Implications of Nutrient Management for Corn Breeding

Michael M. Lohuis, PhD
Monsanto Company

Abstract:

Nutrient management has increasingly become a topic of concern in recent years due to regular spring surges of nitrate levels above safe drinking level (10 mg/L) in Midwestern rivers. This problem was exacerbated in the spring of 2013 due to a drought in 2012 followed by record winter and spring precipitation. Furthermore, climate change is resulting in more variable weather patterns and more intense weather events making nutrient management an even greater challenge. Although nutrient management practices are improving, progress is slow and state-sponsored regulations are becoming more likely. Although EPA typically does not regulate non-point nutrient sources, a growing number of states have enacted regulations that require farmers to create and follow certified nutrient management plans and/or comply with restrictions around Fall/Winter nitrogen or manure applications. These developments coincide with growing world populations and demand for food and the necessity of increasing yields. Fortunately, more is known each year about the relationship between best management practices (BMP), and effects on yield and nutrient levels at edge-of-field. Several management tools have been added in recent years such as protected-N fertilizers, expanded cover-cropping practices, variable rate fertilizer applications, hyper-local weather prediction and timed applications, more versatile equipment for N side-dressing, microbial nutrient availability products and high-density soil mapping. Corn breeders often make breeding starts 8-10 years prior to expected commercialization thus requiring breeding and testing regimes that mimic future conditions and management. With this in mind, it will be critical for breeders to anticipate likely changes in the regulation and use of nutrient applications in corn-growing states. Further, soil health and nutrient conservation practices such as no/strip tillage and cover cropping will likely increase over time thereby improving water and nutrient-holding capacity of the average corn field making simultaneous yield increase and reduced nutrient loss a reality. To adequately prepare for changing nutrient management regimes, investment in quantification of nutrient flux and application of BMPs at the plot level should be considered.

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Michael Lohuis
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50th Annual Illinois Corn Breeders' School

March 4, 2014

Photo from http://www.nutrientstrategy.iastate.edu/

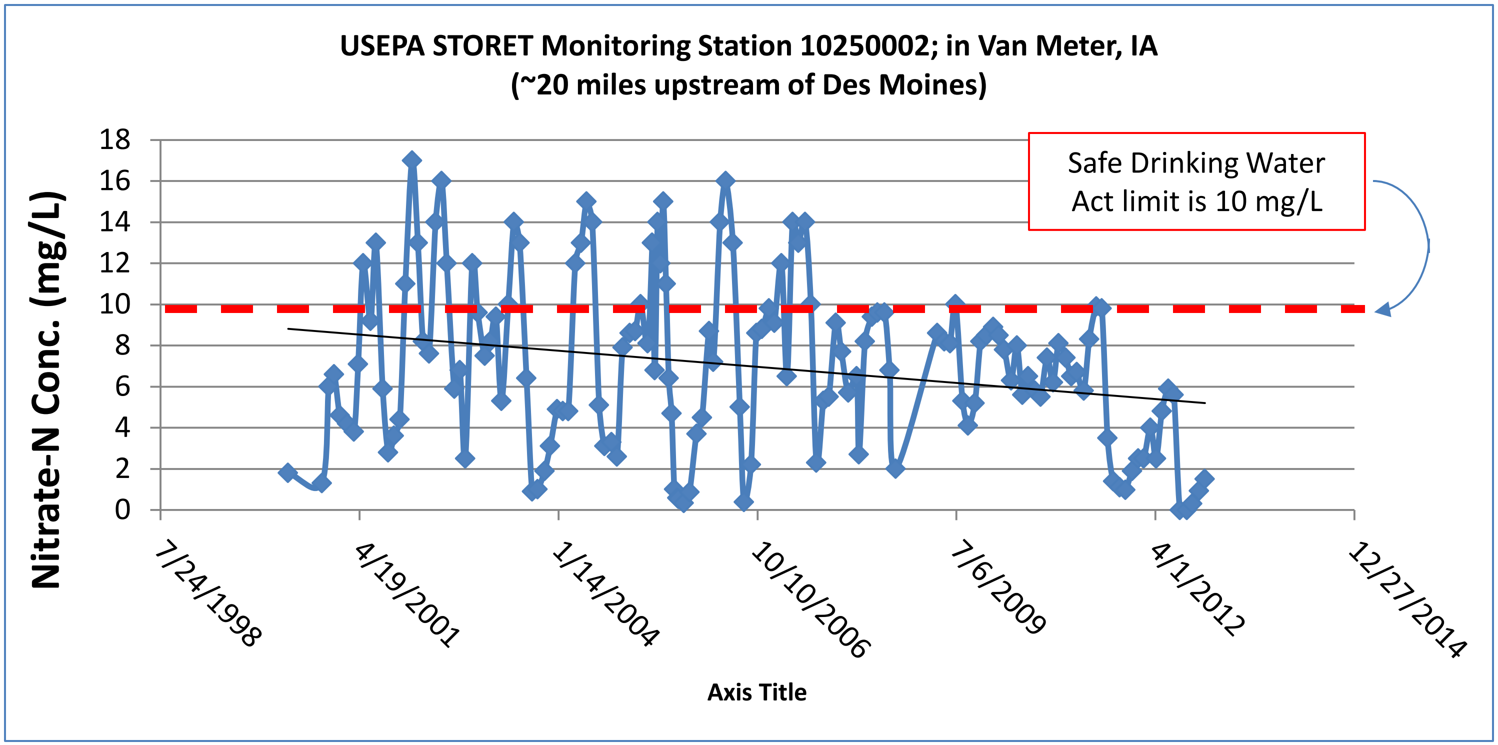
Global Nutrient Management Challenges

The “Problem”

- “Non-point” nutrient runoff from agriculture is identified as a cause of water impairment in the U.S.
- Many drinking water utilities withdraw water from rivers
  - Nutrient pollution increases the cost of treatment
  - Many water treatment plants cannot remove nitrates
- Drought conditions in 2012 in the Midwest followed by a wet winter/spring in 2013 caused a spike in nitrates

