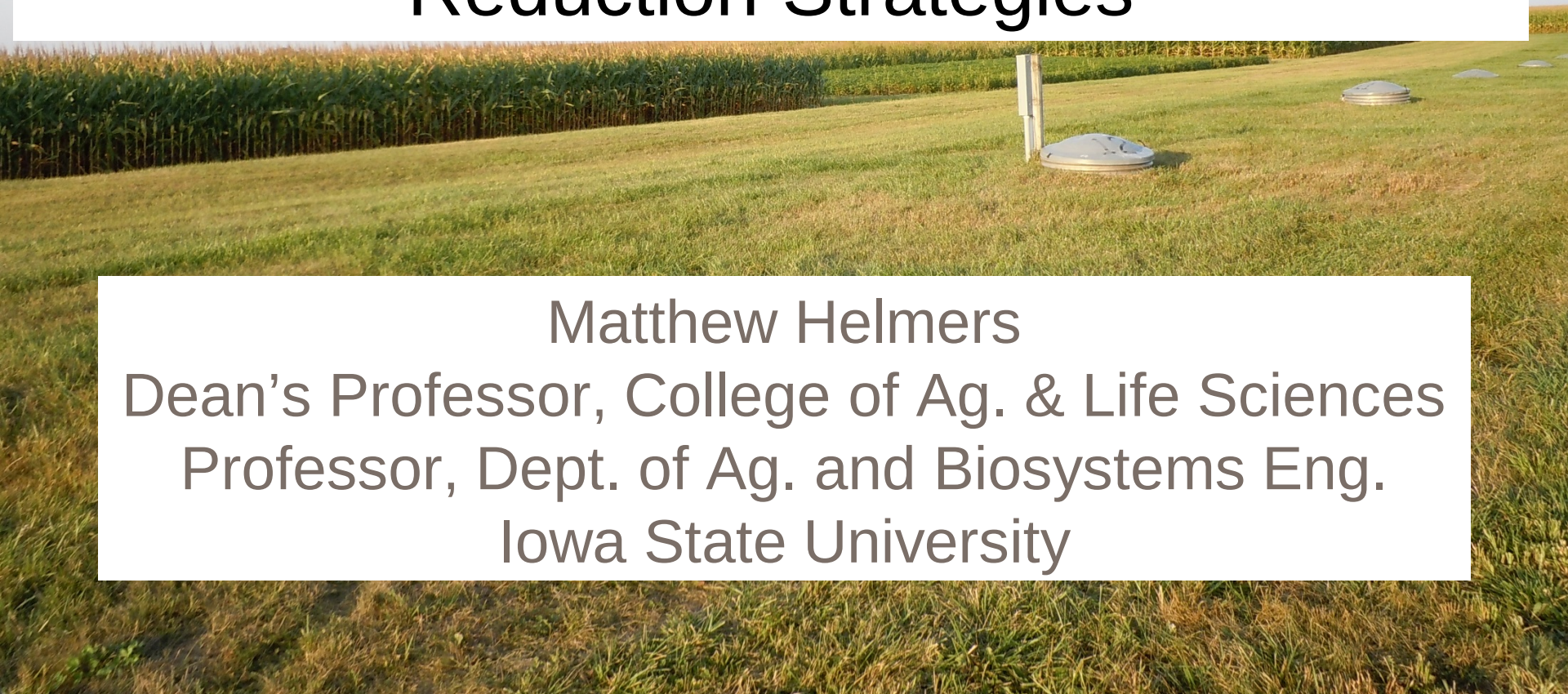
Proceedings of the 4th Annual Nitrogen: Minnesota's Grand Challenge & Compelling Opportunity Conference

IOWA STATE UNIVERSITY
Department of Agricultural and Biosystems Engineering

Drainage Water Quality Research and the Role It Plays in State Level Nutrient Reduction Strategies



Matthew Helmers
Dean's Professor, College of Ag. & Life Sciences
Professor, Dept. of Ag. and Biosystems Eng.
Iowa State University

Situation

- Increasing concern for local and regional waters
- Substantial demand for agricultural products
- Hypoxia Action Plan in 2008 called for development and implementation of comprehensive N and P reduction strategies for states in the Mississippi/Atchafalaya River Basin

Needs

- To develop nutrient reduction strategies need data on performance of practices
- Long-term data is needed to account for weather variability
- Need data to focus on implementation of practices that have greatest potential for achieving the desired results

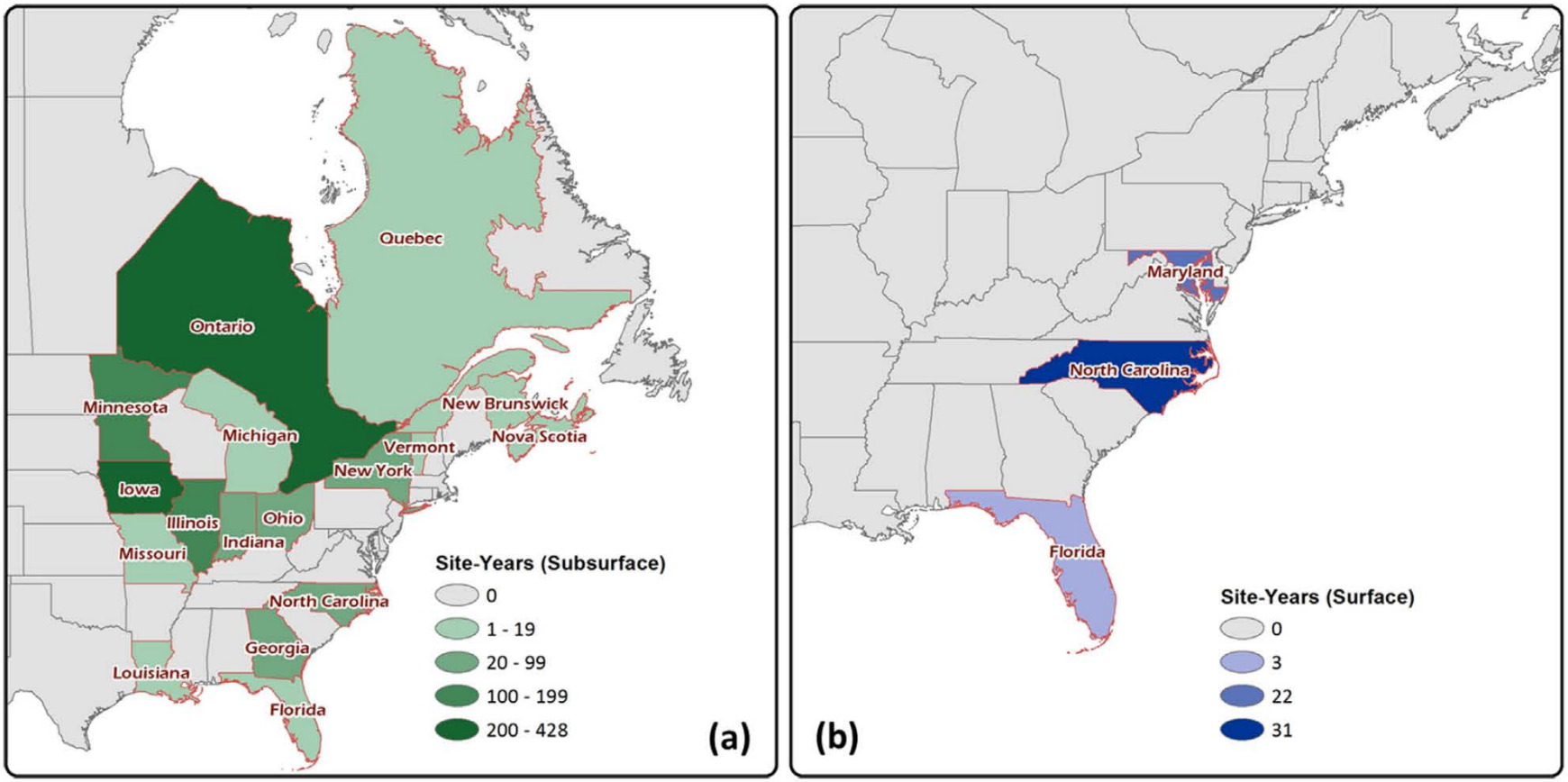
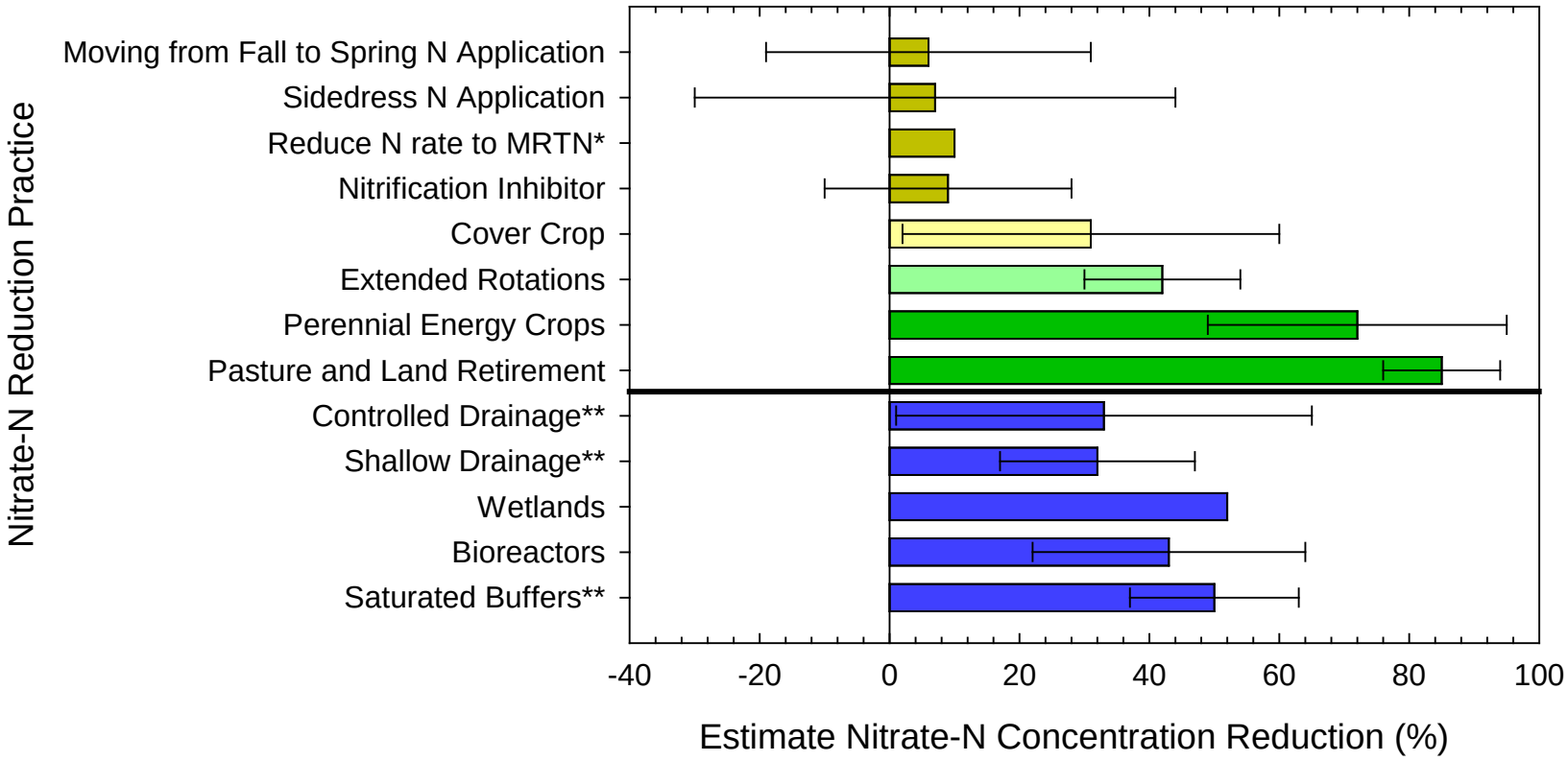


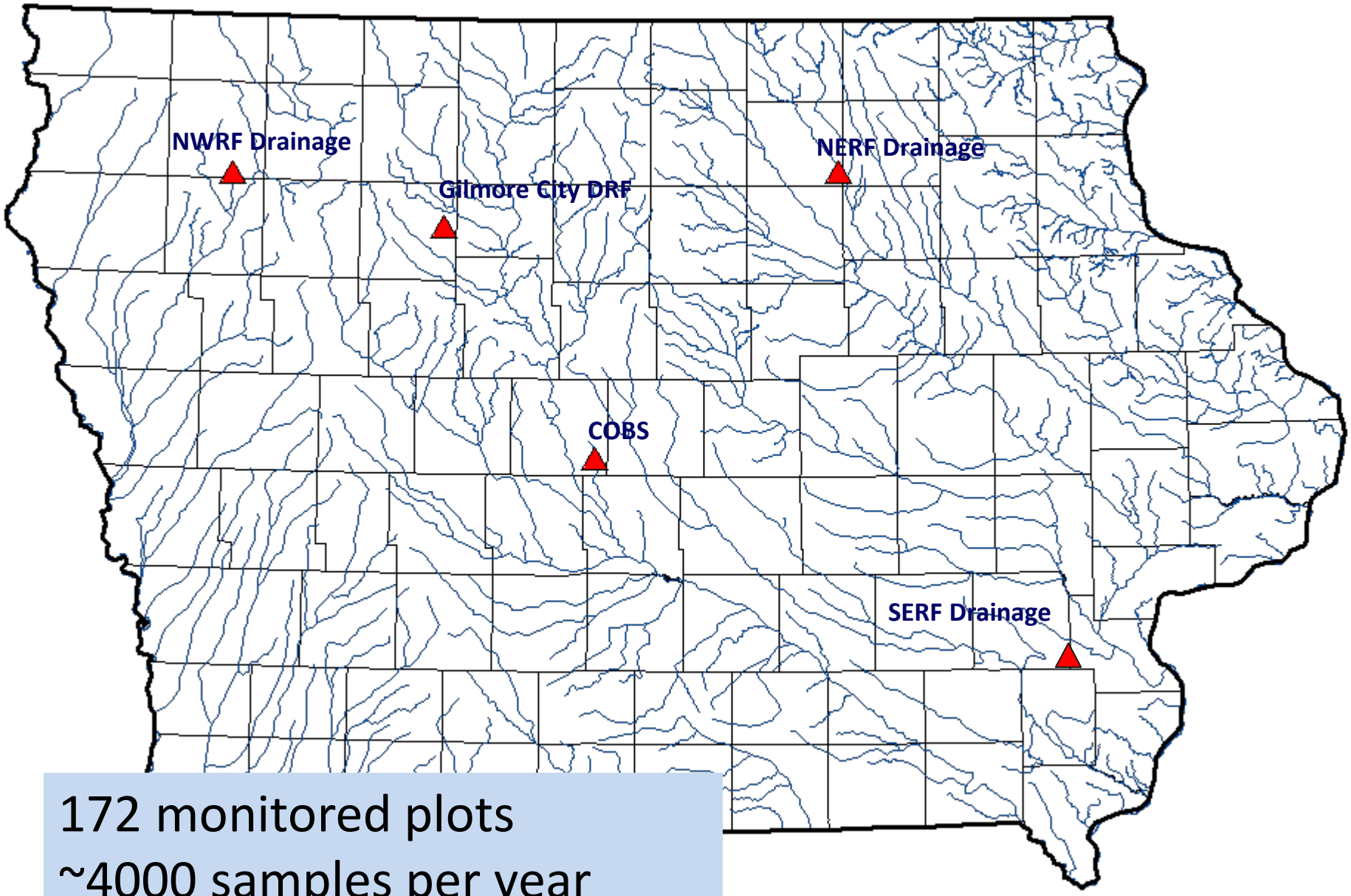
Fig. 1. MANAGE Drain Load subsurface (a) vs. surface drainage site-years (b).

