# 5th Annual Nitrogen: Minnesota’s Grand Challenge & Compelling Opportunity Conference


**Sessions 9:05 a.m.-3:40 p.m.**

### General Session

- **8:15 a.m.** Registration
- **9:00 a.m.** Welcome
  - Tom Rothman  
  - University of Minnesota
- **9:05 a.m.** Lessons Learned in 2018, Opportunities for 2019
  - Brad Carlson  
  - University of Minnesota Extension
  - Dave Nicolai  
  - University of Minnesota Extension
  - Brandon Fast  
  - Minnesota Corn Research & Promotion Council
- **9:55 a.m.** An Industry Perspective on Nitrogen: Beginning with 4R Nutrient Stewardship
  - Dr. Tai Maaz  
  - International Plant Nutrition Institute
- **10:50 a.m.** Break
- **11:05 a.m.** NUE and Potential Environmental Outcomes Associated with N Application Timing
  - Dr. Carrie Laboski  
  - University of Wisconsin-Madison
- **12:00** Lunch

### Breakout Session #1

- **1:00 p.m.** Managing Corn for High Yield and Environmental Stewardship While Controlling Costs
  - Dr. Jeff Coulter  
  - University of Minnesota
- **1:55 p.m.** N loss from Midwest cropping systems: What can we do about it?
  - Dr. Dan Jaynes  
  - USDA ARS, Ames, IA
- **2:50 p.m.** Urea Fertilizer Do’s and Don’ts
  - Dr. Fabián Fernández  
  - University of Minnesota

### Breakout Session #2

- **1:00 p.m.** Improving Nitrogen Mineralization Predictions
  - Dr. Jason Clark  
  - South Dakota State University
- **1:55 p.m.** Soil Health and Implications for Nitrogen Management
  - Dr. Anna Cates  
  - University of Minnesota
- **2:50 p.m.** Nitrogen Management with Manure
  - Dr. Melissa Wilson  
  - University of Minnesota
- **3:40 p.m.** Adjourn

*Thank you to all of our Supporters!*
The impacts and magnitude of N loss from Midwest cropping systems: What can we do about it?

Dan Jaynes
USDA-ARS, Ames, IA
Tests show an excess of nitrates in Iowa lakes

Nitrates trouble won’t evaporate

By PERRY BEMAN
REGISTER STAFF WRITER

Copyright, 1999, Des Moines Register and Tribune Company. A Des Moines Register investigation of the water quality for 17 Iowa beaches found five lakes with nitrates at or above federal health limits. Nitrates have been linked to “blue-baby” syndrome, in which an infant’s blood is robbed of its ability to carry oxygen. Some studies have raised questions about nitrates’ possible role in spontaneous abortions and several types of cancer.

The Register’s tests, analyzed by the University of Iowa Hygienic Laboratory, found water quality at or above federal standards for 14 of the 17 lakes. Water at three others exceeded federal limits. Three of those lakes had high levels of nitrates, specifically Big Creek Lake, Lake Okoboji and Lake MacBride.

The Register’s tests found high levels of nitrates at Big Creek Lake and Lake Okoboji. Lake MacBride had elevated levels of nitrates in the past but had lower levels this year.

The Register tested four lakes near Des Moines for nitrates: Middle Bass, Big Creek, Lake Pancheri and Lake Zorinsky. All four lakes had nitrates at or above federal health limits.

The Register also tested water from three lakes near Des Moines: Red Oak, Lake MacBride and Lake Okoboji. All three lakes had nitrates at or above federal health limits.

The Register’s tests found high nitrates in water from all three lakes near Des Moines. The highest levels were found in water from Lake Okoboji, which had nitrates at or above federal health limits.

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Hypoxic Zones around the World

Diaz & Rosenberg, Science, 2008
Gulf Hypoxic Zone or “dead zone”

Bottom-water dissolved oxygen across the Louisiana shelf from July 24 – 30, 2017

Source: N. N. Rabalais (Louisiana Universities Marine Consortium) and R. E. Turner (Louisiana State University)

Funded by: NOAA, Center for Sponsored Coastal Ocean Research
Coastal Goals of the HTF to reduce 5-year average by 20% by 2025 and by 45% by 2035
Sources of nutrients delivered to the Gulf of Mexico

**PHOSPHORUS**
- Corn and soybean crops: 37%
- Other crops: 18%
- Pasture and range: 12%
- Urban and population-related sources: 8%
- Atmospheric deposition: 5%
- Natural land: 4%

**NITROGEN**
- Corn and soybean crops: 52%
- Other crops: 16%
- Pasture and range: 9%
- Urban and population-related sources: 14%
- Atmospheric deposition: 4%

*Sources*
- U.S. Department of the Interior
- U.S. Geological Survey
Sub-basin Nitrogen Contribution

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Contribution to Total Nitrogen Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Mississippi</td>
<td>39%</td>
</tr>
<tr>
<td>Missouri/Platte</td>
<td>13%</td>
</tr>
<tr>
<td>Ohio/Tennessee</td>
<td>41%</td>
</tr>
<tr>
<td>Arkansas/Red</td>
<td>6%</td>
</tr>
<tr>
<td>Lower Mississippi</td>
<td>1%</td>
</tr>
</tbody>
</table>

Major Mississippi River Sub-basins

What Have We Accomplished?