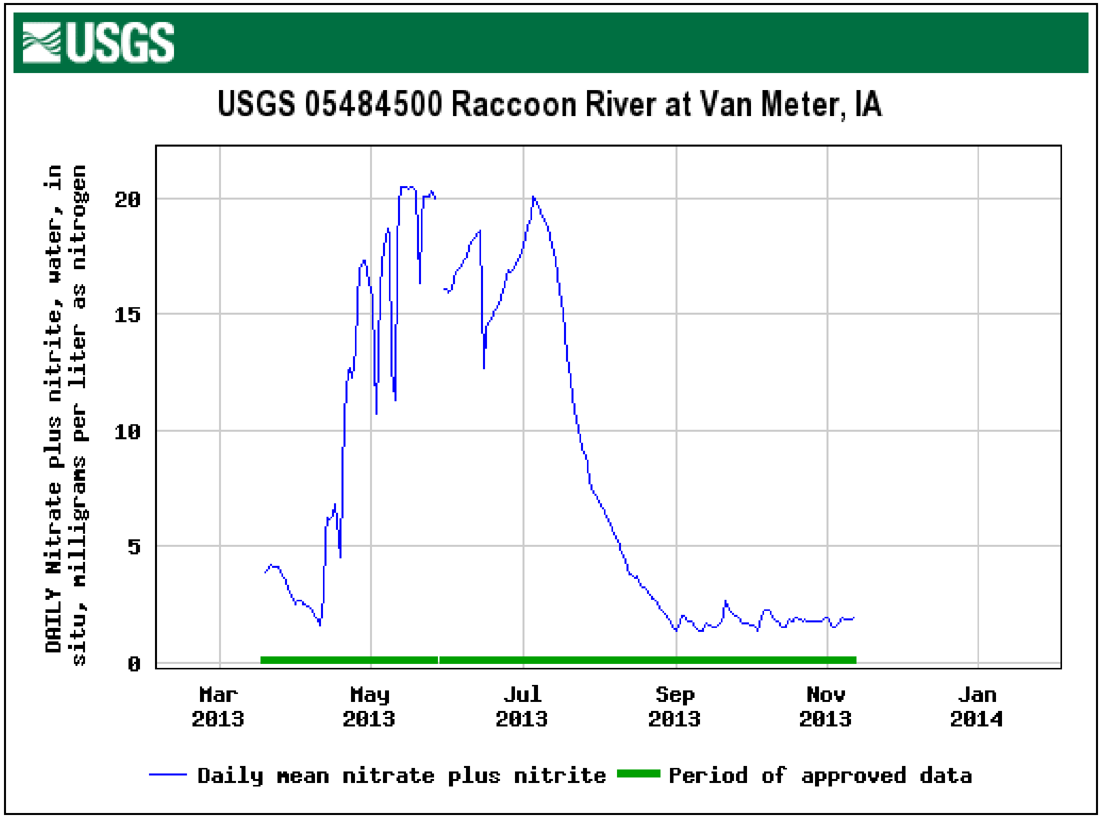
Nitrate in the Raccoon River

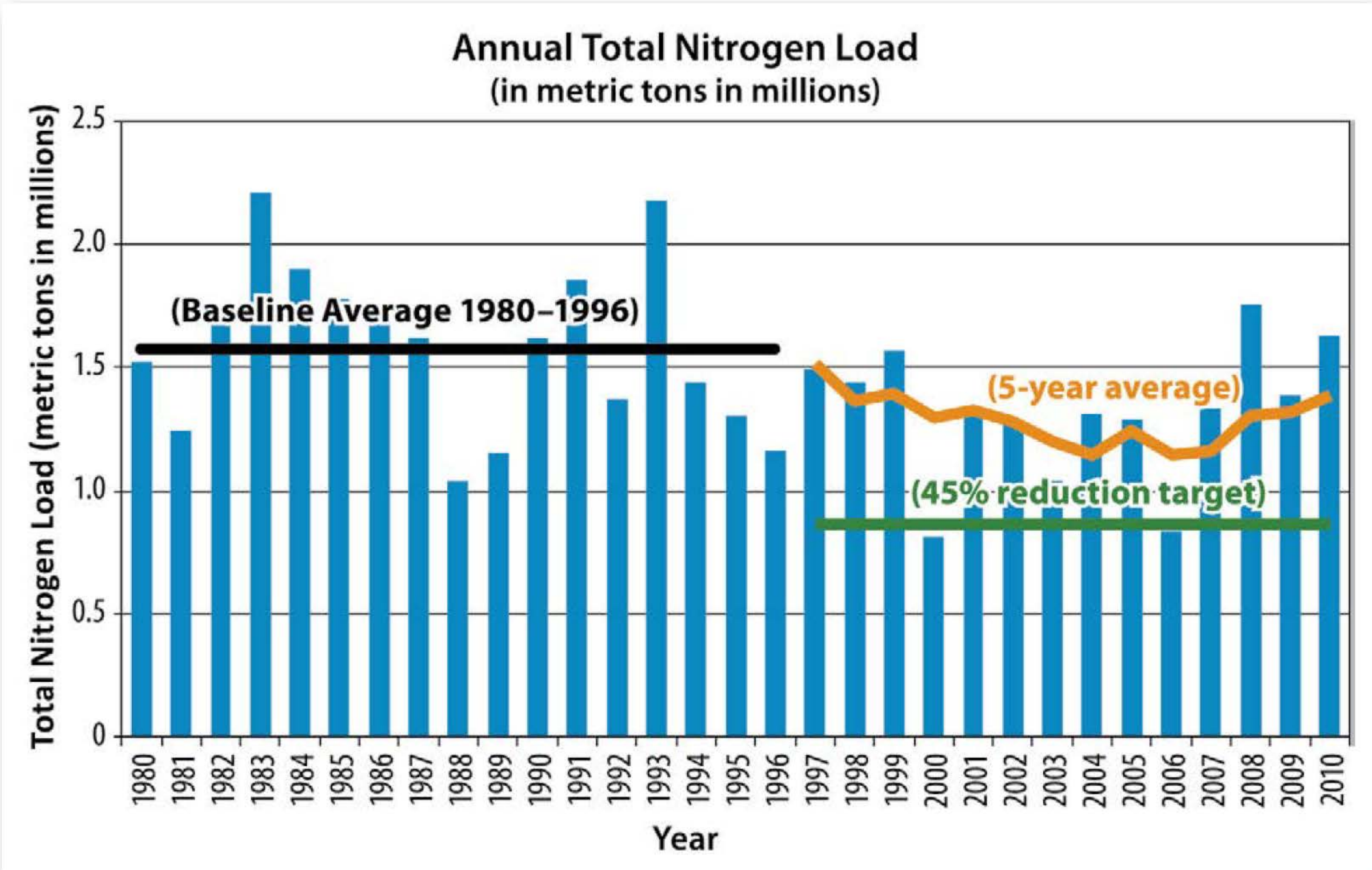
- Between 2000 and 2012, the concentration of nitrate in the Raccoon River upstream of Des Moines trended downward
  - Springtime “flushes” are evident from monthly sampling data



Nitrate in the Raccoon River

- In comparison, the magnitude and duration of the nitrate release in 2013 was historic:





2011 Gulf Hypoxia Task Force report

Unfortunate Headlines & Consequences

Local and National Groups Defend Clean Water Act against Agricultural Pollution

Friday, August 2, 2013 | http://potomacriverkeeper.org/updates/press-release-WV%20CAFO

Chicken manure threatens Potomac River in West Virginia case;