Nitrate-N Practice Performance



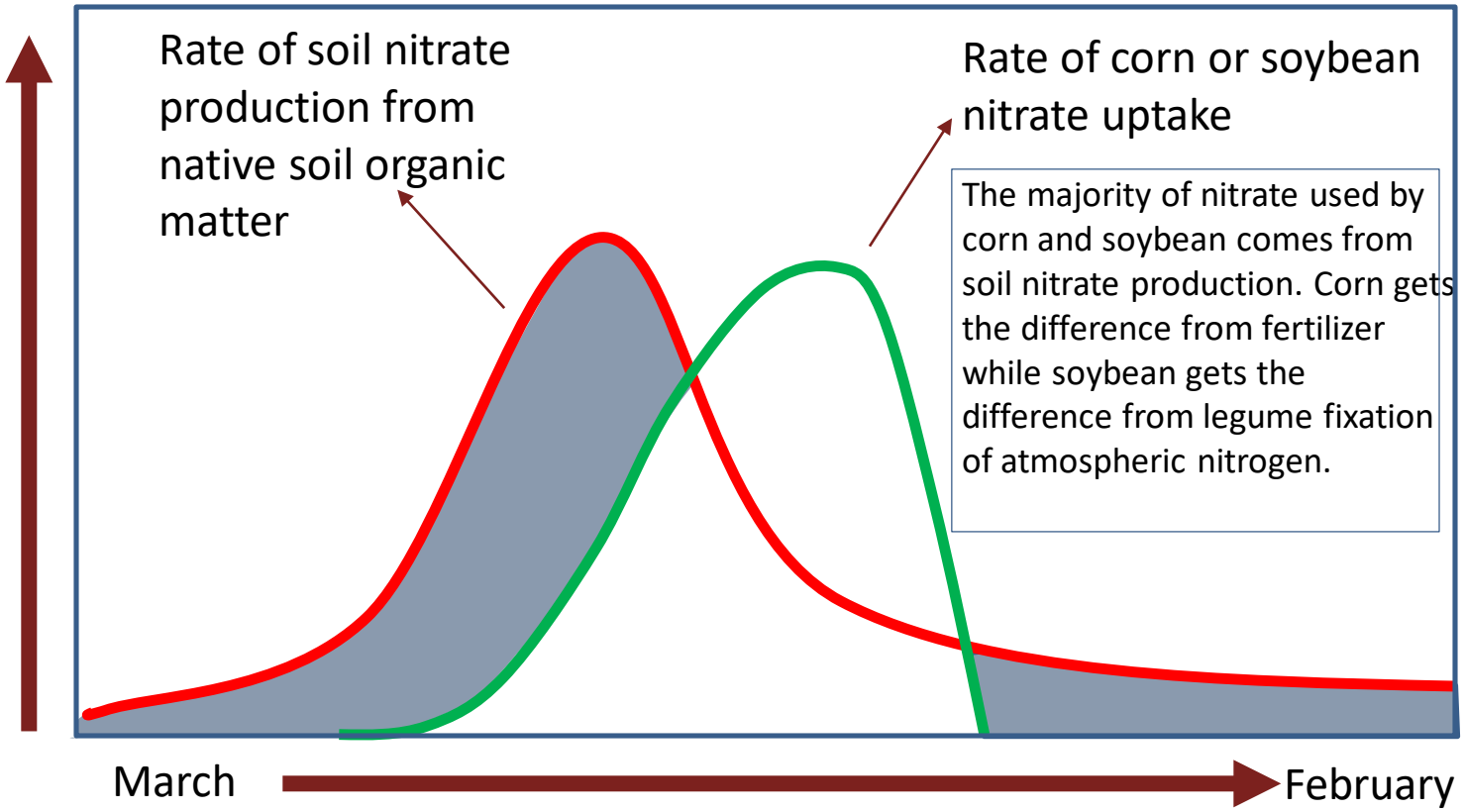
*MRTN - Maximum Return to Nitrogen Application Rate from Corn Nitrogen Rate Calculator (http://cnrc.agron.iastate.edu/)
** Load reduction
Error bars show standard deviation of practice performance

Replicated subsurface drainage plots to evaluate performance of various in-field management practices



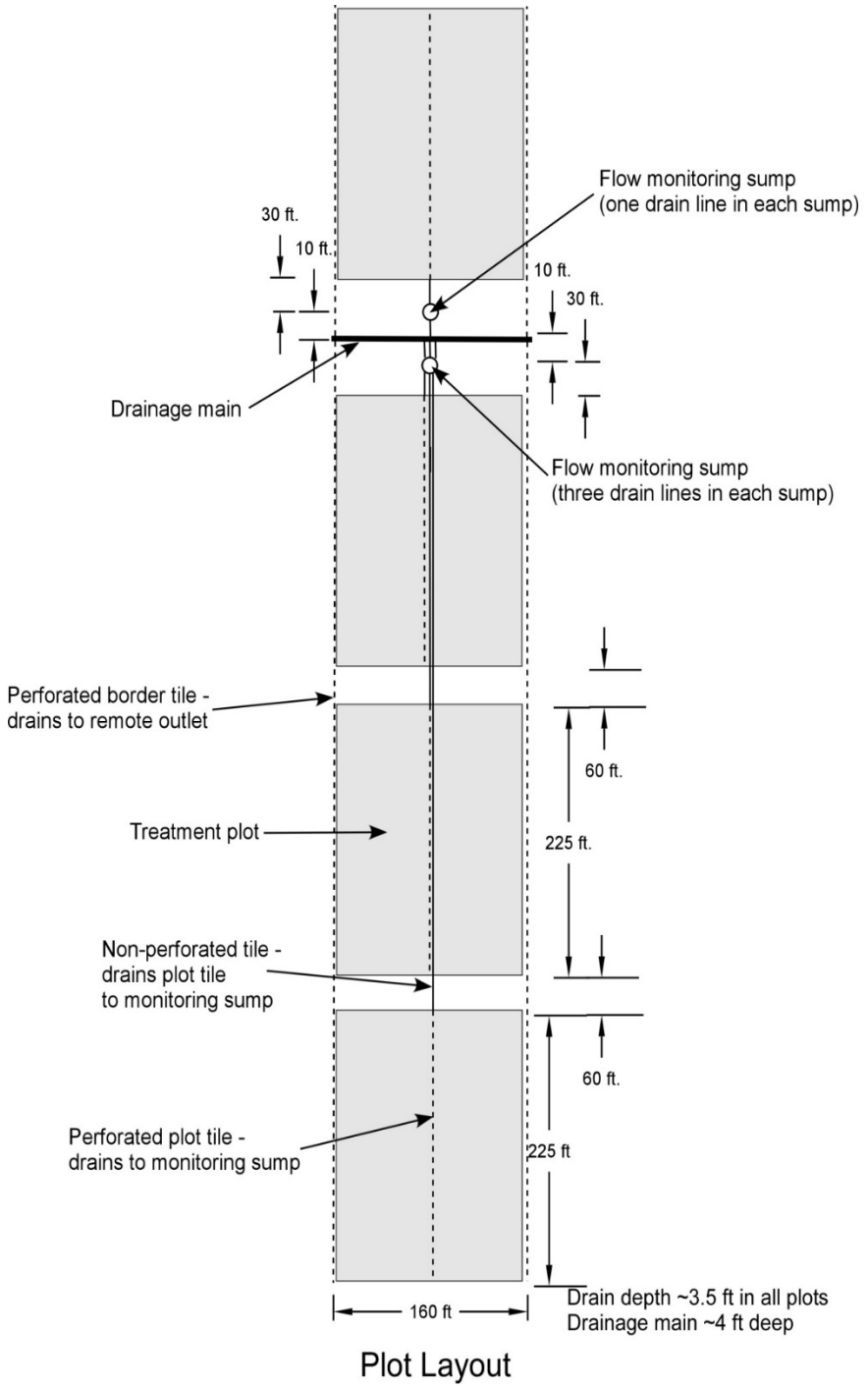
172 monitored plots
~4000 samples per year

Soil Nitrate Production *vs.* Crop Nitrate Uptake



In the shaded areas, the soil produces nitrate, but there is no crop to use it. As a result, some nitrate is lost to waterways.

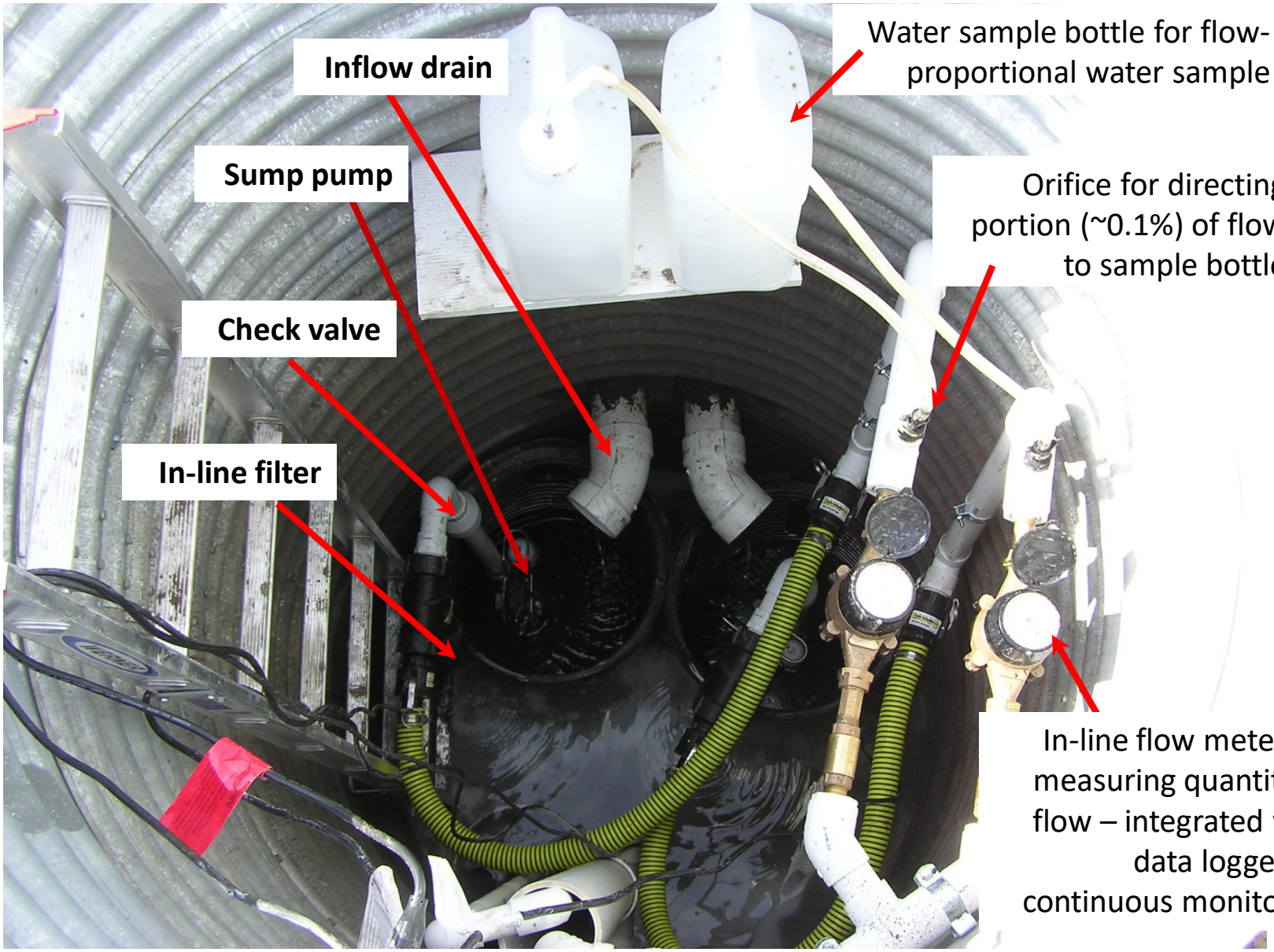
Subsurface Drainage Layout



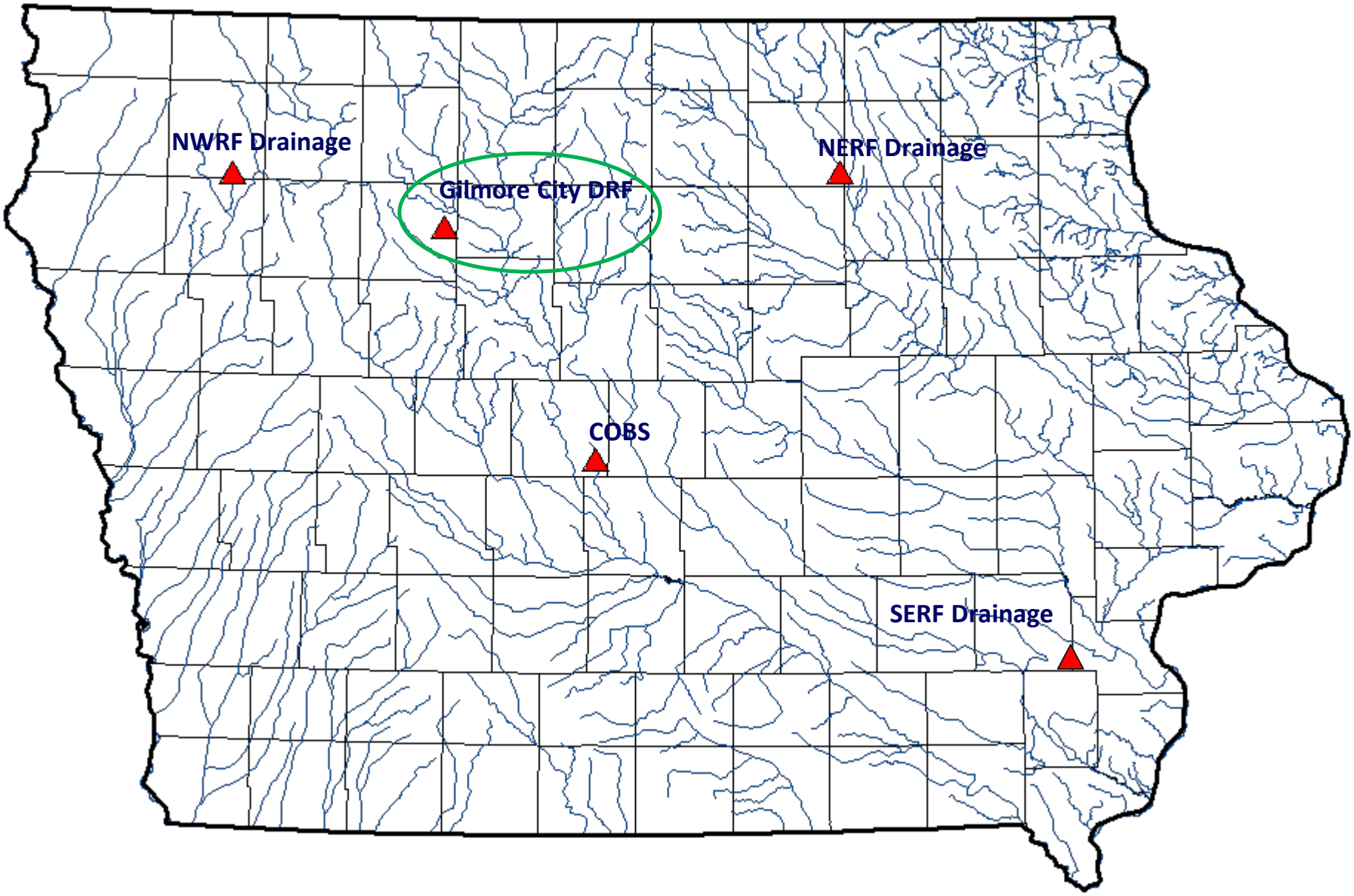
Plot Layout

Flow Monitoring System

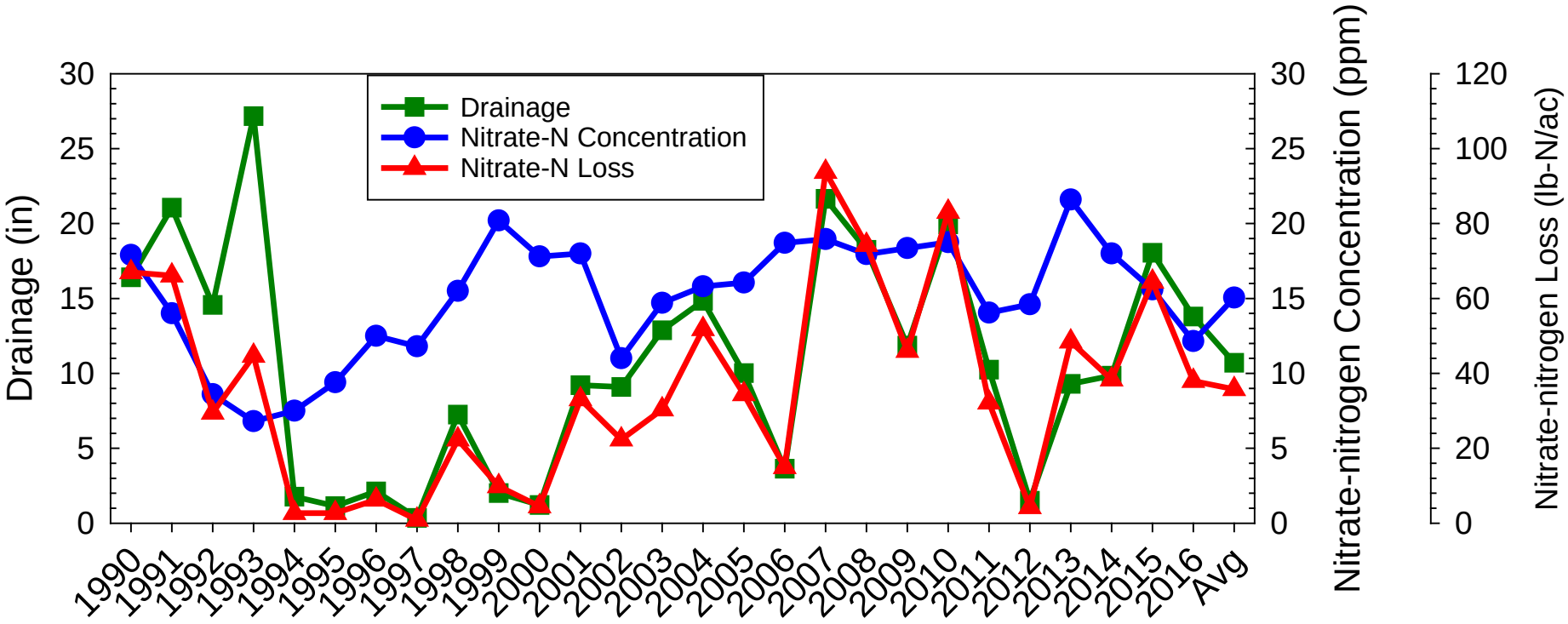
Drainage Monitoring System



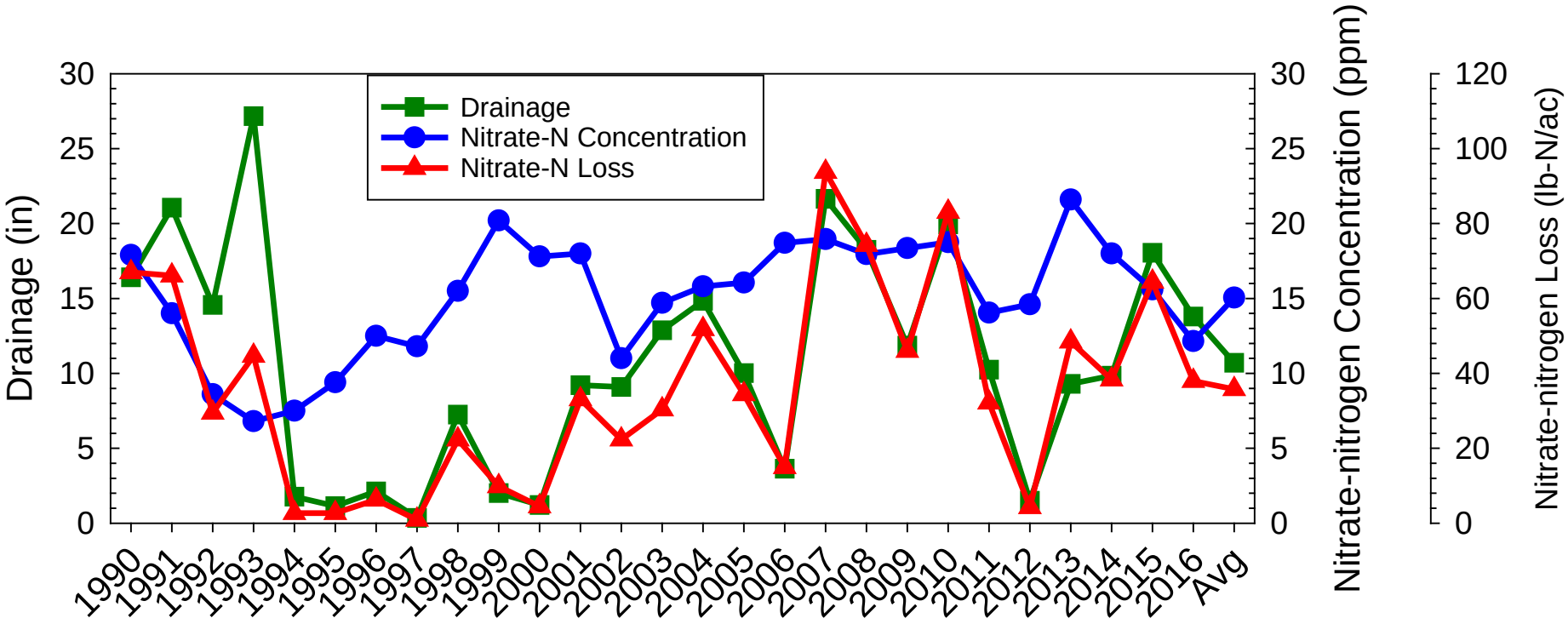
Replicated subsurface drainage plots to evaluate performance of various in-field management practices



Twenty-Seven Year Summary

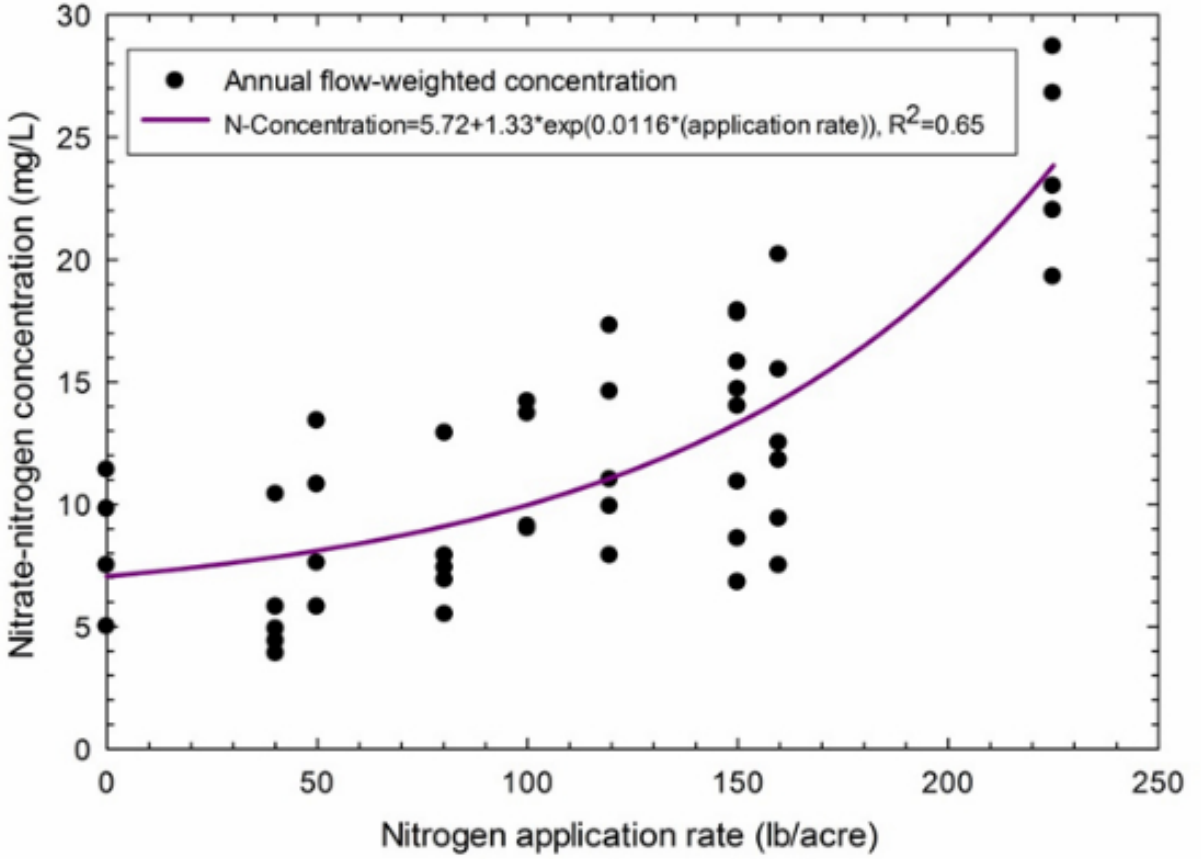


Twenty-Seven Year Summary

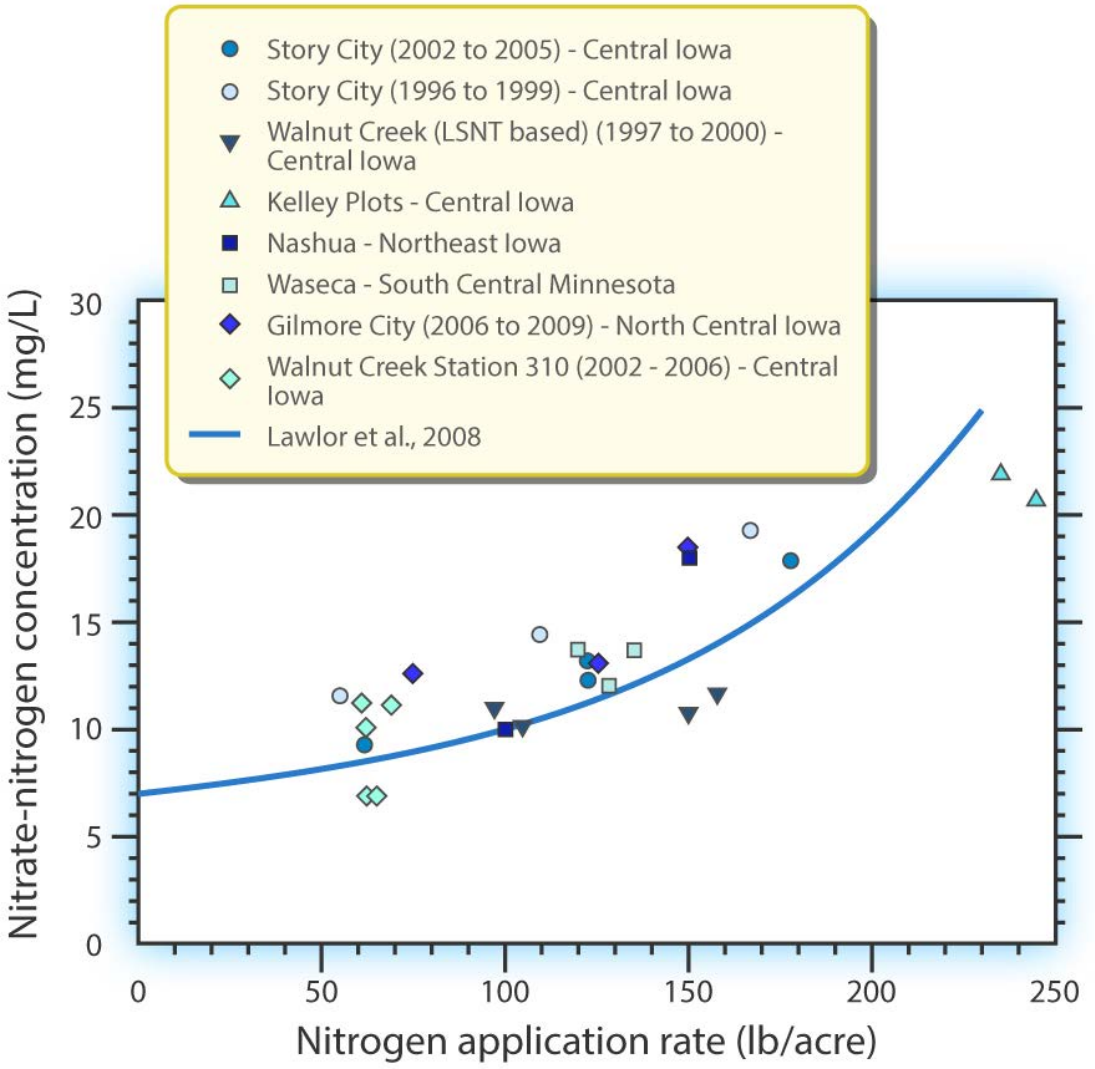


Combined Corn-Soybean System – Same N management – Early Spring Sidedress at 150-160 lb-N/acre

Nitrate Response to Nitrogen

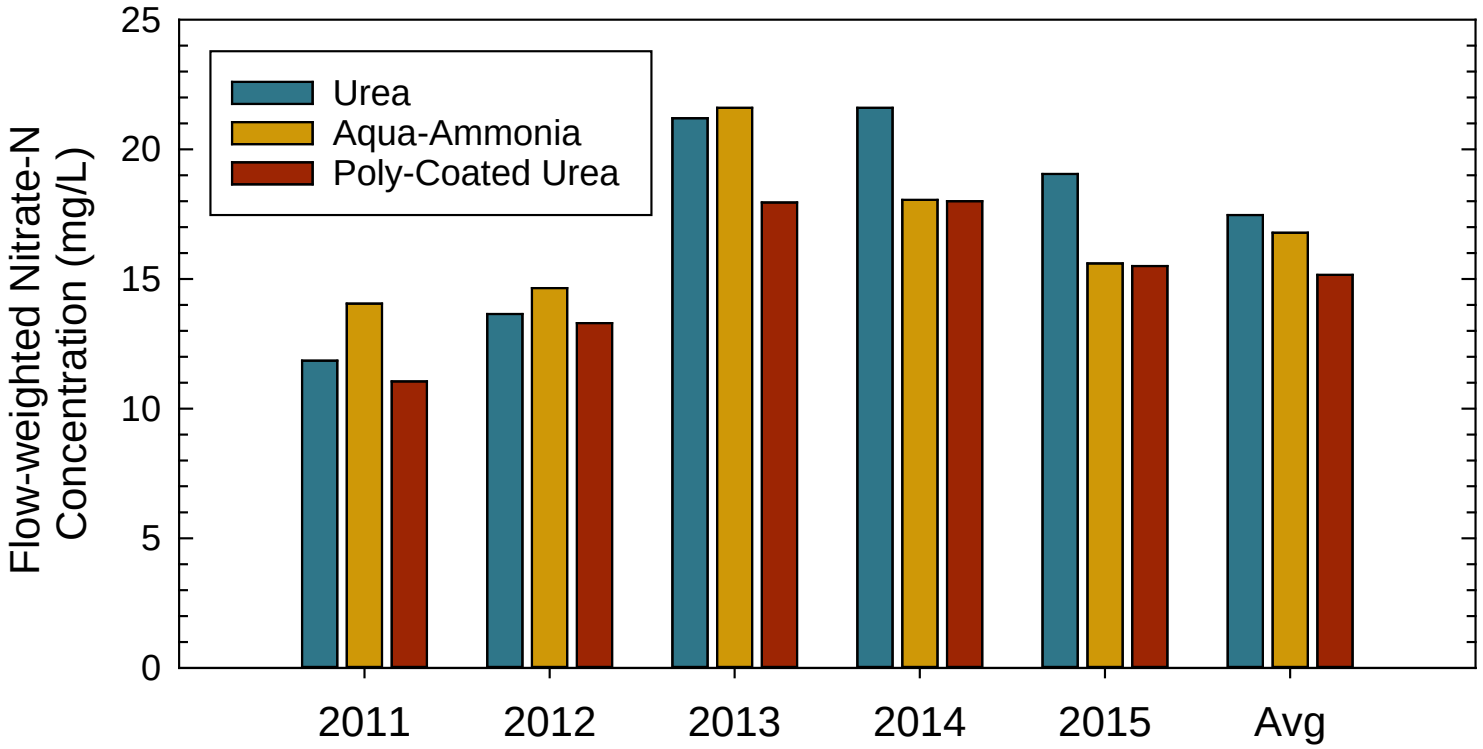


Nitrate Response to Nitrogen



Results → Nitrogen source

Averaged over the corn-soybean rotation



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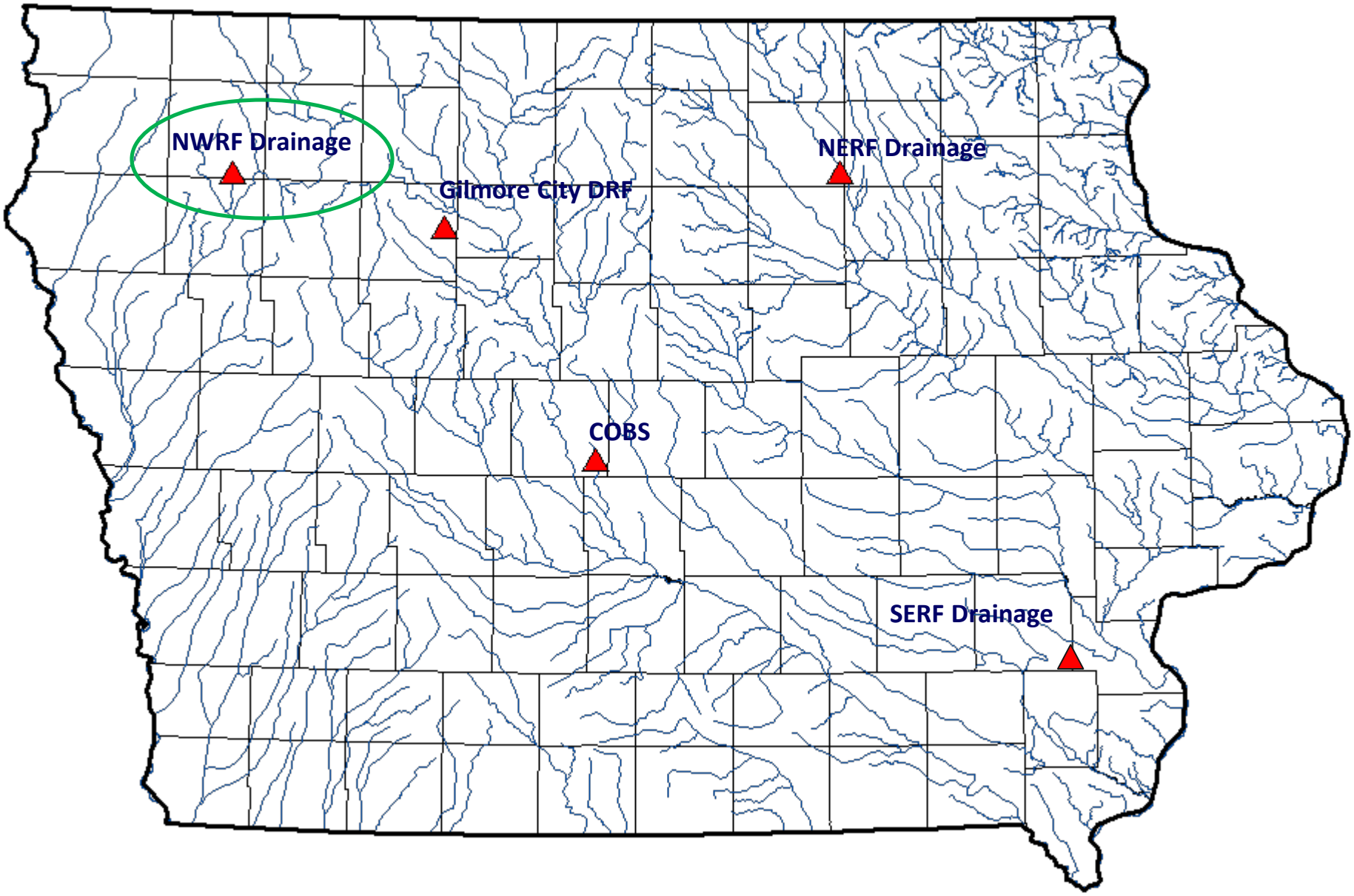
Replicated subsurface drainage plots to evaluate performance of various in-field management practices



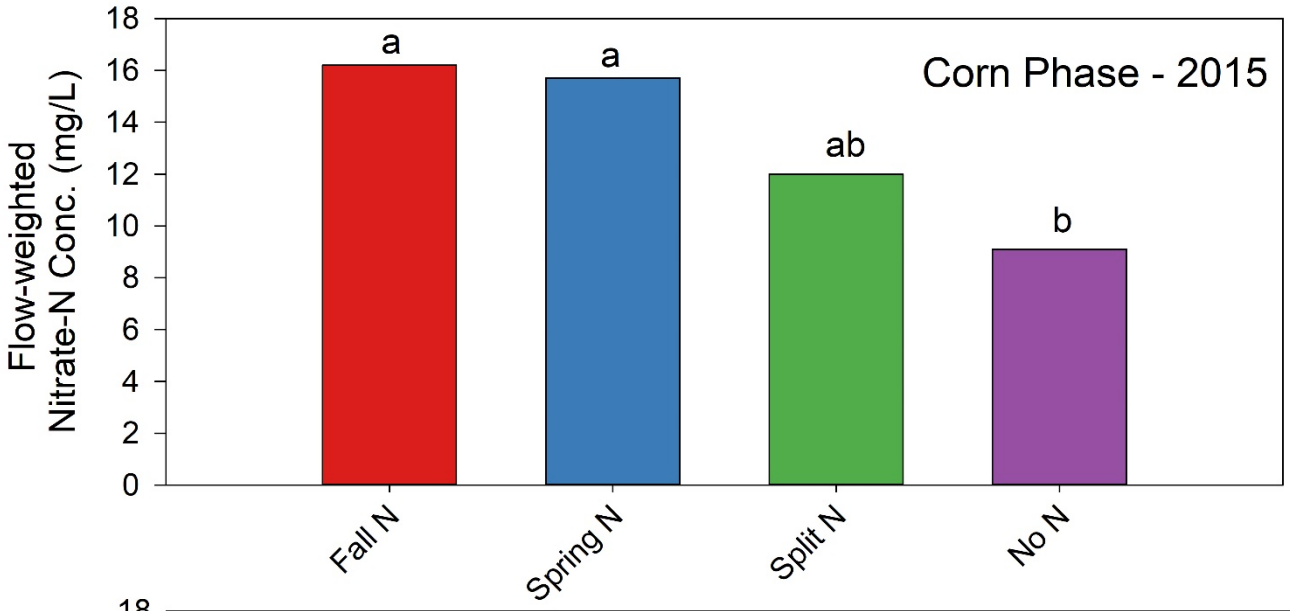
Treatments

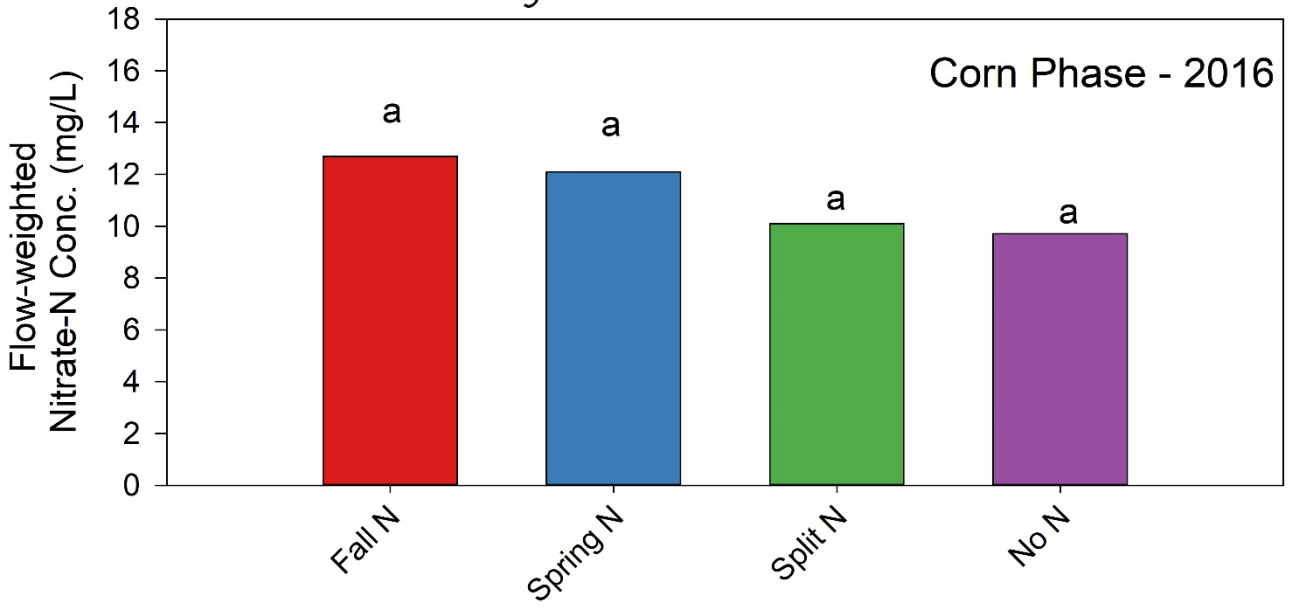
Treatment Number	Tillage	Nitrogen Application Time	Nitrogen Application Rate (lb N/acre)*
1	Conventional tillage*	Fall (anhydrous ammonia with nitrapyrin)**	135
2	Conventional tillage	Spring (anhydrous ammonia)	135
3	Conventional tillage	Split with variable N at sidedress (40 lb/acre of urea 2x2 starter at planting plus in-season agrotain treated urea)	135
4	Conventional tillage	None	0

* Fall chisel corn stalks with spring disk/field cultivate, and spring disk/field cultivate soybean stubble.