Groups file legal brief to protect public health and environment

Environmental groups sue EPA to limit nutrient pollution

Wed March 14, 2012| By Véronique LaCapra | KBIA.org

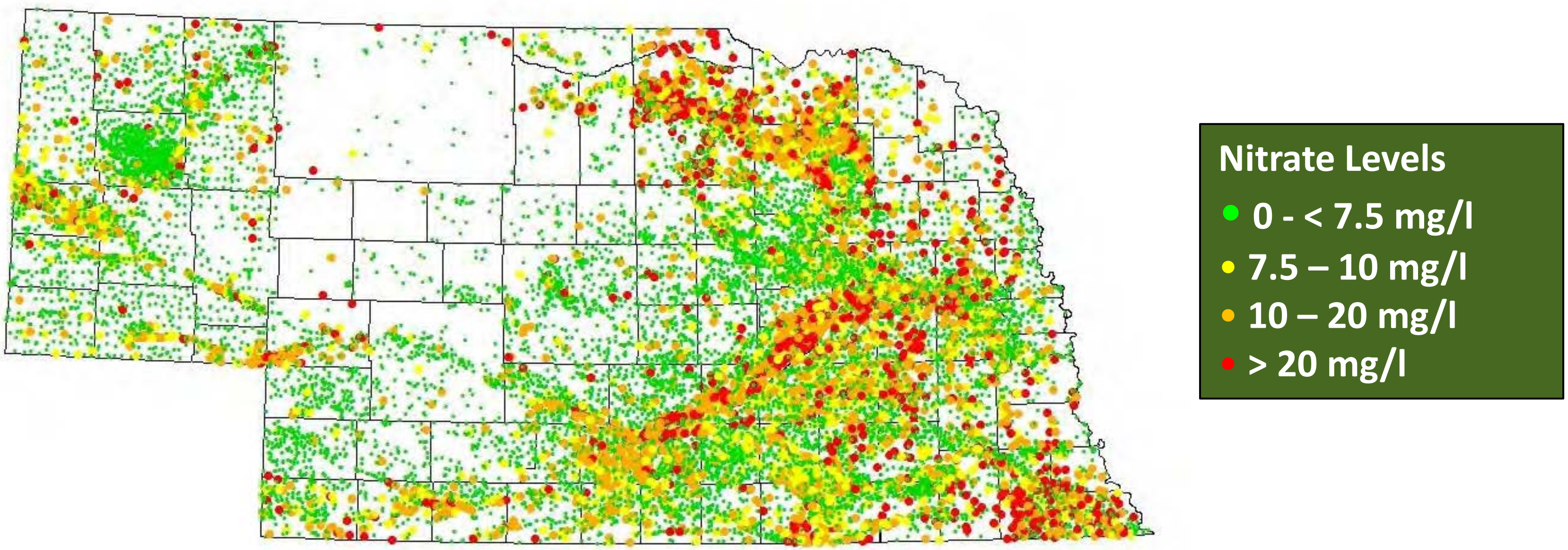
Photos from: http://www2.epa.gov/nutrientpollution/

“Drinking Water Roulette”

Citizens for a Healthy Iowa – Jan 15, 2014

http://blogs.desmoinesregister.com/dmr/index.php/2014/01/15/iowa-activist-group-releases-tv-ad-calling-for-clean-water-in-iowa/article?nclick_check=1

Well Water Issues

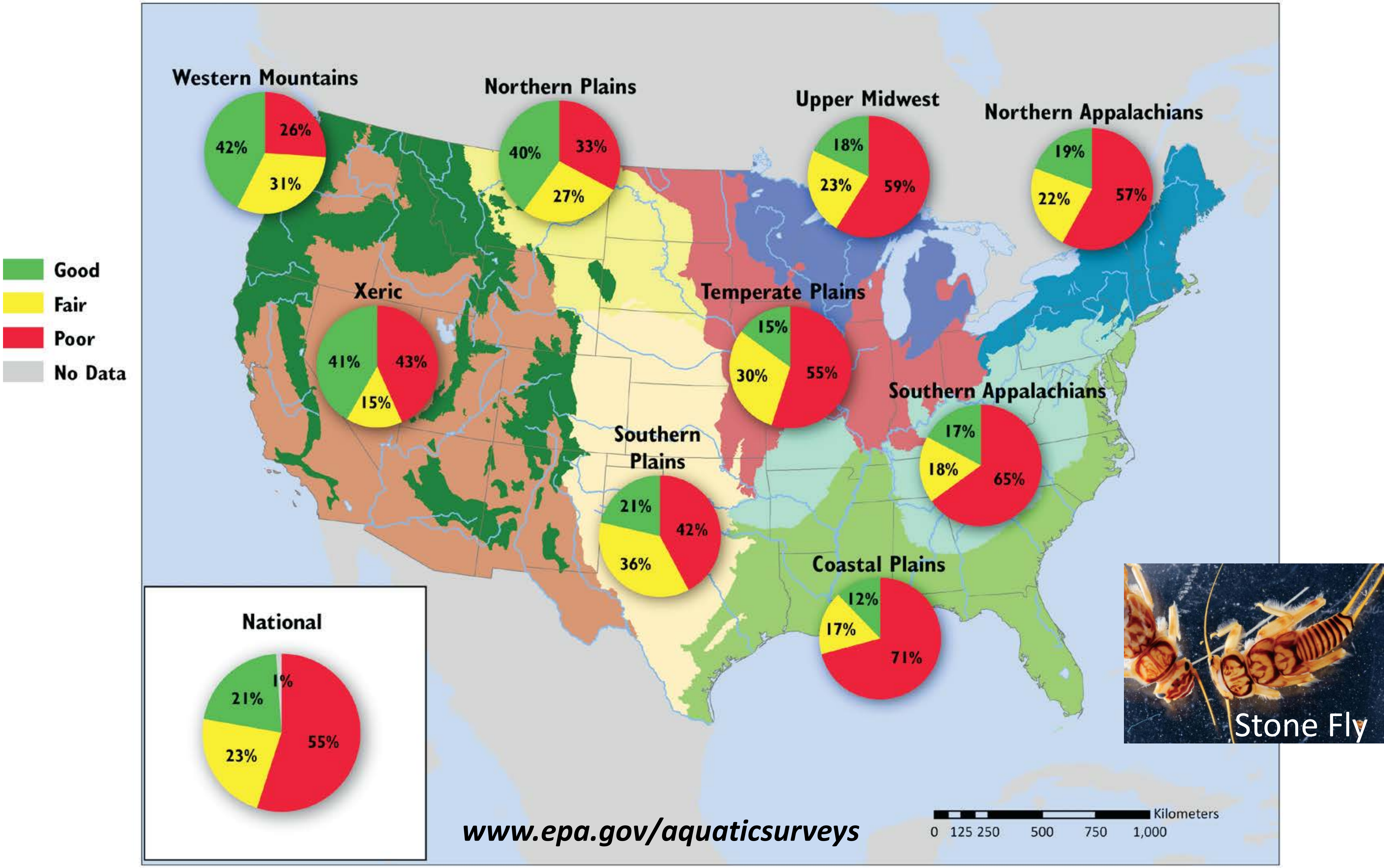


Map from: ***2010 Nebraska Groundwater Quality Monitoring Report*** *Nebraska Department of Environmental Quality Water Quality Assessment Section Groundwater Unit*