**In fall of 2014 freezing conditions occurred early and prevented fall application. Application occurred in early spring 2015.

Flow-weighted Nitrate-N Concentration

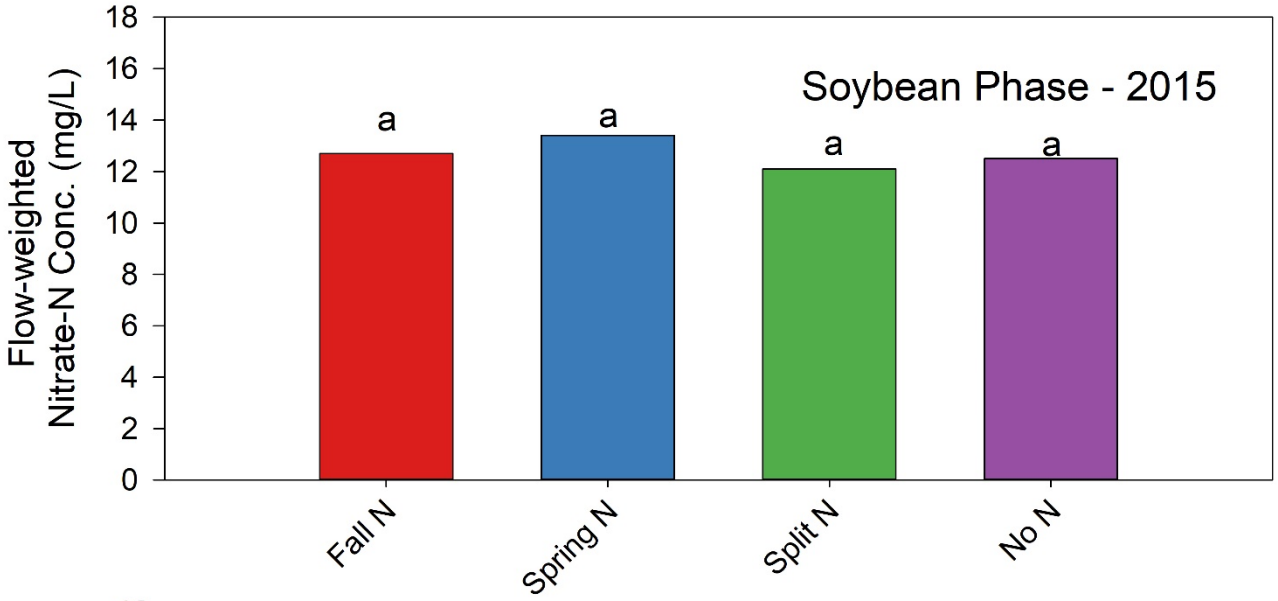


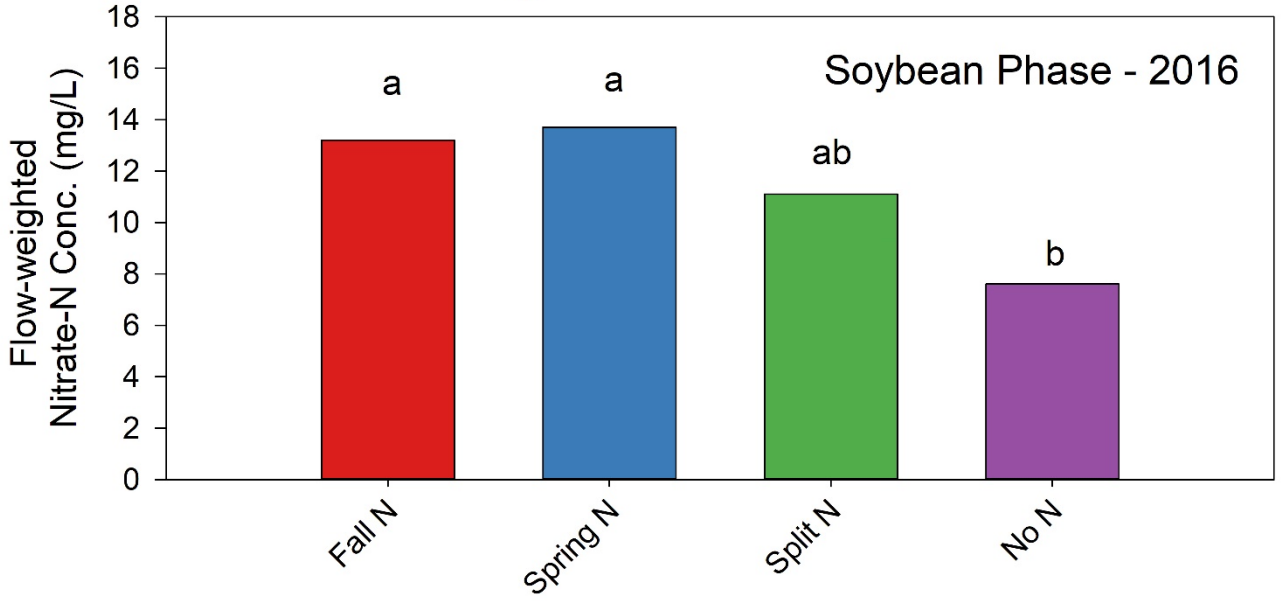


Research Fund

*Means with the same letter in the same year are not significantly different, *P*=0.05.

Flow-weighted Nitrate-N Concentration





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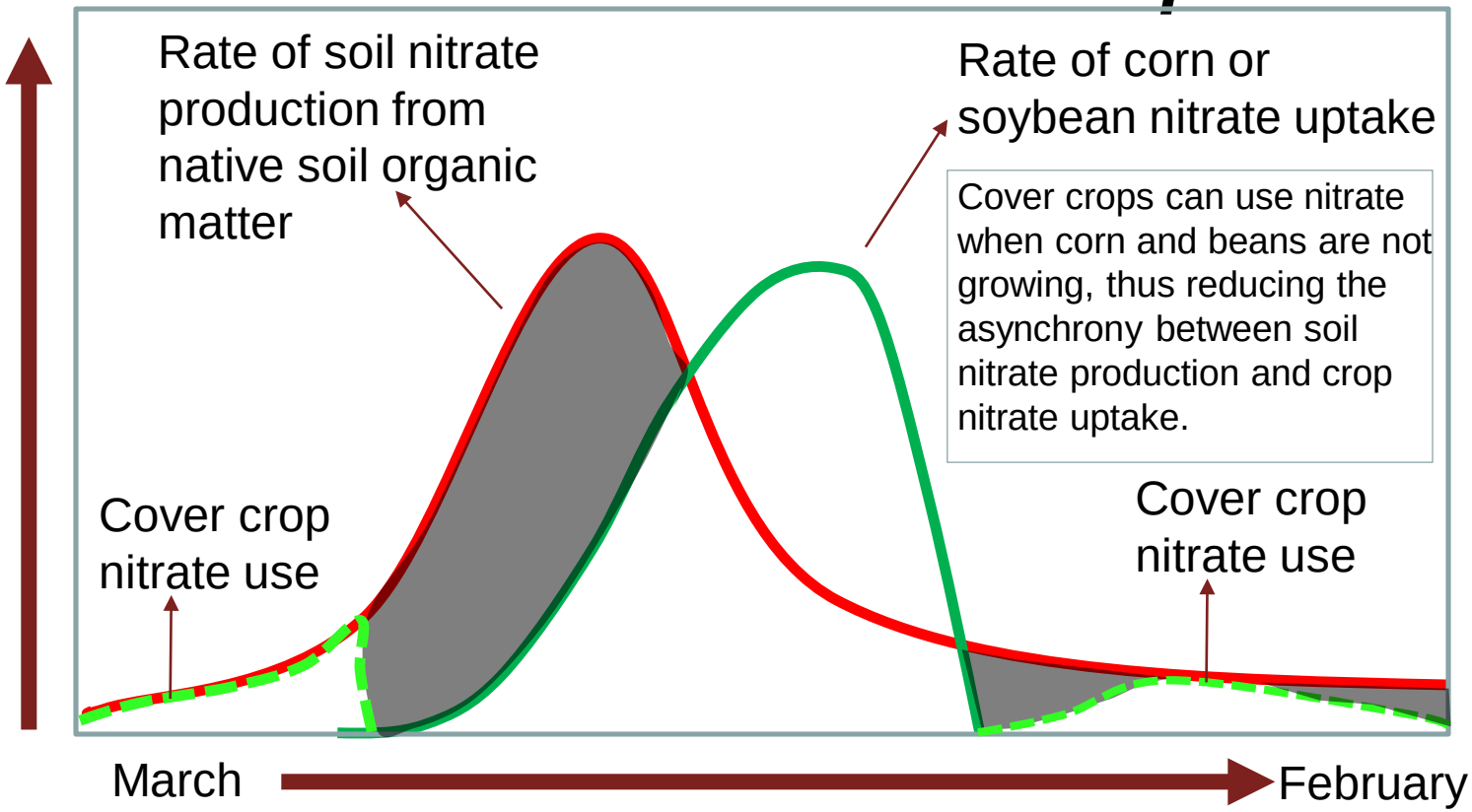
Soil Nitrate Production *vs.* Crop Nitrate Uptake

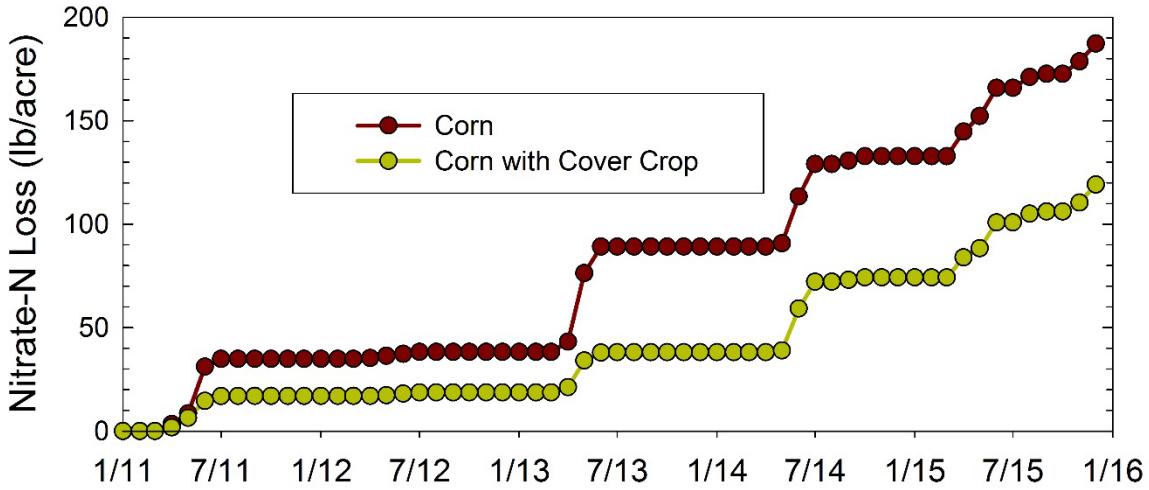
Addition of a Cover Crop



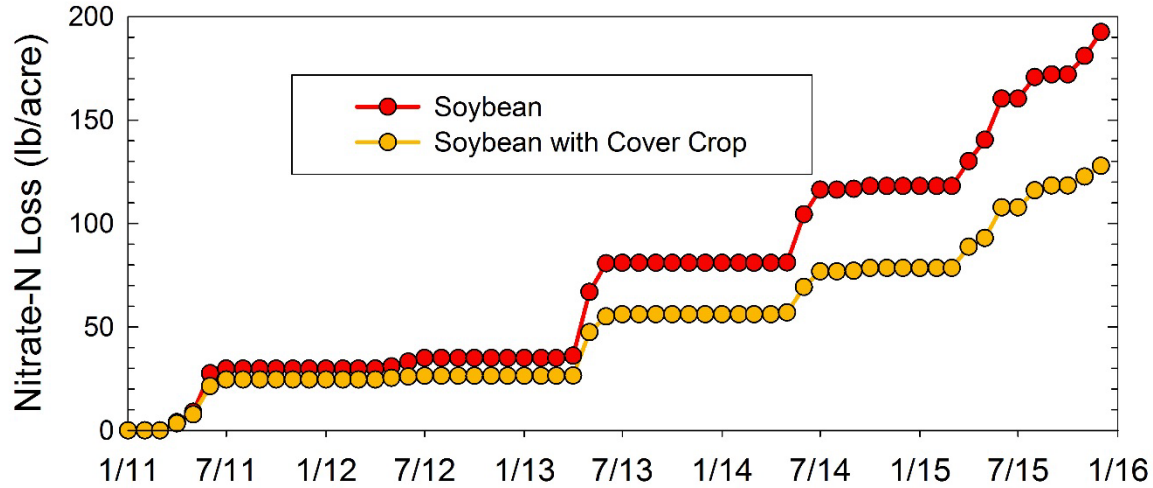
In the shaded areas, the soil produces nitrate, but there is no crop to use it. As a result, <u>some</u> nitrate is lost to waterways.