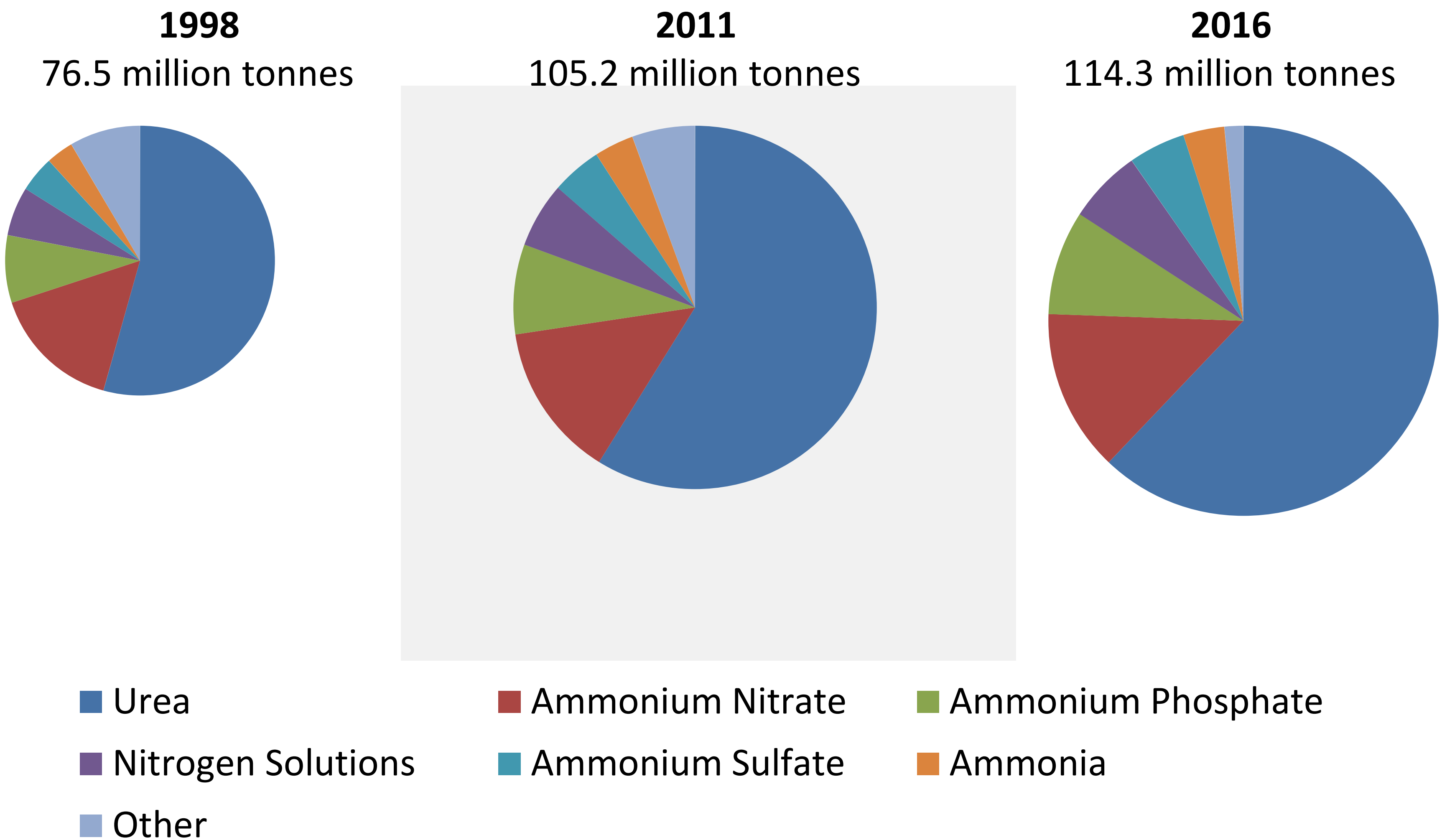
The National Rivers and Streams Assessment 2008-2009: A Collaborative Survey

Biological Condition — Macroinvertebrate MMI

March 2013, EPA 841-F-13-004

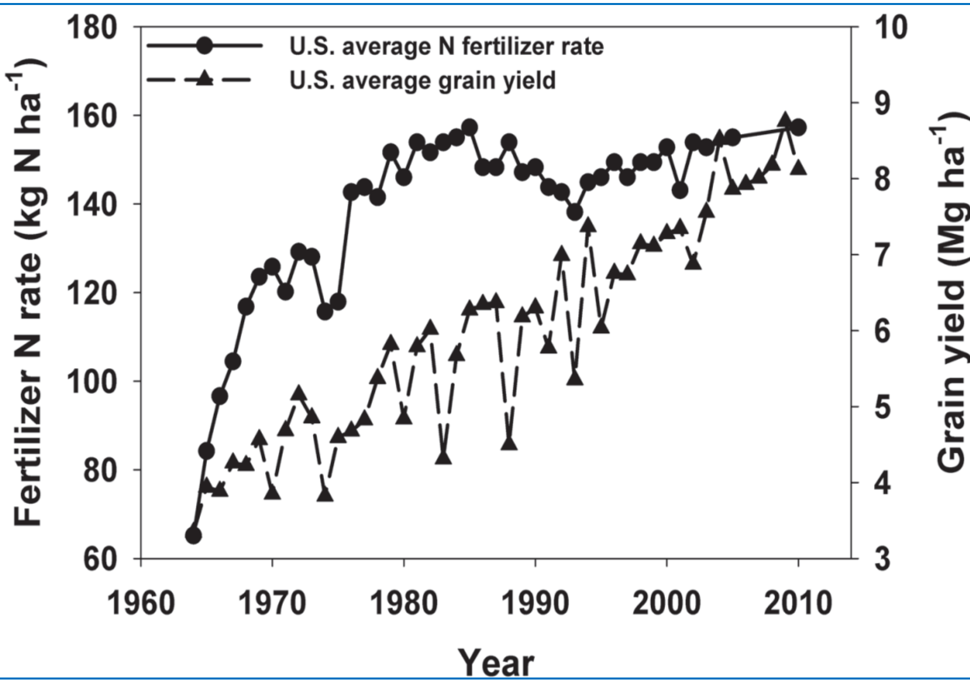


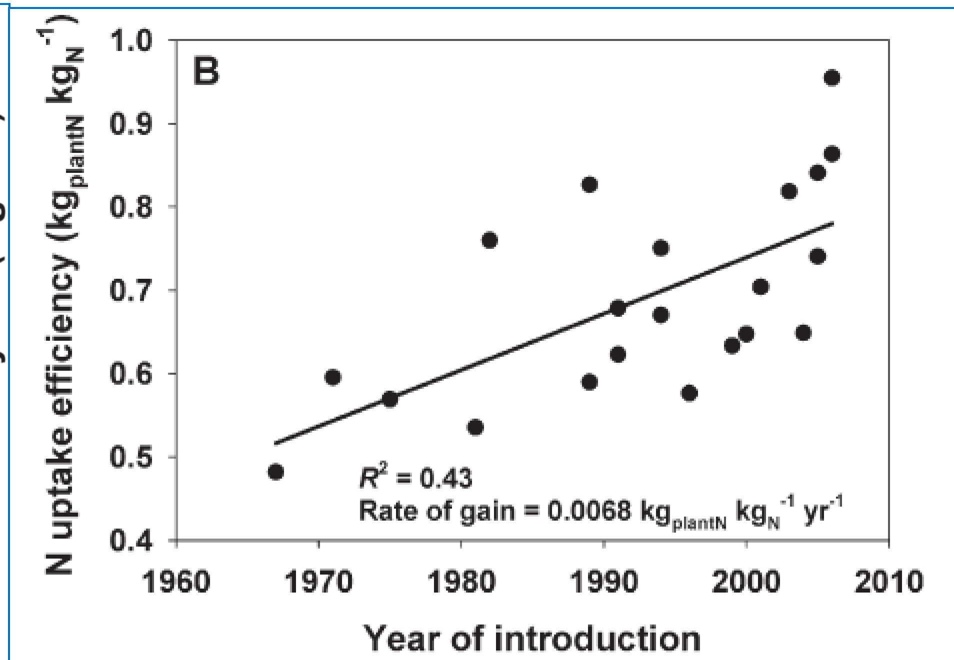
World Consumption of Nitrogen Fertilizer by Product



Changes in Nitrogen Use Traits Associated with Genetic Improvement for Grain Yield of Maize Hybrids Released in Different Decades

Jason W. Haegele, Kevin A. Cook, Devin M. Nichols, and Frederick E. Below*





"The response of grain yield to fertilizer N in current hybrids is more dependent on uptake of fertilizer N than the efficiency of fertilizer N utilization, and approximately two-thirds of genetic gain for grain yield at high N can be explained by improvements in grain yield at low N."

CROP SCIENCE, VOL. 53, JULY–AUGUST 2013

Big Questions

1. Potential for Nutrient Regulation in Midwest?
2. Industry's Role?
3. Academia's Role?
4. New Opportunities?

Non-Point Sources Managed by States

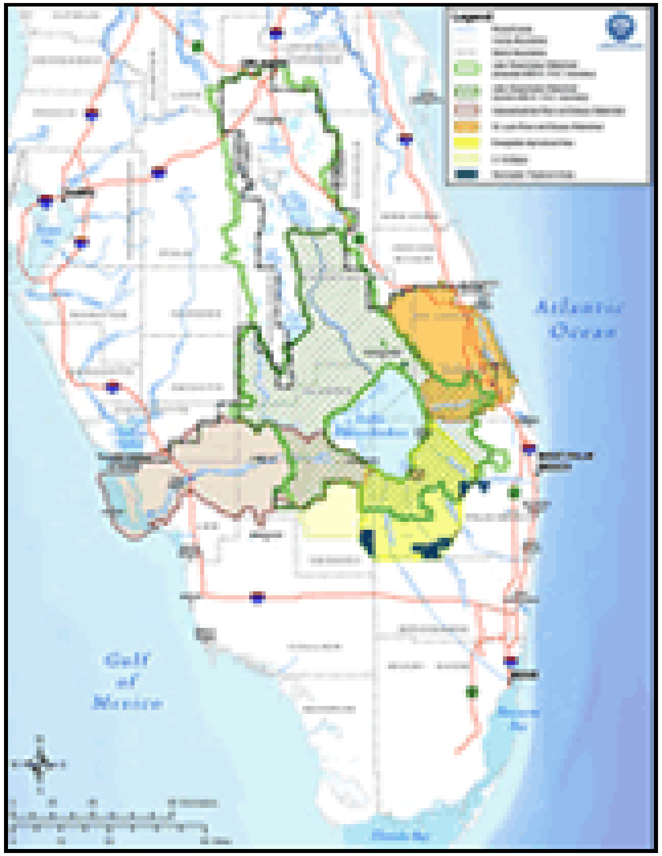
- States are being pressured to adopt standards that impose BMP’s on growers, for example:
  - Site-specific BMP’s in impaired watersheds (FL)
  - Uncertified/certified nutrient management plans (MD, ME, PA, WI, OH)
  - Restrictions on fall and/or winter applied fertilizer/manure (ME, MD, PA, NE, VE)
  - Restrictions on total nitrogen applied (NE)
  - Riparian buffers (MD, MN, PA, VE, WI)
  - Cover crops (MD, PA)

Will this be considered a point-source?

S. FLORIDA: SOURCE CONTROLS AND BEST MANAGEMENT PRACTICES (BMPs)

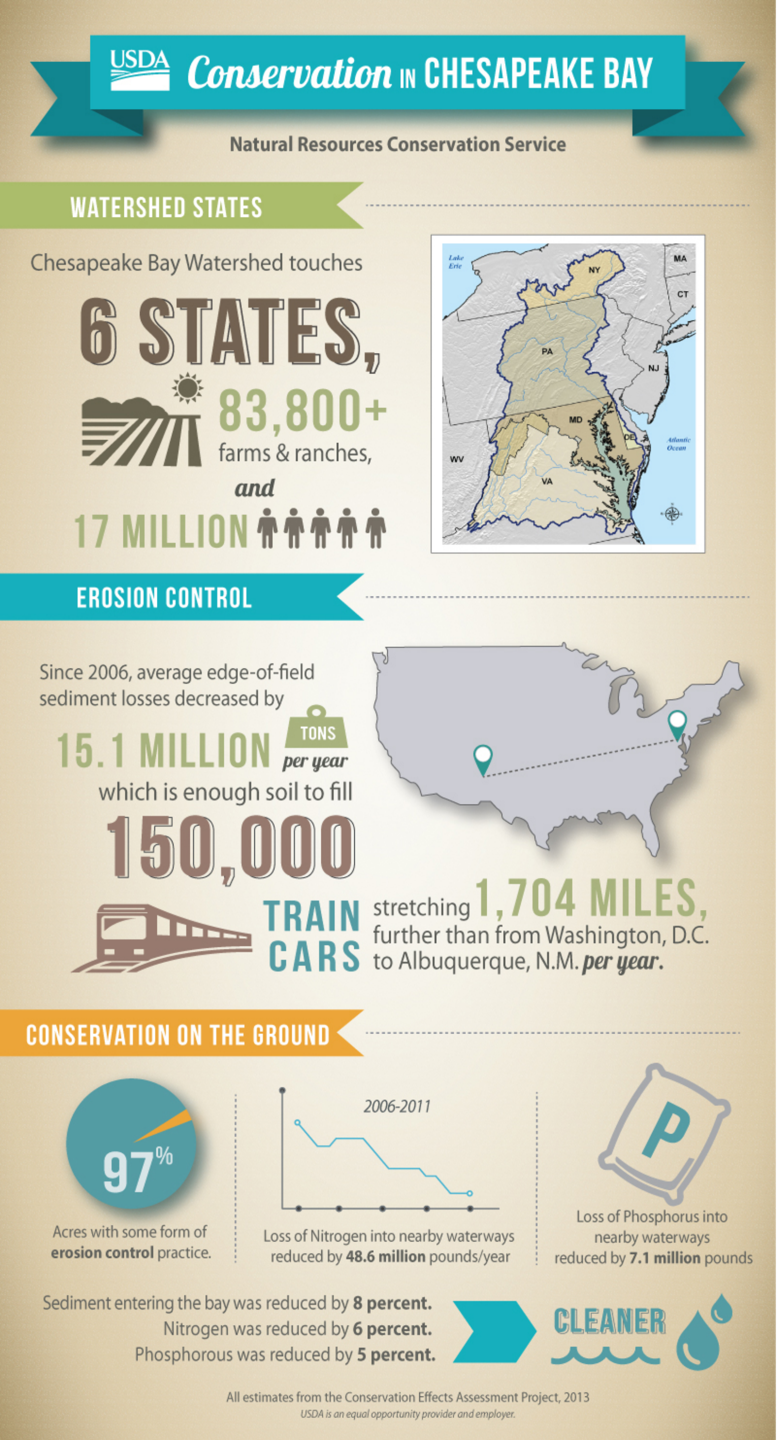
Successful source control programs have seven essential components:

1. Comprehensive BMP plans
2. Deadlines for BMP implementation
3. Field verification of BMP implementation
4. Water quality monitoring
5. Performance metrics
6. Research and demonstration projects to improve BMPs
7. Cost-effective implementation



MAP OF SOURCE CONTROL PROGRAM WATERSHEDS »

http://www.sfwmd.gov/portal/page/portal/xweb%20protecting%20and%20restoring/best%20mangement%20practices



Impact Statement for Chesapeake Bay (Dec 5, 2013)

Key Findings (from 2011 survey):

- Voluntary, incentives-based conservation approach continues to be effective.
- Reduced edge-of-field sediment losses by 62 percent since 2006
- Annual rate of soil carbon loss was reduced by 50 percent
- Reduced edge-of-field phosphorus losses by 45% vs 2003-06 loss rates.
- Edge-of-field N losses were reduced:
  - 38% in surface runoff
  - 12% in subsurface flows
- Cumulative in-stream loads delivered to the Chesapeake Bay reduced by 8% for sediment, 6% for N, and 5% for P
- Cover crops increased from 5 to 52%

http://www.nrcs.usda.gov/wps/PA_NRCSConsumption/

Trends in Environmental Policy

- Fewer rural voters
- More focus on environmental and food safety
- Less patience for voluntary programs
- Less money available for PTP programs (>$500M removed from USDA budget in 2011)
- More interest in incorporating PPP principles
- Modeling and monitoring capabilities have improved

What’s the Good News?