Winter Cereal Rye Cover Crops

Impacts of Cover Crops on Nitrate-N Load in Drainage Water – Gilmore City



36% Reduction



34% Reduction

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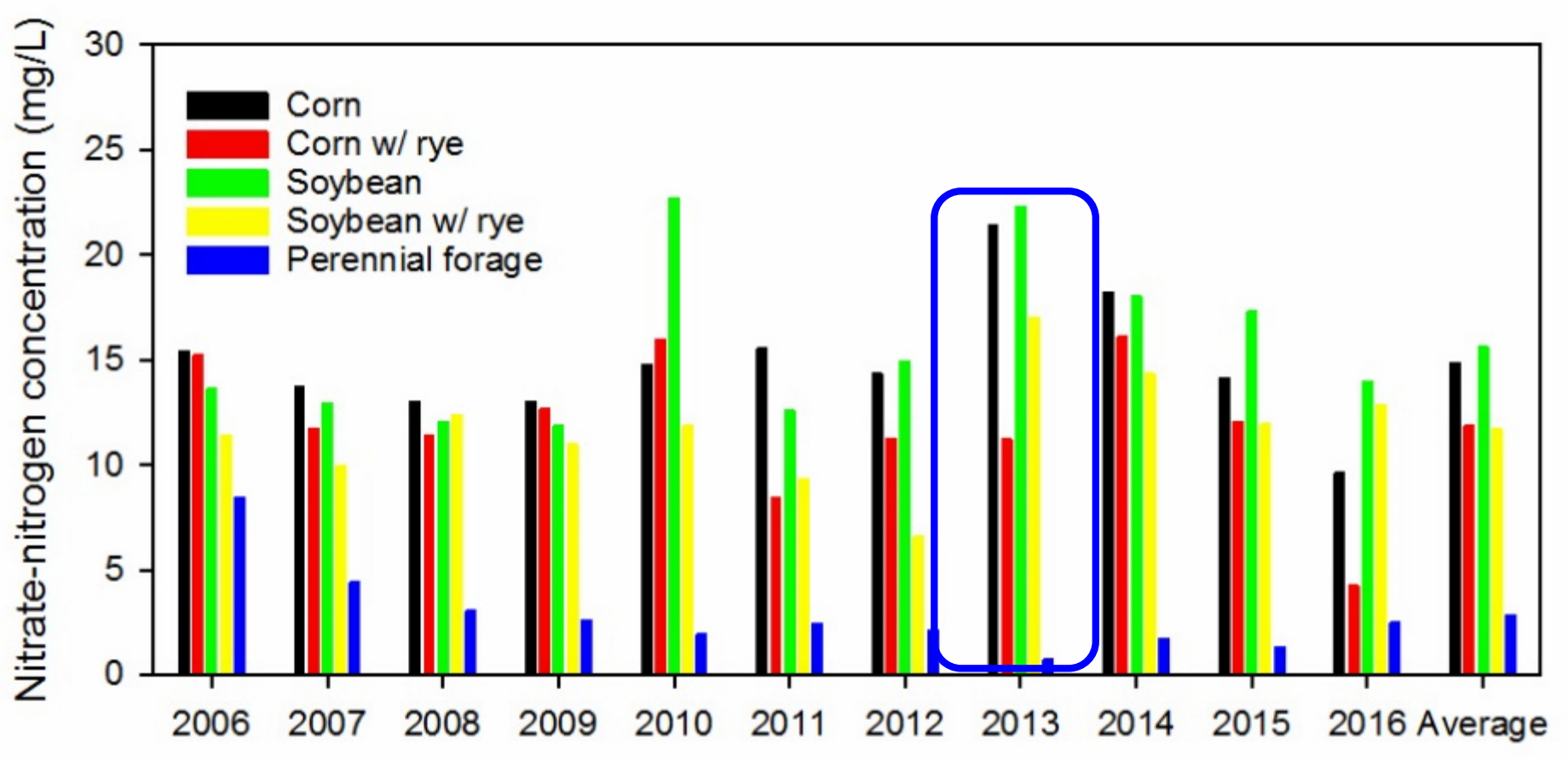
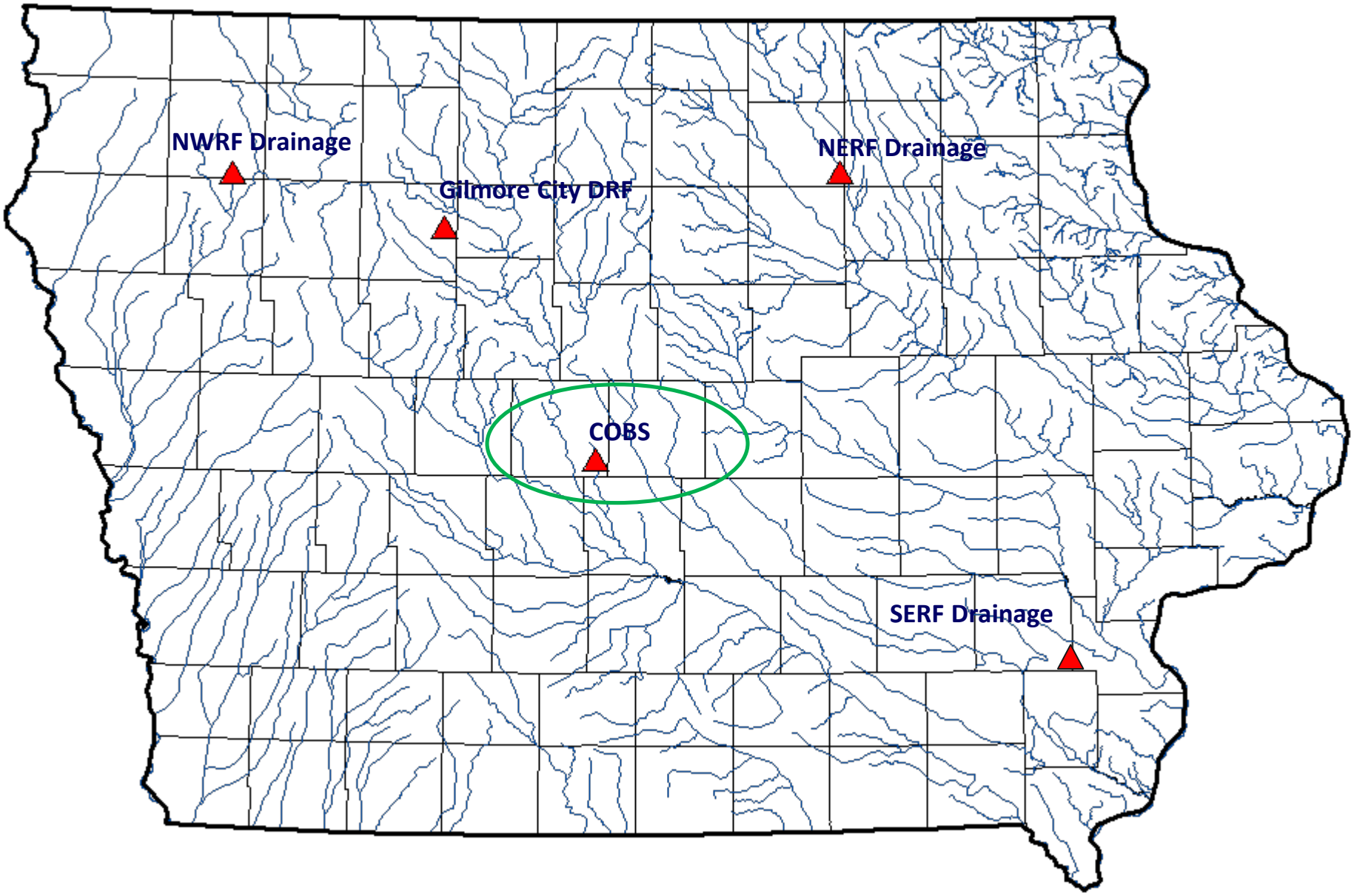
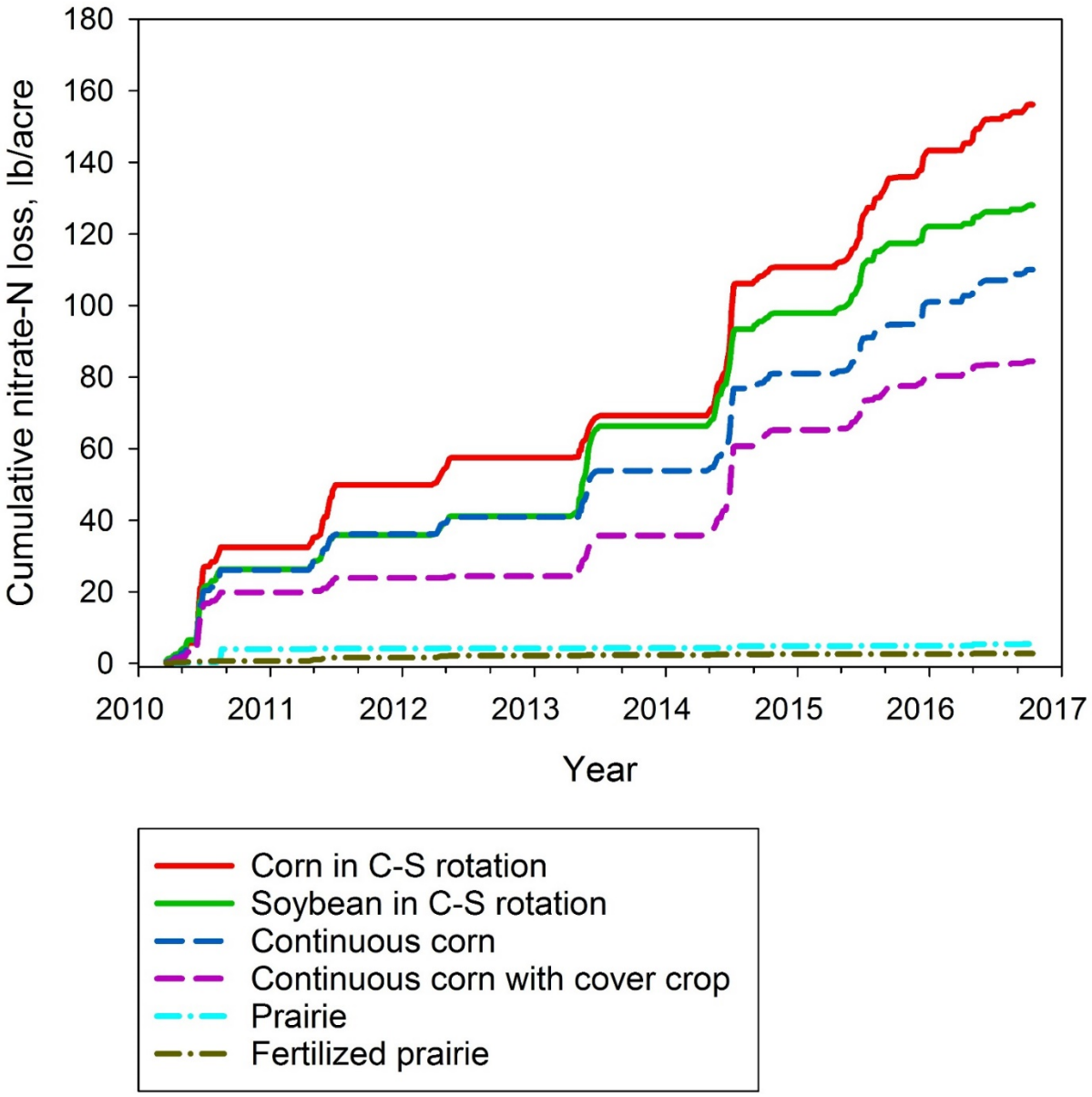
Impacts of Cover Crops



Replicated subsurface drainage plots to evaluate performance of various in-field management practices



Impact of Land Management



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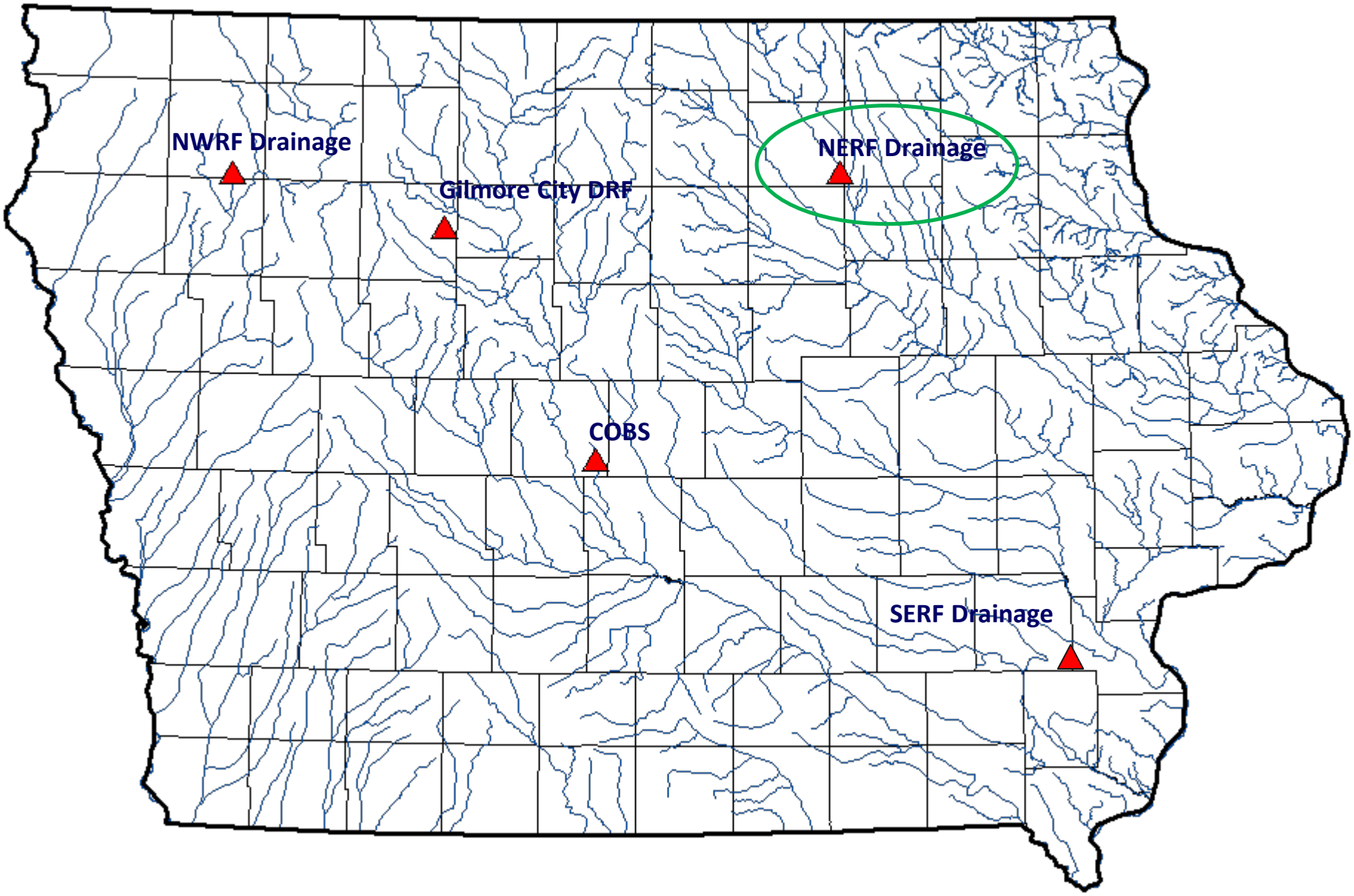
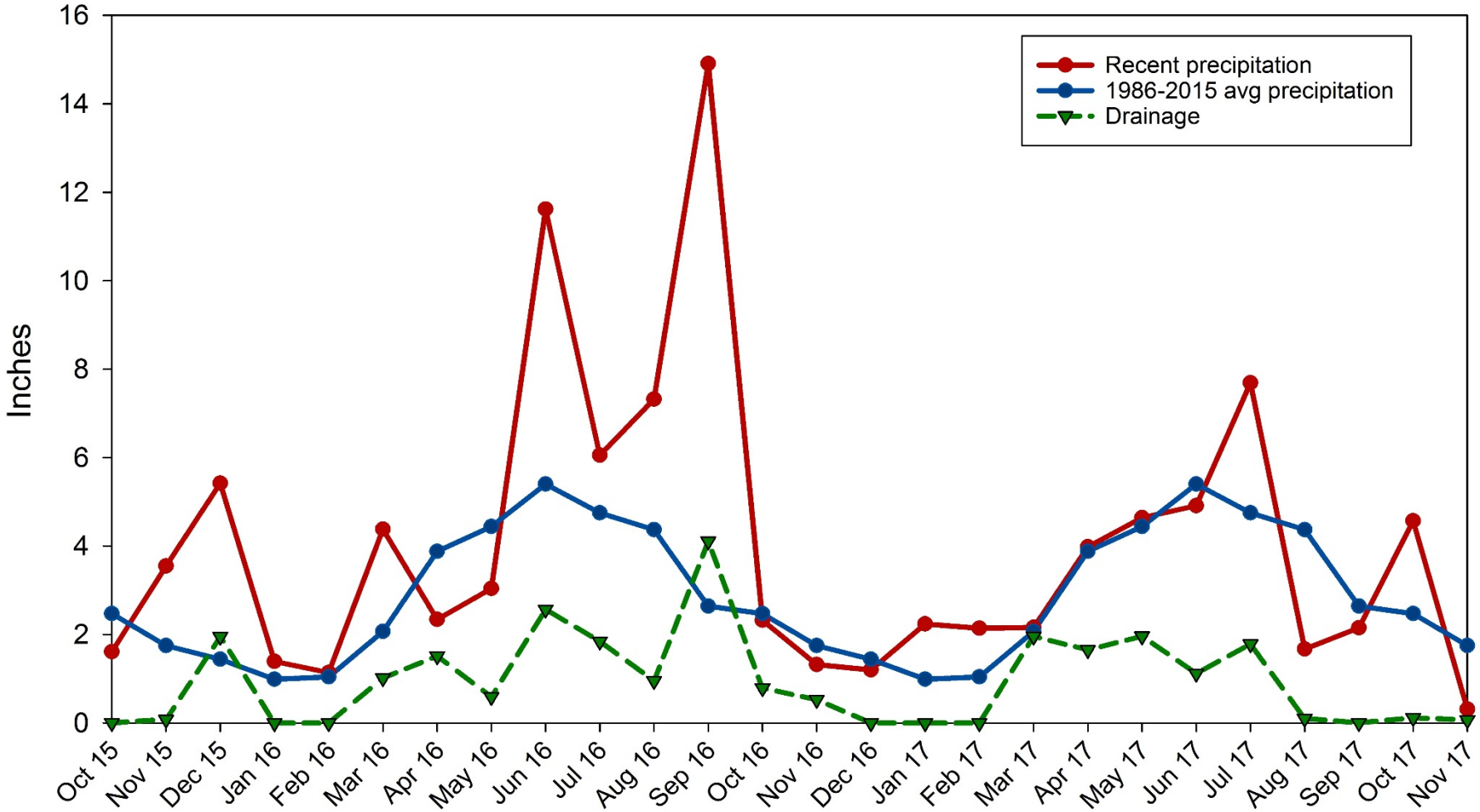


Management systems for 2016 - 2018 study

System	Application timing and N source	Crop	Tillage	N rate (lb/ac)
1	Spring UAN -	Corn Soybean	Chisel plow Field cultivate	150 -
2	Early fall manure -	Corn Soybean	No-till No-till	150 -
3a	Late fall manure + Instinct	Continuous corn	Chisel plow	200
3b	Spring manure	Continuous corn	Chisel plow	200
4a	Late fall manure	Continuous corn	Chisel plow	200
4b	Late fall manure + 1 ton/ac gypsum	Continuous corn	Chisel plow	200
5	Early fall manure -	Corn + Rye cover Soybean + Rye cover	No-till No-till	150 -
6	Late fall manure -	Corn Soybean	No-till No-till	150 -

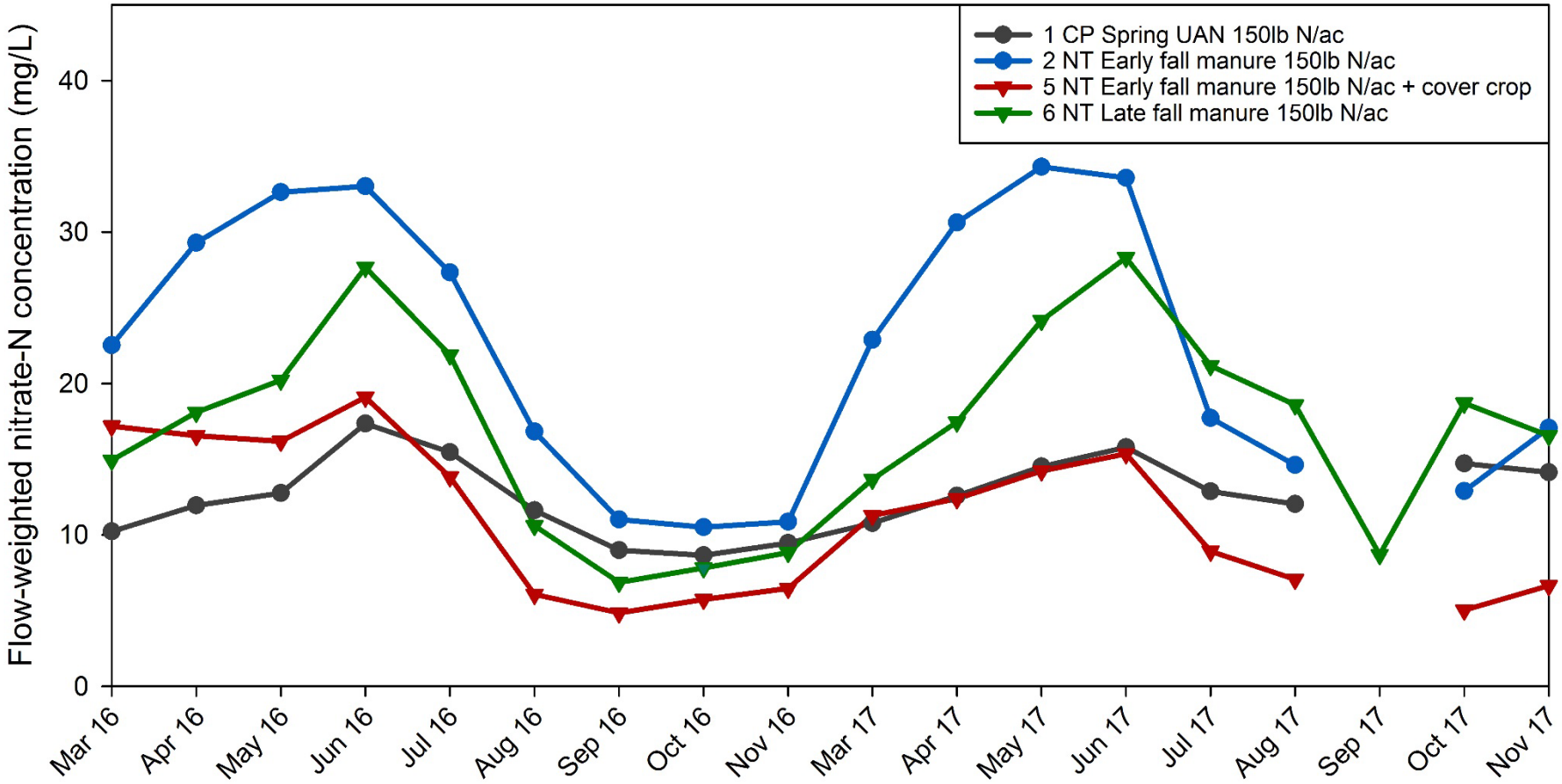
Research funded by Iowa Pork Producers Association and Calcium Products Inc.