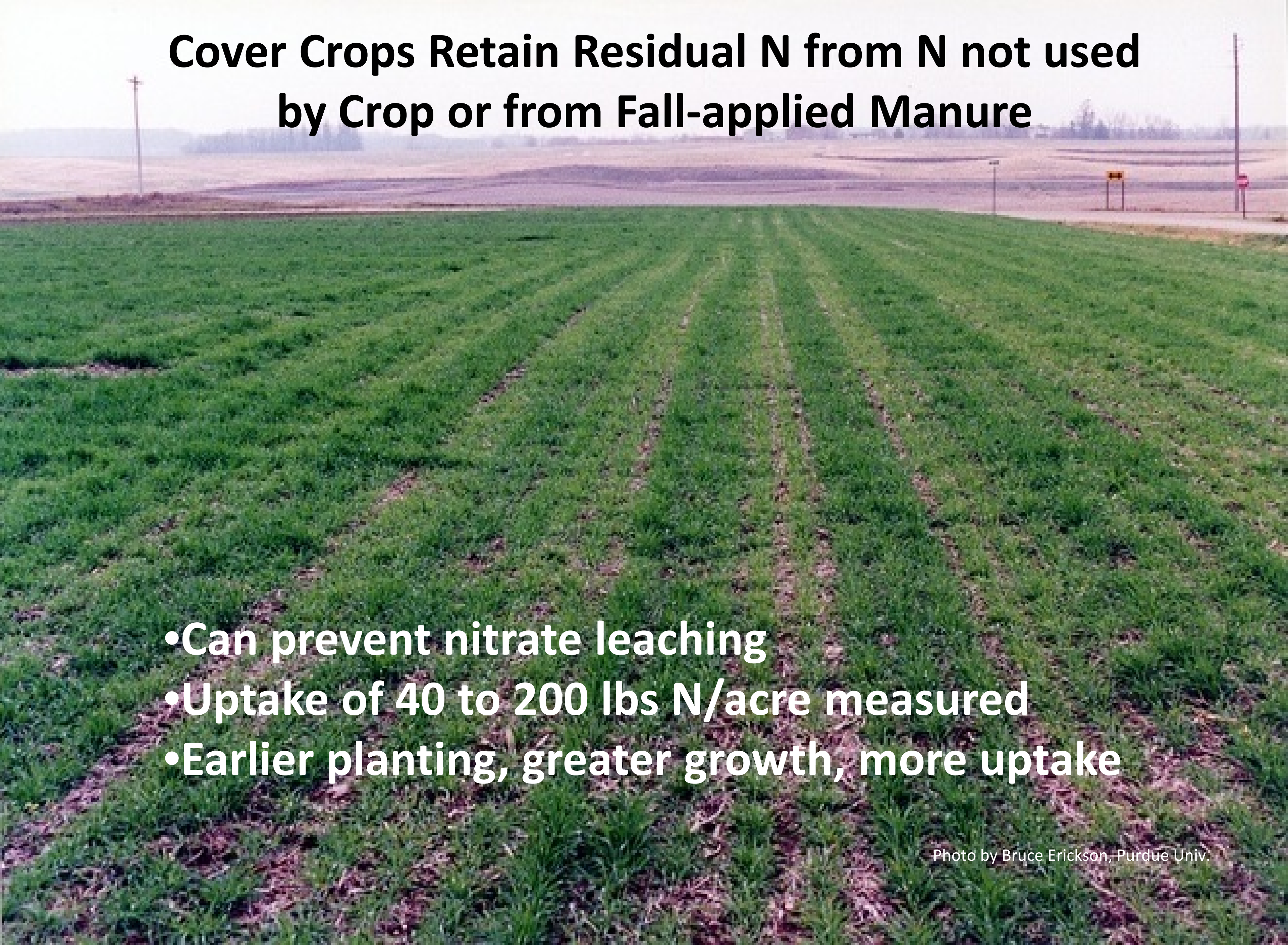
- There are plenty of BMPs that have been shown to reduce nutrient losses
- Plenty of room for improvement
- Barriers to BMP adoption are not intractable
- There is a window to demonstrate industry action <u>and</u> results
- Still possible to avoid most restrictive regulation

Iowa Strategy to Reduce Nutrient Loss: Nitrogen Practices

	Practice	Comments	% Nitrate-N Reduction+	% Corn Yield Change++
			Average (SD*)	Average (SD*)
Nitrogen Management	Timing	Moving from fall to spring pre-plant application	6 (25)	4 (16)
		Spring pre-plant/sidedress 40-60 split Compared to fall-applied	5 (28)	10 (7)
		Sidedress – Compared to pre-plant application	7 (37)	0 (3)
		Sidedress – Soil test based compared to pre-plant	4 (20)	13 (22)**
	Source	Liquid swine manure compared to spring-applied fertilizer	4 (11)	0 (13)
		Poultry manure compared to spring-applied fertilizer	-3 (20)	-2 (14)
	Nitrogen Application Rate	Nitrogen rate at the MRTN (0.10 N:corn price ratio) compared to current estimated application rate. (ISU Corn Nitrogen Rate Calculator – http://extension.agron.iastate.edu/soilfertility/nrate.aspx can be used to estimate MRTN but this would change Nitrate-N concentration reduction)	10	-1
	Nitrification Inhibitor	Nitrapyrin in fall – Compared to fall-applied without Nitrapyrin	9 (19)	6 (22)
	Cover Crops	Rye	31 (29)	-6 (7)
		Oat	28 (2)	-5 (1)
	Living Mulches	e.g. Kura clover – Nitrate-N reduction from one site	41 (16)	-9 (32)

http://www.nutrientstrategy.iastate.edu/ ISU, Extension & Outreach (2013)

Cover Crops Retain Residual N from N not used by Crop or from Fall-applied Manure



- Can prevent nitrate leaching
- Uptake of 40 to 200 lbs N/acre measured
- Earlier planting, greater growth, more uptake

Photo by Bruce Erickson, Purdue Univ.