Precipitation and drainage



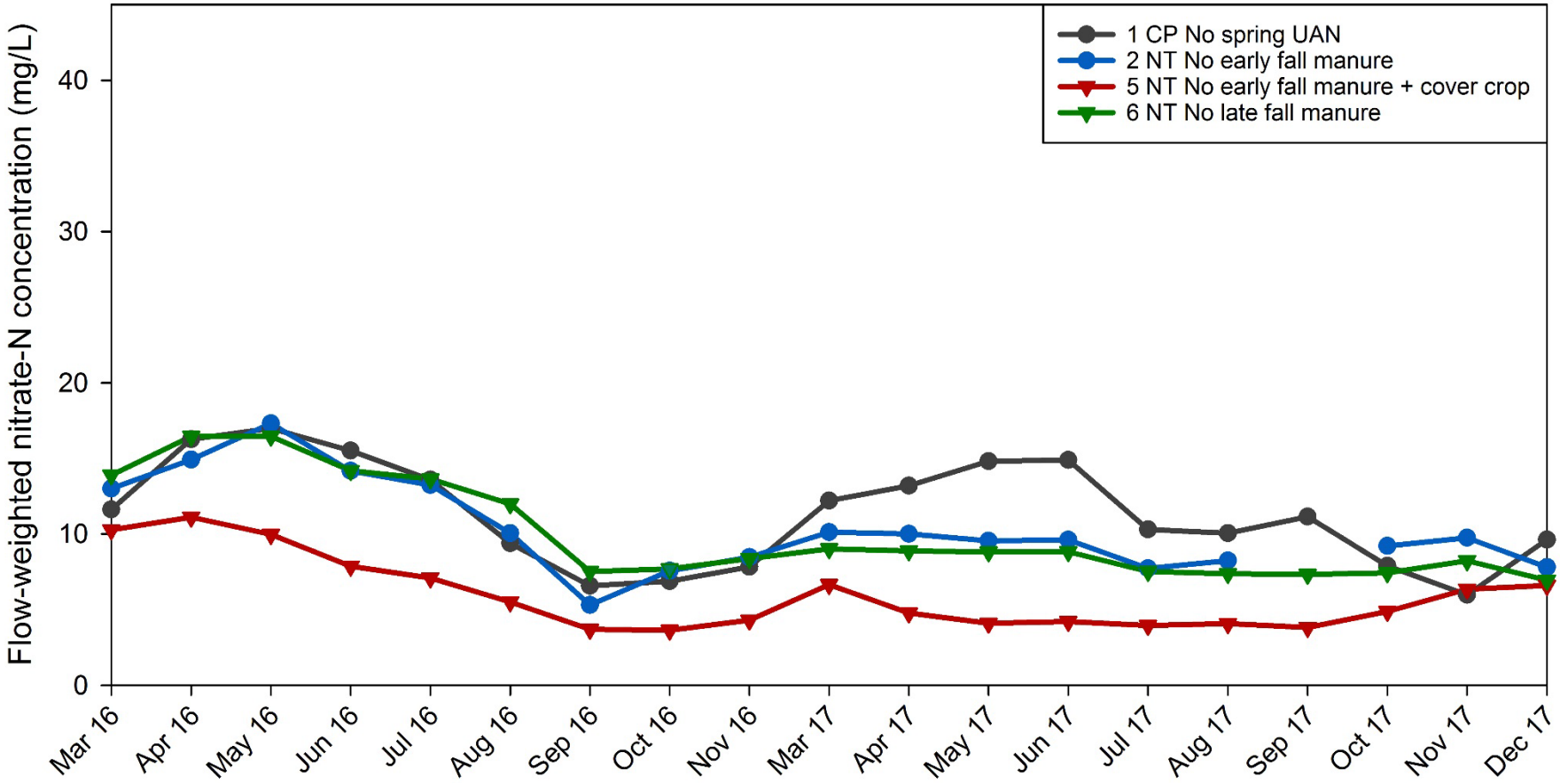
Research funded by Iowa Pork Producers Association and Calcium Products Inc.

Monthly nitrate-N levels in corn 2016-2017



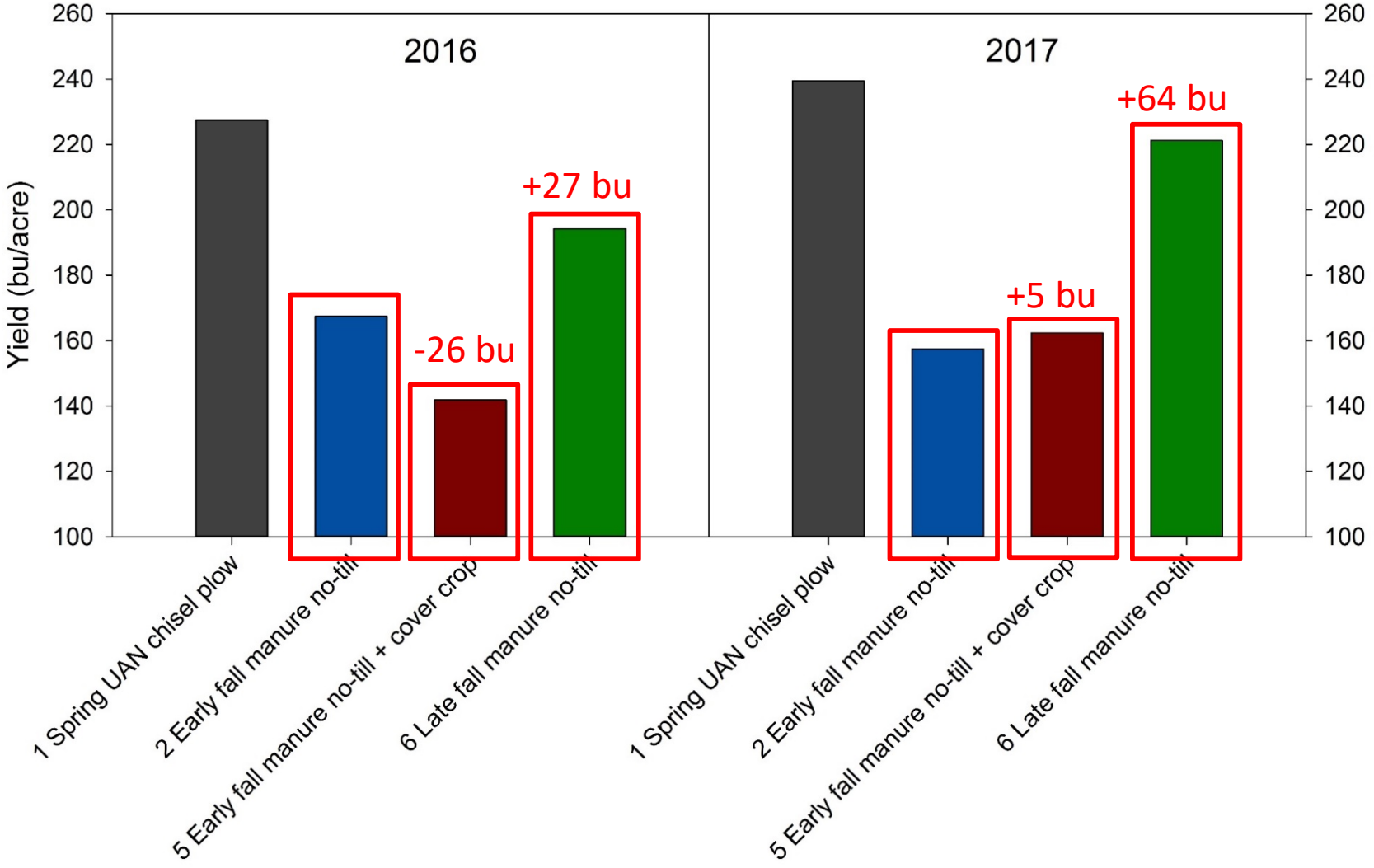
Research funded by Iowa Pork Producers Association and Calcium Products Inc.

Monthly nitrate-N levels in soybeans 2016-2017



Research funded by Iowa Pork Producers Association and Calcium Products Inc.

Corn phase yields



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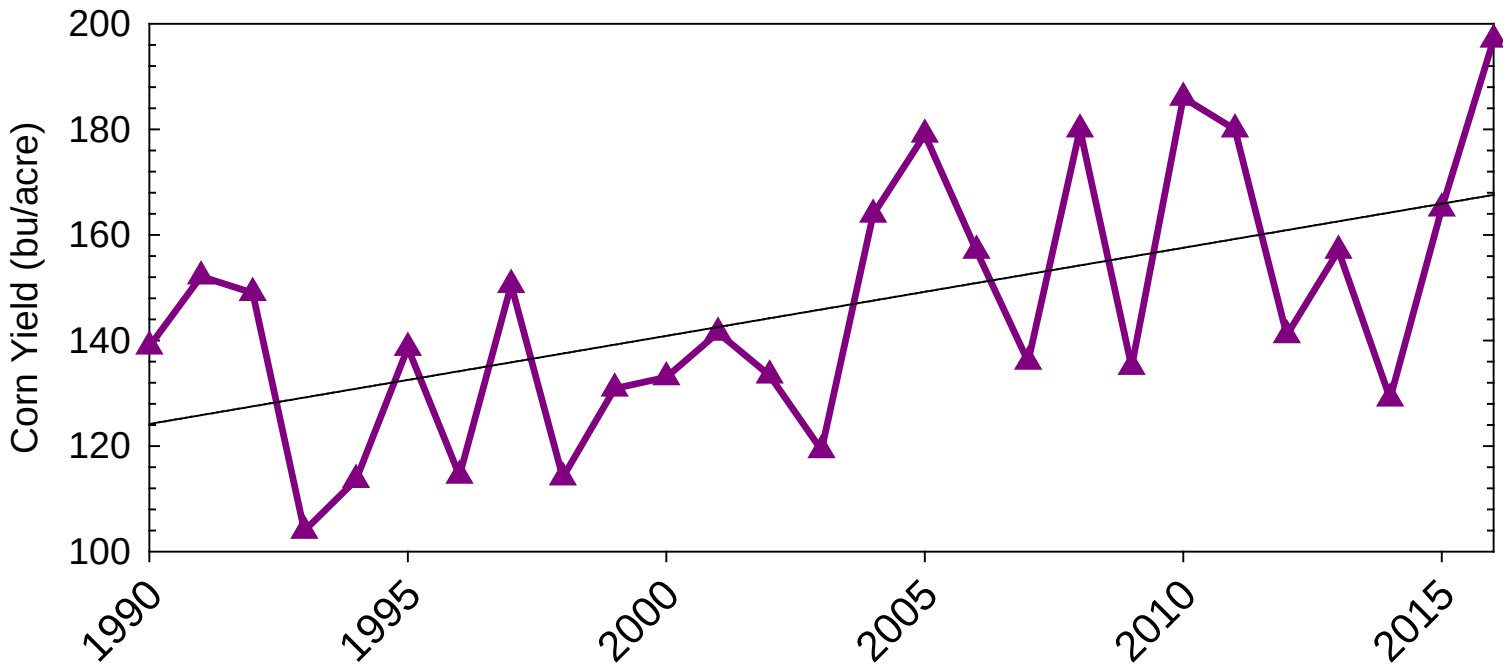
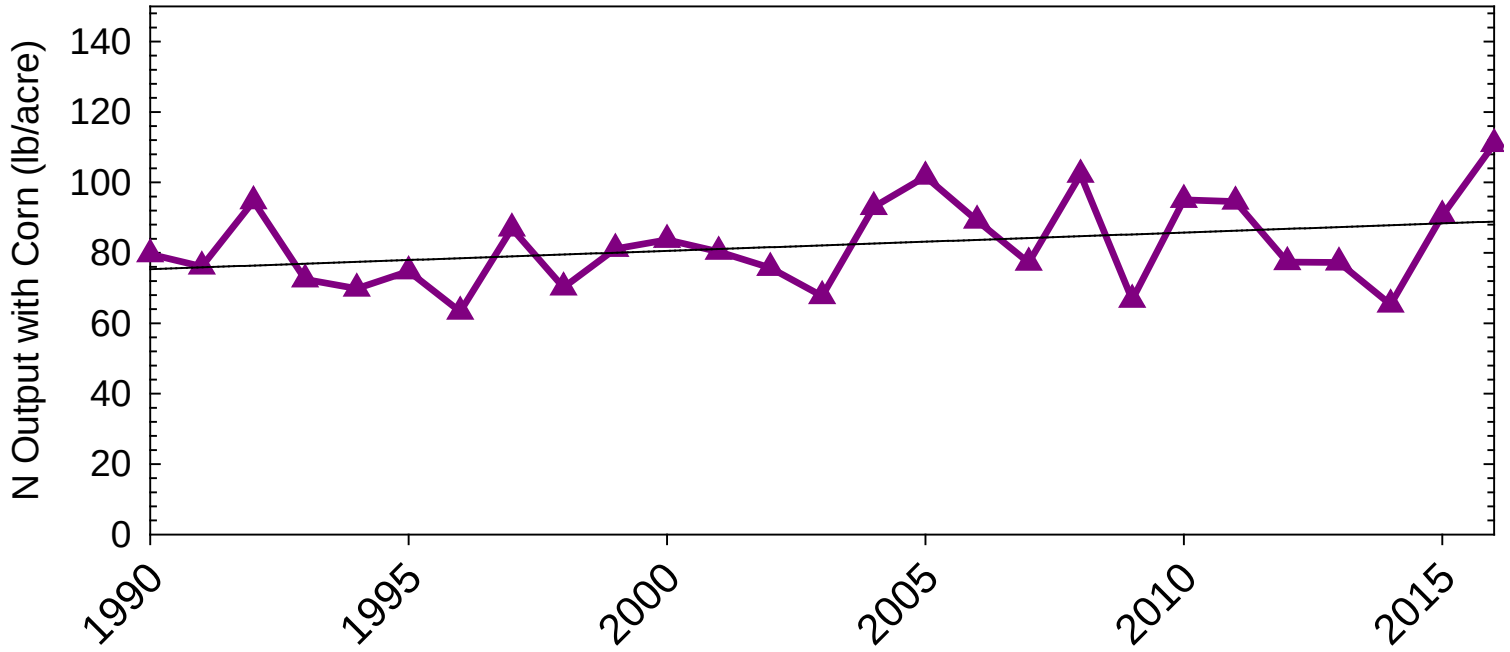
Temporal Changes

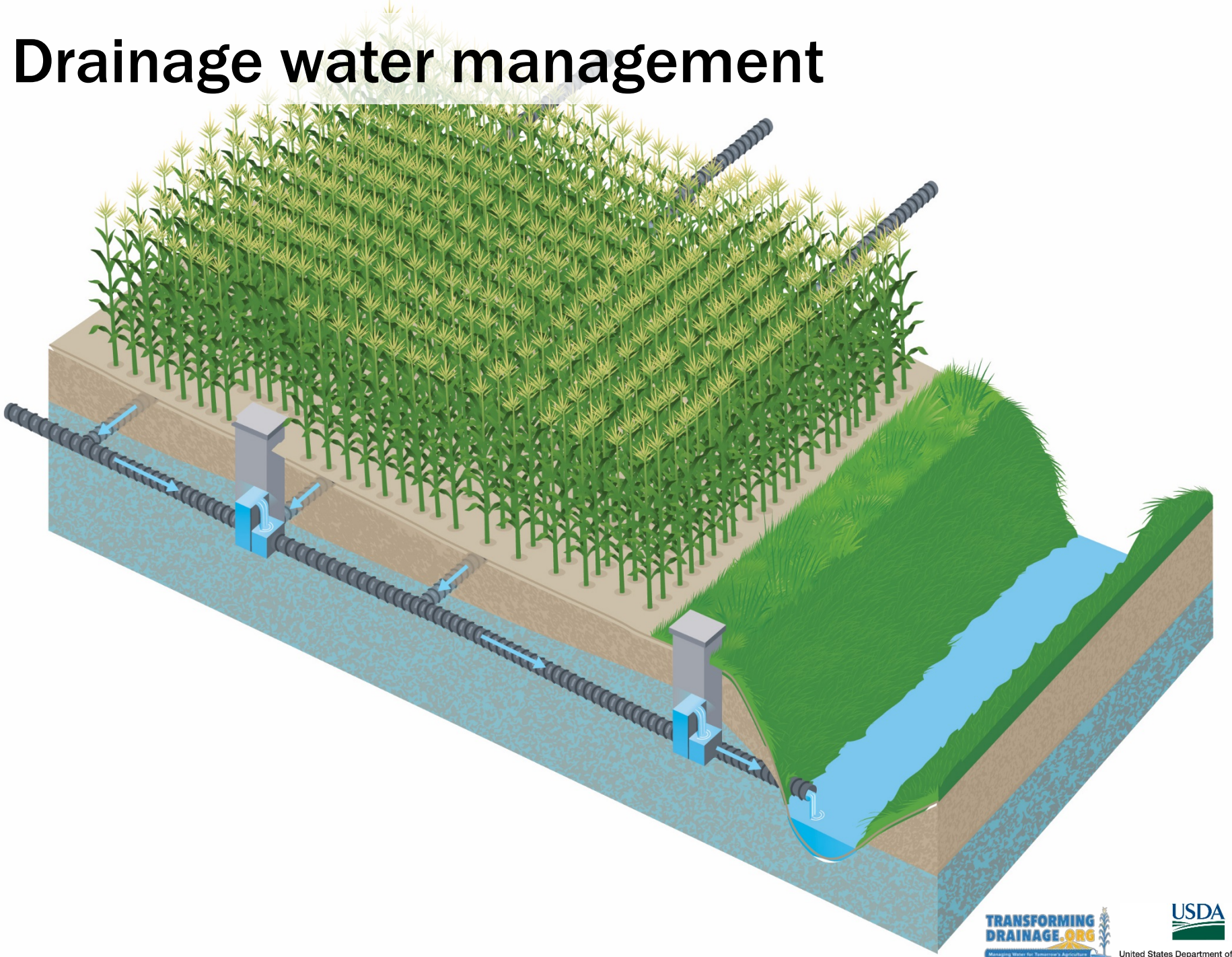
Corn Yield


Corn Yield (bu/acre)
200
180
160
140
120
100
1990
1995
2000
2005
2010
2015

N Output with Grain



Drainage water management



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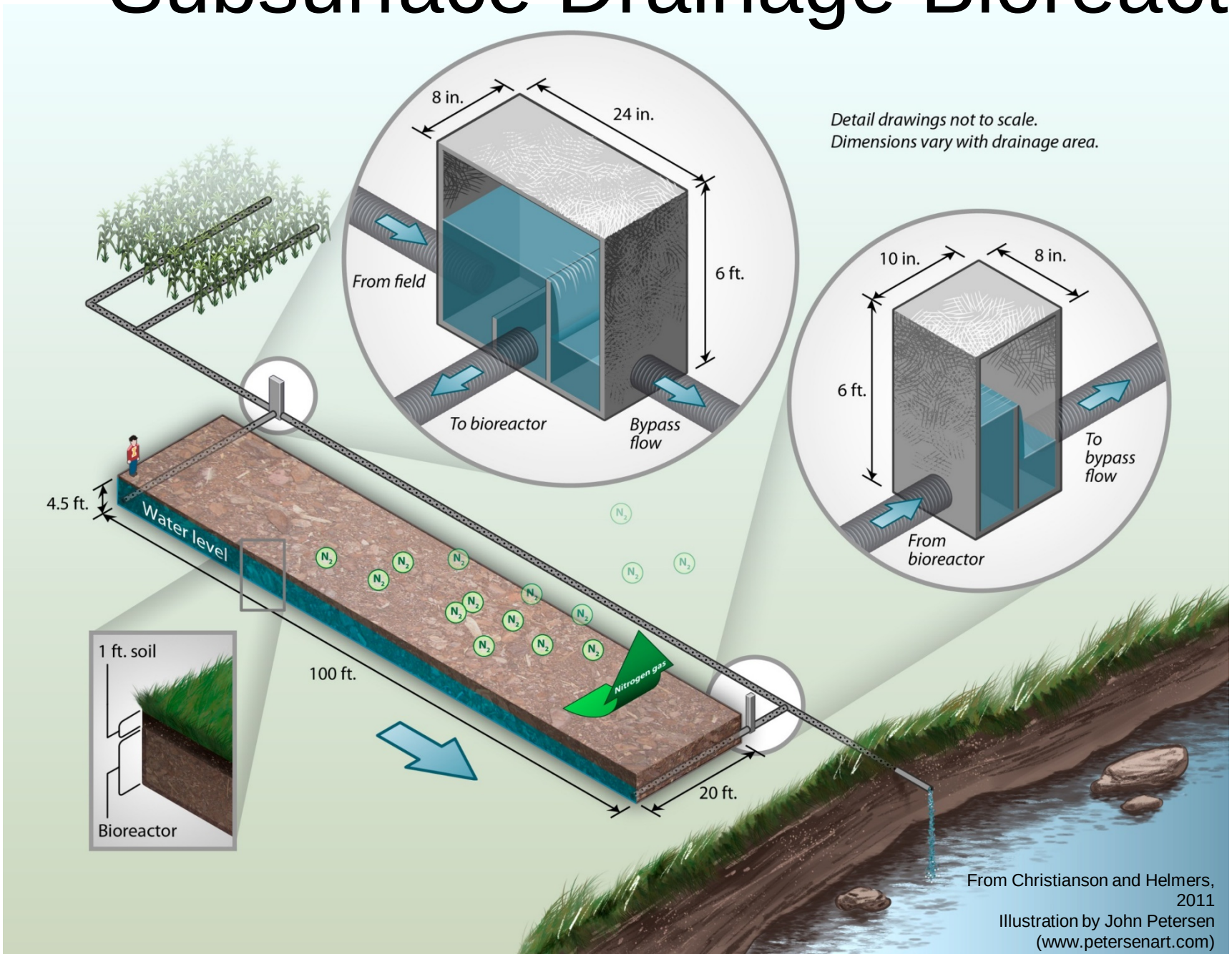
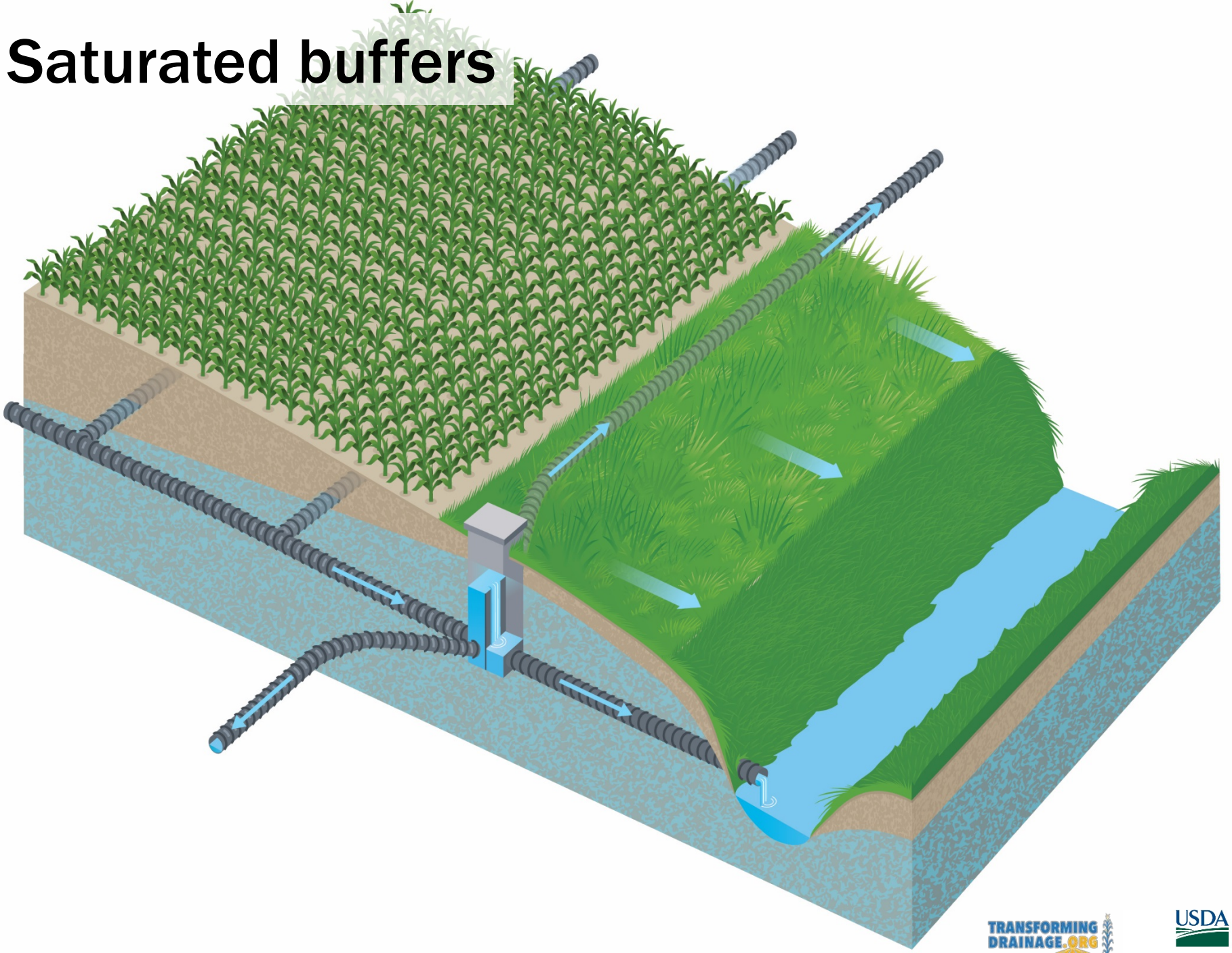
Subsurface Drainage Bioreactor



From Christianson and Helmers, 2011
Illustration by John Petersen (www.petersenart.com)

Saturated buffers



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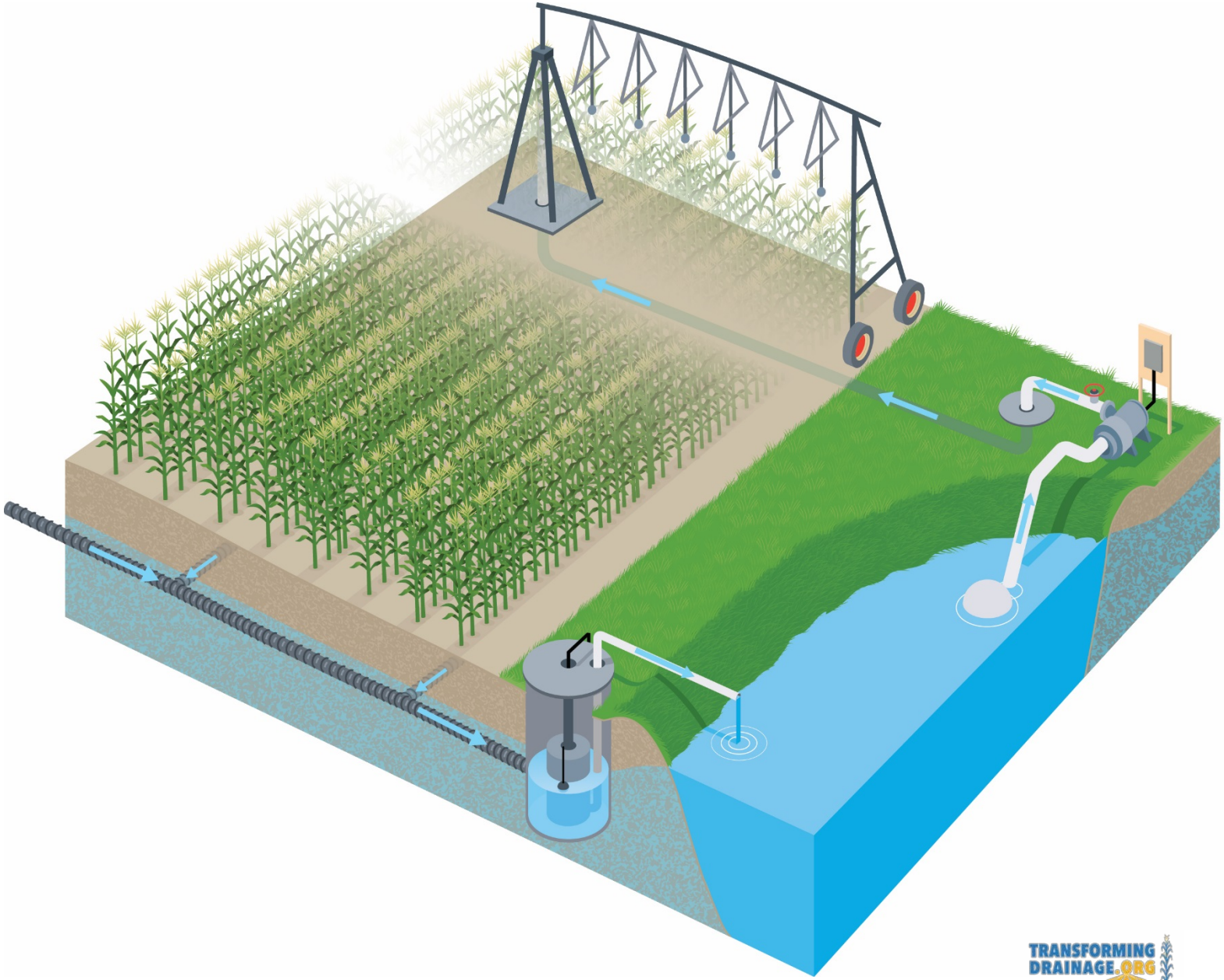
Nitrate Removal Wetland

Drainage water recycling



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To Reach our Goals

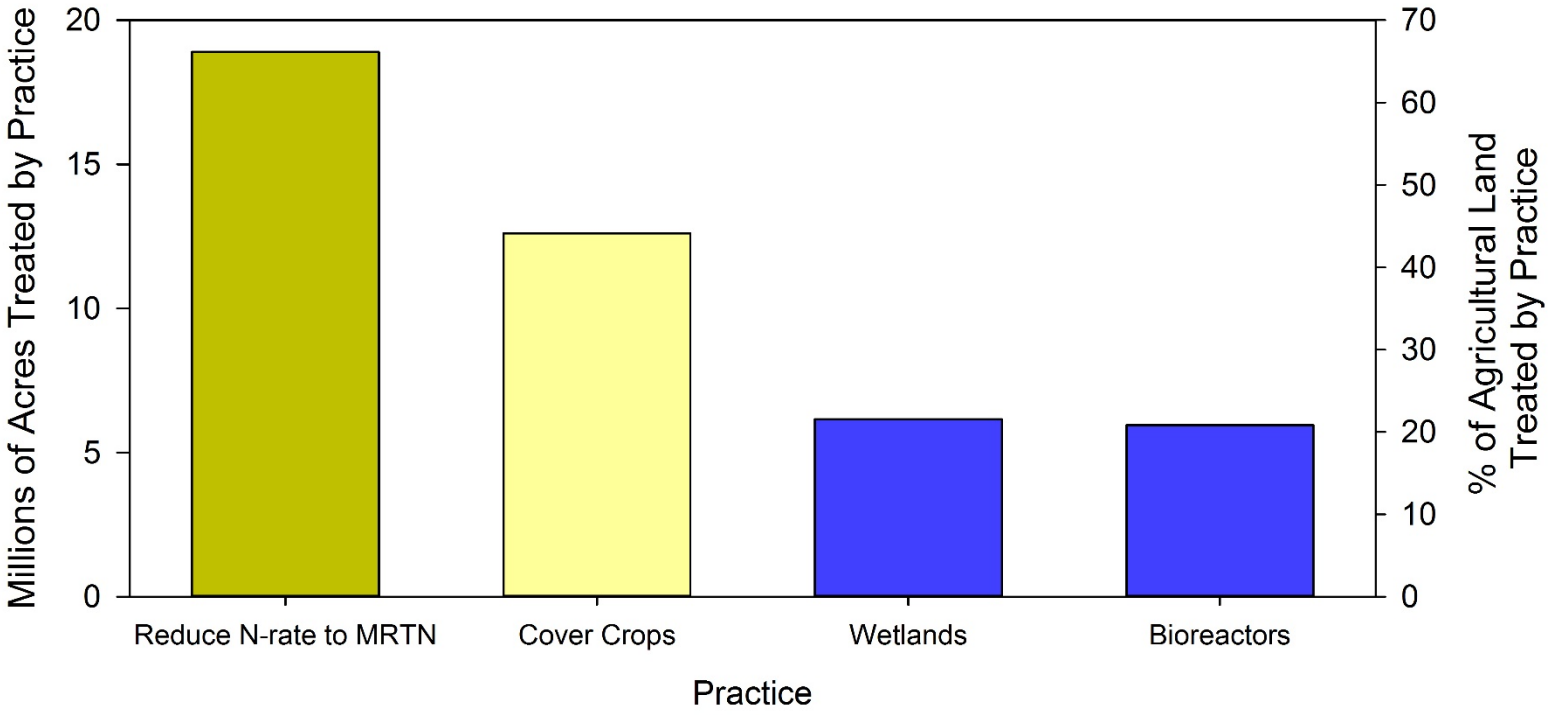
- WE NEED IT ALL!!
  - N Management
  - Cropping practices/landuse
  - Edge-of-Field Practices

What Might it Take to Reach our Goals?

Example: Combination Scenarios that Achieves N Goal From Non-Point Sources for Nutrient Reduction Strategy

Practice/Scenario	Nitrate-N Reduction % (from baseline)	Total Equal Annualized Cost Million $/yr
N management - Maximum Return to Nitrogen Application Rate and 60% of all Corn-Bean and Continuous Corn Acres with Cover Crop **Edge-of-Field** - 27% of all ag land treated with wetland and 60% of all subsurface drained land with bioreactor	42	756

Level of Implementation Needed for one Nitrate-N Reduction Scenario



Resources

- 10 Ways to Reduce Nitrate Loss - http://draindrop.cropsci.illinois.edu/wp-content/uploads/2016/09/Ten-Ways-to-Reduce-Nitrate-Loads_IL-Extension-_2016.pdf
- Drainage Water Quality Impacts of Various In-Field Nutrient Management Practices
  - Agricultural Drainage Research and Demonstration Site – Gilmore City – AE 3614
  - Comparison of Biofuel Systems Site – AE 3615
  - Northeast Research and Demonstration Farm – AE 3616
  - Northwest Research and Demonstration Farm – AE 3617
  - Southeast Research and Demonstration Farm – AE 3618

Coordinated Site Network for Studying the Impacts of 4R Nutrient Management on Crop Production and Nutrient Loss

Dr. Matt Helmers, Professor Iowa State University
Dr. Sylvie Brouder, Professor Purdue University
Dr. Laura Christianson, Assistant Professor University of Illinois
Dr. Cameron Pittelkow, Assistant Professor, University of Illinois
Dr. Kelly Nelson, Professor University of Missouri
Dr. Dan Jaynes, Soil Scientist USDA-ARS National Laboratory for Ag. and the Environment
Dr. John Kovar, Soil Scientist USDA-ARS National Laboratory for Ag. and the Environment
Lowell Gentry, Research Scientist University of Illinois
Dr. Craig Drury, Research Scientist Agriculture and Agri-Food Canada
Dr. Fabian Fernandez, Assistant Professor University of Minnesota
Dr. Alison Eagle, Scientist, Sustainable Agriculture, Ecosystems Program, EDF
Dr. Jeffrey Volenec, Professor Purdue University
Dr. Cliff Snyder, Nitrogen Program Director for the International Plant Nutrition Institute (IPNI)

Justification

- Eagle et al. (2015) noted that only one study reported simultaneous nitrous oxide (N_2O) emissions and NO_3 leaching losses, along with crop yield information. (4R Research Funded Project)
- In addition, we are aware of no studies explicitly aimed at understanding the interactions between 4R management strategies, soil health, drainage water quality, and nitrous oxide emissions

Objectives

- Our **objective** is to: *Quantify the impact of 4R Nutrient Stewardship on crop yield, soil health, nutrient use efficiencies, nutrient losses with leaching, and gaseous nitrogen losses across a network of coordinated studies in the major corn producing area of North America*.