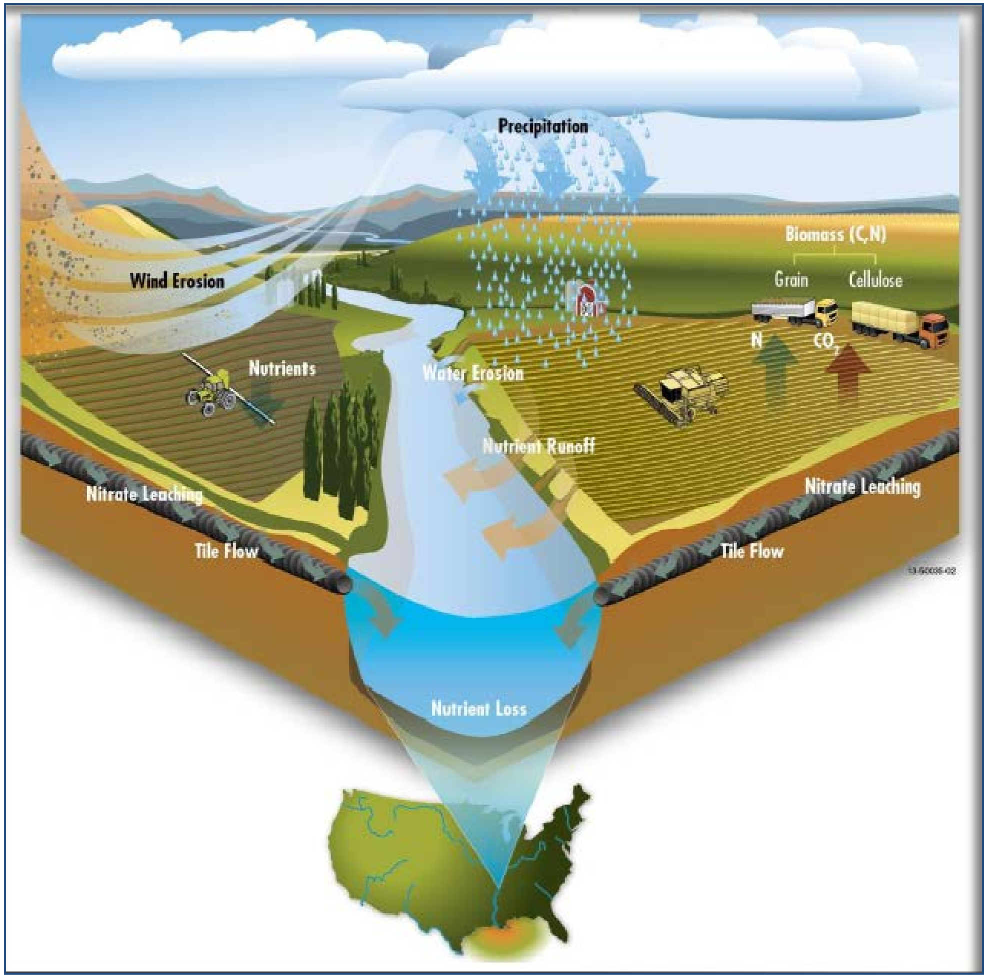
Protected-N Fertilizers

- Nitrapyrin (N-Serve®)
- NBPT-treated Urea (Agrotain™)
- Sulfur coated urea
- Polymer-coated urea
- Sulfur and polymer-coated urea
- Various coatings on N-P-K homogenous fertilizers for use in greenhouse, nursery and turf

Nutrient management requires year-round enterprise management

What happened during the fall, winter and early spring?

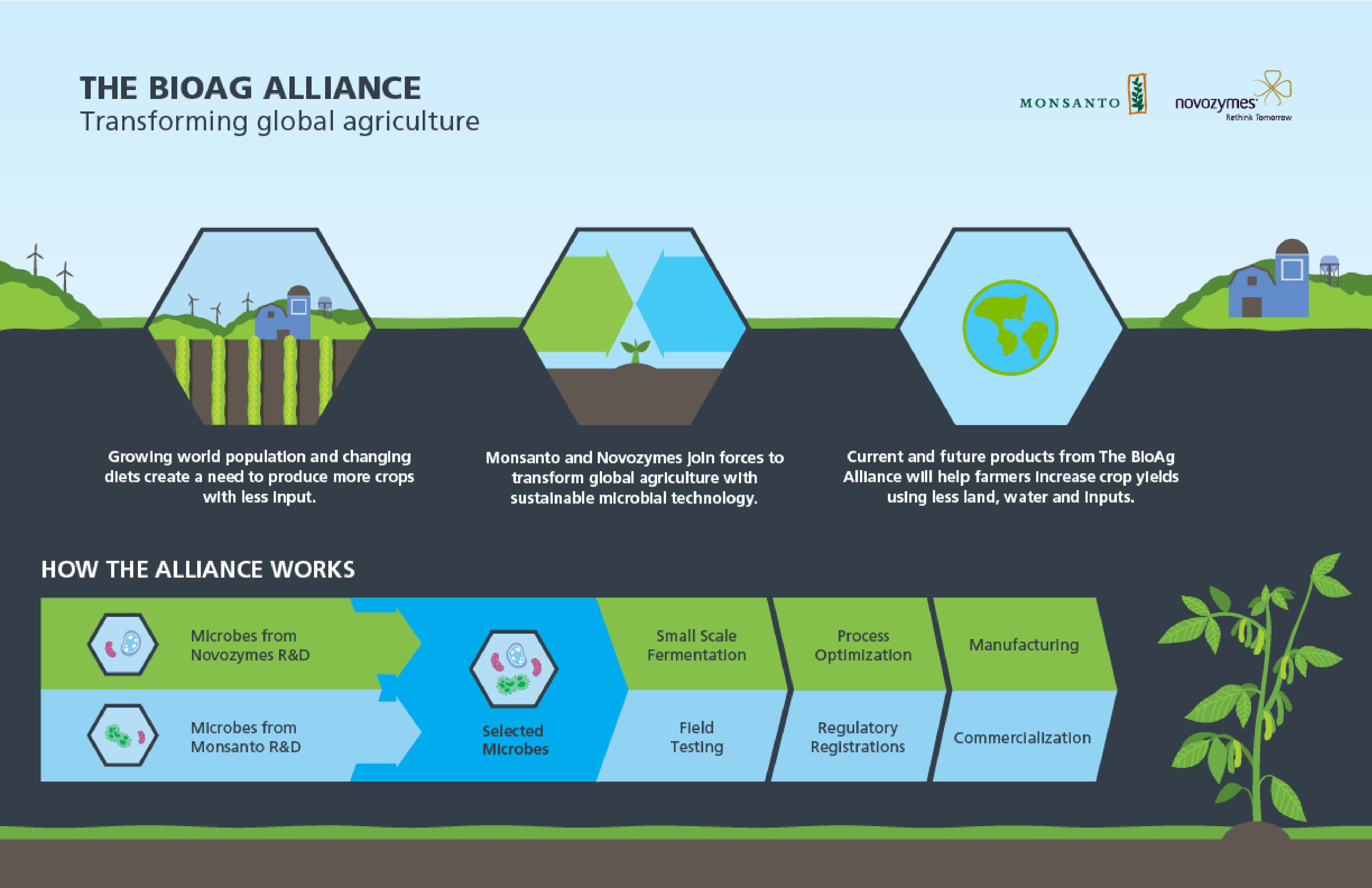
What parts of the field need additional applications?