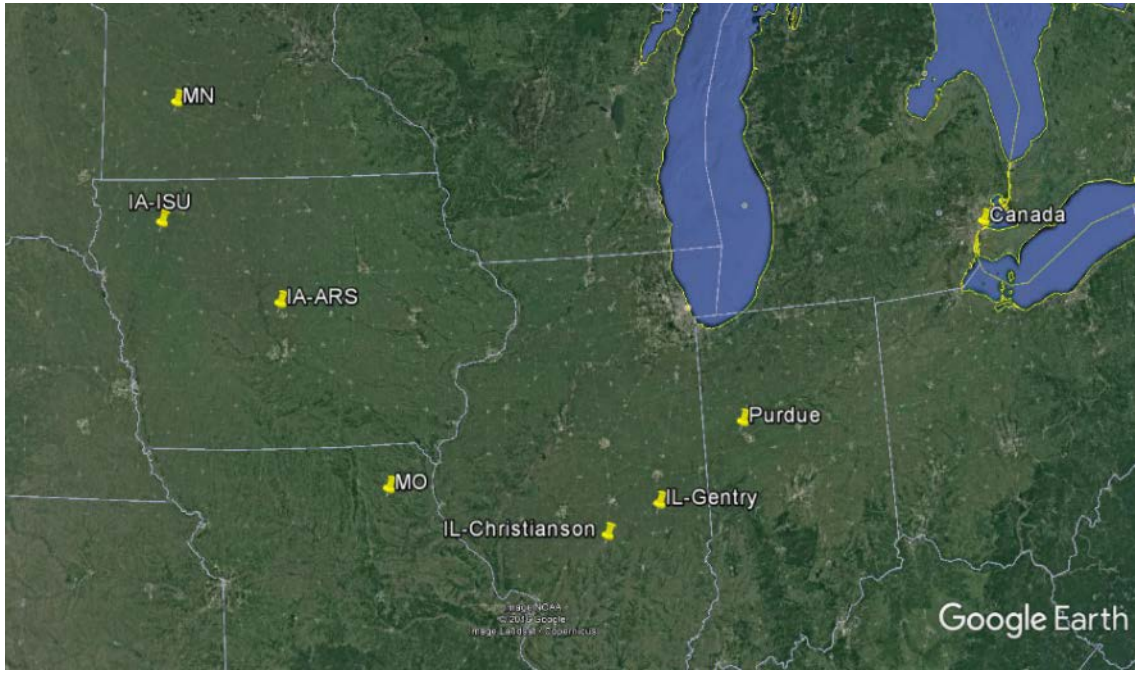


Figure 1. Location of study sites.

Project Funded by the FFAR (Foundation for Food and Agriculture Research) and The 4R Research Fund

Discussion

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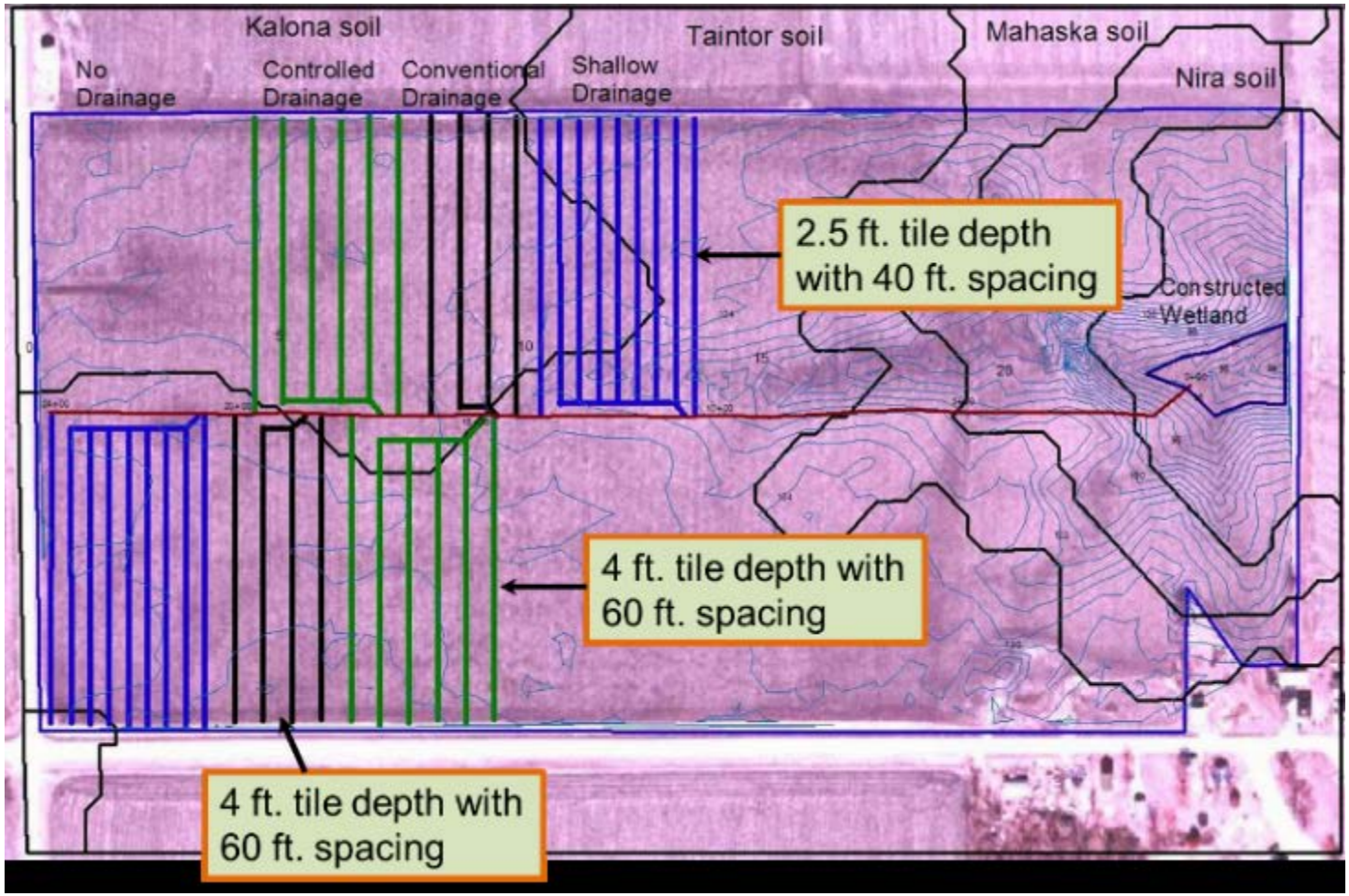
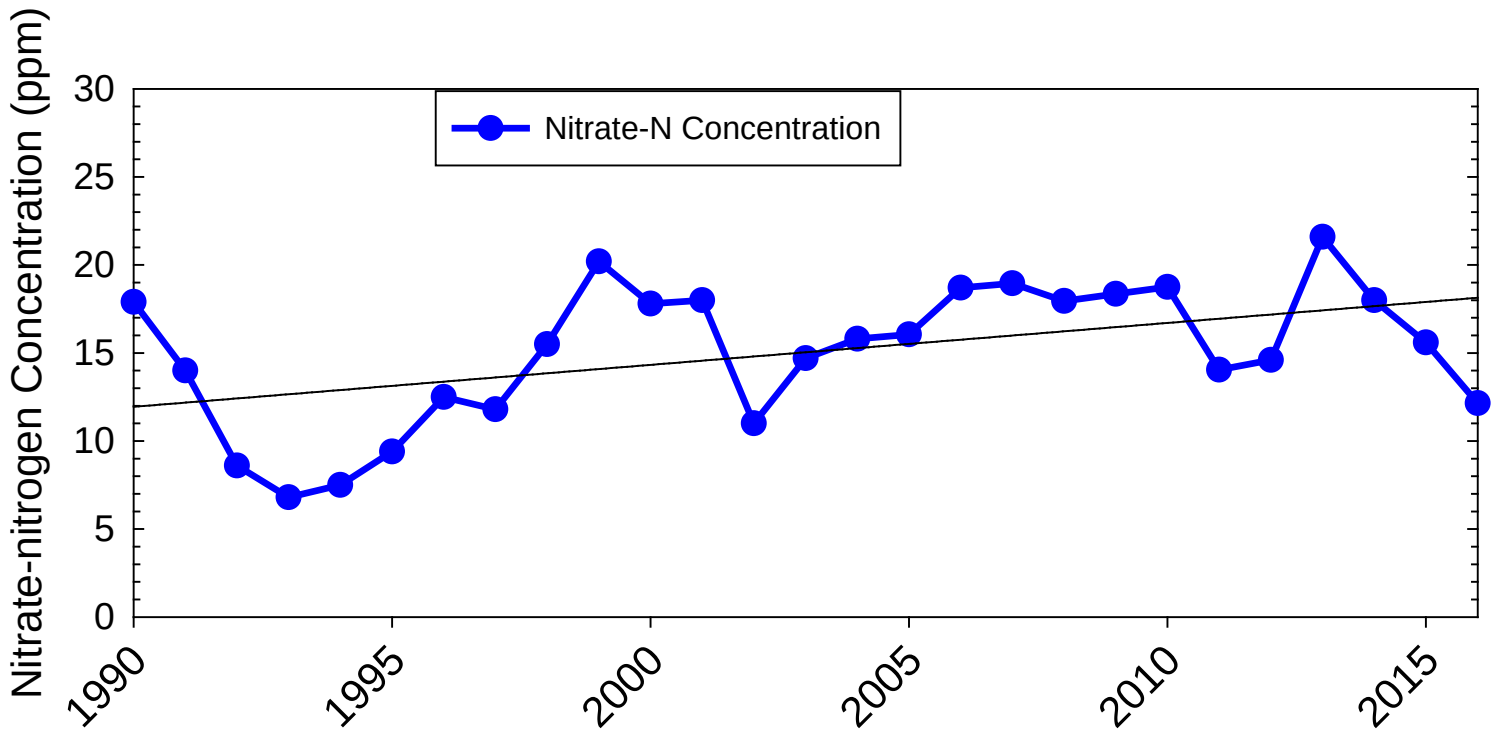
Website: http://agwatermgmt.ae.iastate.edu/

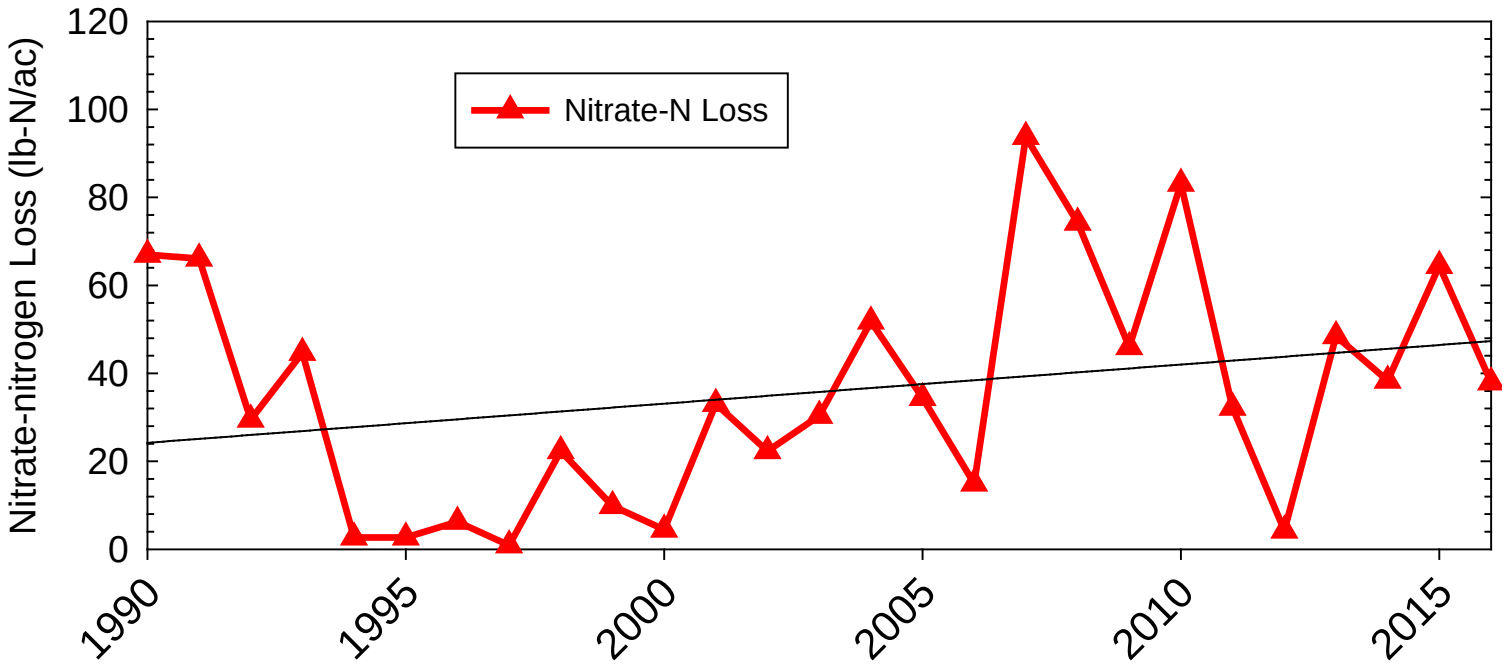
Drainage Water Management



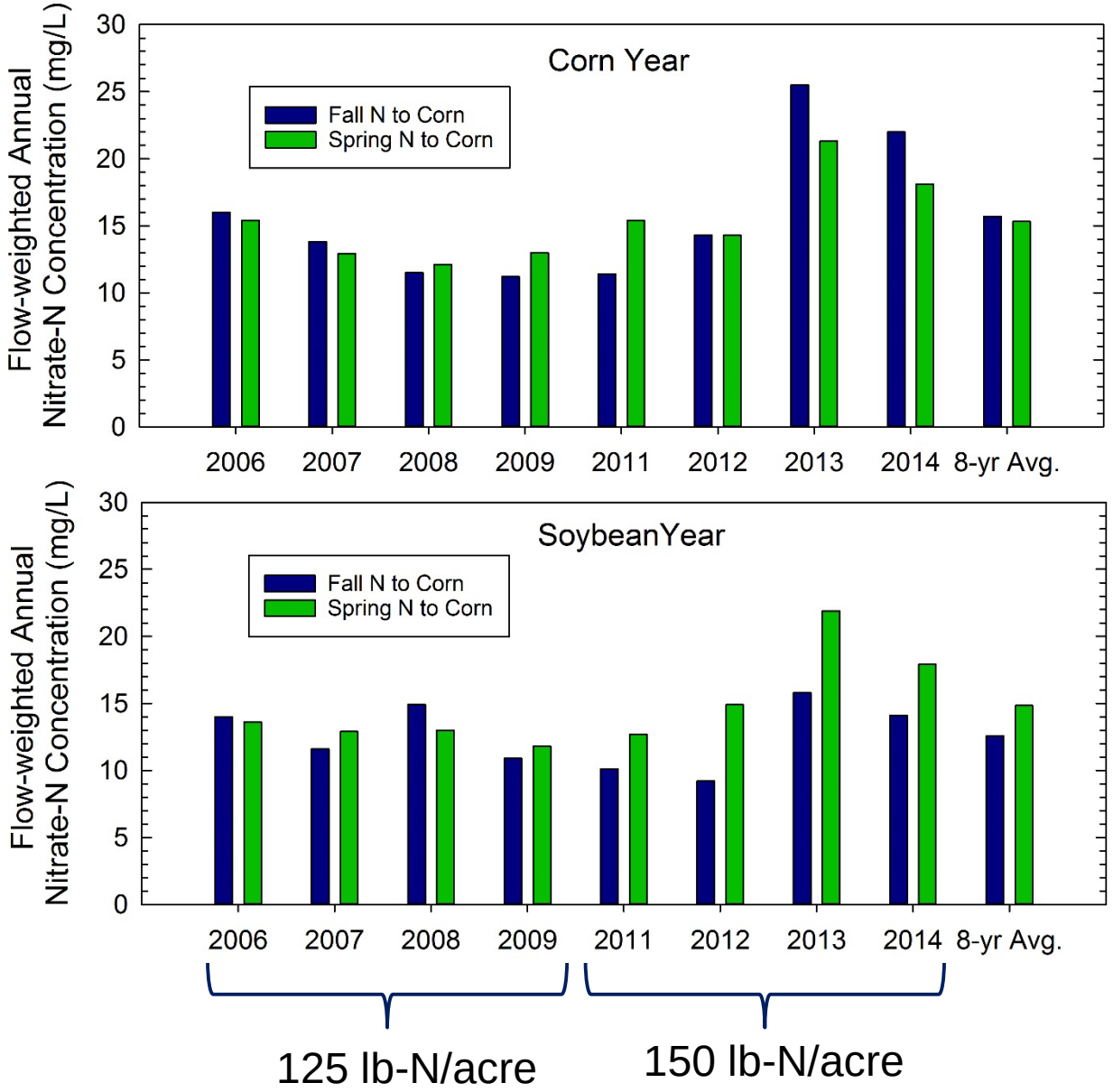
N Concentration



N Loss


Nitrate-nitrogen Loss (lb-N/ac)
120
100
80
60
40
20
0
Nitrate-N Loss
1990
1995
2000
2005
2010
2015

Impact of Application Timing: 2006-14



Impact of Application Timing: 2006-14