THE CLIMATE CORPORATION

Weather is the single largest factor determining nutrient losses

Using the microbiome to produce more with less



Nutrient mapping will help determine the N status over four dimensions

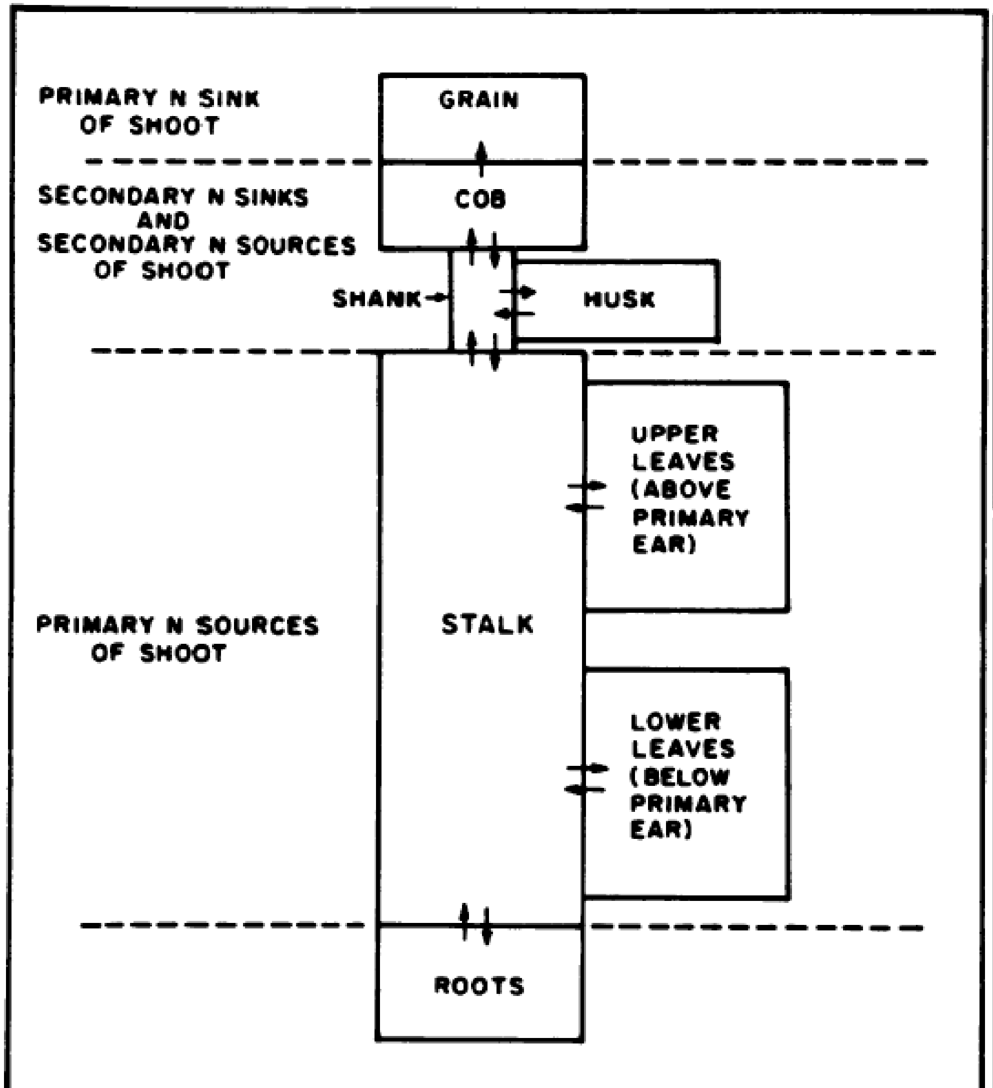
Insight from the Ground Up

Soil measurements are the base layer for precision agriculture. Better measurements lead to increased profitability and yield. Get more from every trip to the field.

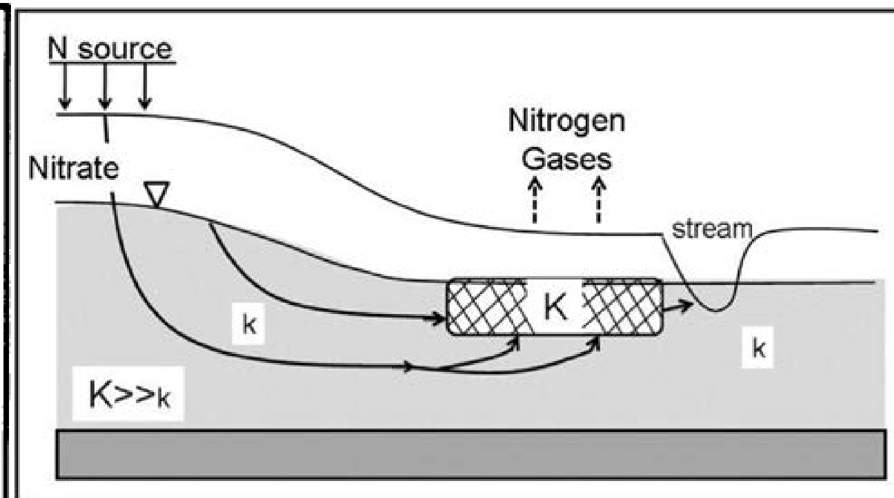
How should corn breeders prepare?

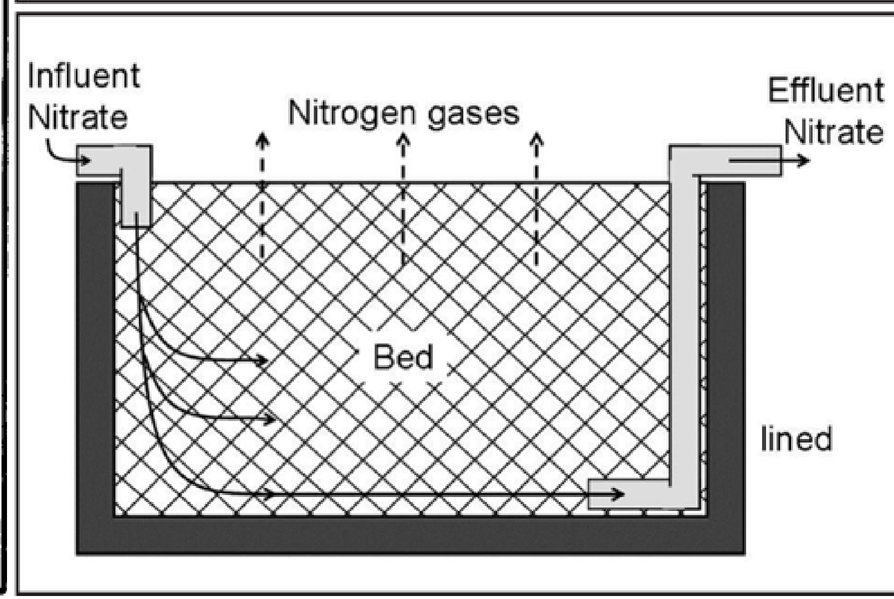
- Understand coming regulations
- Mimic future nutrient management regimes
- Breeding & Testing programs with:
  - Variable rate everything!
  - Protected N sources
  - Just-in-time N applications
  - HD Soil mapping
  - Cover cropping and building SOC
  - Closer match of nutrient availability to sink
    - Estimate nutrient uptake curves per hybrid?
    - Nutrient flux modeling at test sites?
    - Understanding microbial impact on N availability?

Source-Sink (Then and Now)



Crawford et al., Plant Physiol. (1982) 70, 1654-1660





J. Cont. Water Research & Ed., V.151, 1, pp 9–19, 2013

Questions?