Reductions from Current Practices

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment</td>
<td>69%</td>
</tr>
<tr>
<td>Pesticides</td>
<td>51%</td>
</tr>
<tr>
<td>P</td>
<td>49%</td>
</tr>
<tr>
<td>N</td>
<td>5%</td>
</tr>
</tbody>
</table>
Moving forward

• No silver bullet
• Need to attack problem from all directions simultaneously
NRCS – MRBI

Practices that:
• Avoid
• Control
• Trap
Avoid

• Increase use of perennials
• Improve N fertilizer management
• Plant cover crops
Perennials

Markets? Cellulosic biofuel crops? Avoid
Improve N Use Efficiency

The 4 Rs

• Right Time – N is used most efficiently when its availability is synchronized with crop demand
• Right Rate – match the amount of N fertilizer applied to the crop need
• Right Place – place N where available to crops but shielded from environmental loss
• Right Source – optimize N availability and risk of loss
N management

Yield response curve

Average corn yield

Yield (bu ac\(^{-1}\))

Fertilizer N added (lbs ac\(^{-1}\))
N management

Yield & NO₃ loss response curve

Average corn yield

Nitrate concentration

Drinking water MCL

Avoid
N management

Yield & NO$_3$ loss response curve

Yield (bu ac$^{-1}$)

Fertilizer N added (lbs ac$^{-1}$)

Nitrate concentration (mg N L$^{-1}$)

average corn yield

B

A

C

nitrate concentration

drinking water MCL

Avoid
2% loss in SON and SOC in 10 yr.

Potential for Mining of SON & SOC

1996 - 2005 Field N Balance
Corn - Soybean Rotation

N Inputs and outputs

kg-N/ha

Avoid
Optimum N Fertilizer Rate Variability

- Yield (bu/ac)
- Drainage NO₃ (mg N/L)

- Total N fertilizer (#/ac)


Avoid
Yield varies over space and among years

Avoid
Improve N fertilizer rate

- Fine-tune N-fertilizer rates
  - Improve University recommendations
    - MRTN (Maximum Rate of Return to N)

![Avoid](image.png)
Improve N fertilizer rate

- Fertilize by zones within field
Improve N fertilizer rate

- Fertilize by zones within field

Yield Zones

1 & 2 "toeslope"
3 "footslope"
4 "shoulder"
5 "backslope"

Avoid
Average N response per yield zone (landscape position)

N from soil (kg/ha)
EONR (kg/ha)
Maximum yield (Mg/ha)

Avoid
Opportunities for Improving N Use Efficiency in U.S. Agriculture

The 4 Rs

• Right Time – N is used most efficiently when its availability is synchronized with crop demand

• Right Rate – match the amount of N fertilizer applied to the crop need

• Right Place – place N where available to crops but shielded from environmental loss

• Right Source – optimize N availability and risk of loss
N management

- Improve N synchronization
  - Polymer coated sources
  - Chemically stabilized N
  - Urease inhibitors

Corn N Uptake:

% of Total N Uptake

Avoid
Opportunities for Improving N Use Efficiency in U.S. Agriculture

The 4 Rs

• Right Time – N is used most efficiently when its availability is synchronized with crop demand
• Right Rate – match the amount of N fertilizer applied to the crop need
• Right Place – place N where available to crops but shielded from environmental loss
• Right Source – optimize N availability and risk of loss
Right Time
(N is used most efficiently when its availability is synchronized with crop demand)

- Best NUE
- Highest crop yields
- Positive WQ impact
- Increased Risk
Improve N synchronization – sidedressing

Avoid
Opportunities for Improving N Use Efficiency in U.S. Agriculture

The 4 Rs

• Right Time – N is used most efficiently when its availability is synchronized with crop demand
• Right Rate – match the amount of N fertilizer applied to the crop need
• Right Place – place N where available to crops but shielded from environmental loss
• Right Source – optimize N availability and risk of loss

Avoid
Soil test guided sidedress rate

Sidedress

Late Spring Nitrate Test

Watershed study

Iowa

WCW

Des Moines

Walnut Creek district drain
subbasin
flow gage

CN1
TR1
CN2

field boundary
220 sub-basin
C - corn
S - soybean
P - pasture

1 0 1 2 3 4 kilometers

0 1 2 3 4 kilometers
N-fertilizer Applied

- 1997: Farmer's program - 157 kg/ha, LSNT - 166 kg/ha
- 1998: Farmer's program - 175 kg/ha, LSNT - 117 kg/ha
- 1999: Farmer's program - 189 kg/ha, LSNT - 174 kg/ha
- 2000: Farmer's program - 193 kg/ha, LSNT - 121 kg/ha

Avoid
Additional Risk to Farmers

LSNT Yield as % of Non-limiting N Yield

<table>
<thead>
<tr>
<th>Year</th>
<th>LSNT Yield as % of High N Rate Strip (250 lb N/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>99</td>
</tr>
<tr>
<td>1998</td>
<td>92*</td>
</tr>
<tr>
<td>1999</td>
<td>99</td>
</tr>
<tr>
<td>2000</td>
<td>98</td>
</tr>
</tbody>
</table>

Avoid
Change in [NO₃] for LSNT vs. fall anhydrous

Jaynes et al., 2004
N Application Timing and Rate

Adjusted N rate, sidedress vs. spring pre-plant
- N loss reduction: -50 to 70% reduction
- Expected long-term reduction: 15%

Adjusted N rate, sidedress vs. fall
- N loss reduction: -25 to 70%
- Expected long-term reduction: 30%

Avoid
Reduction in $[\text{NO}_3]$ for LSNT vs. fall anhydrous
Soil sampling

On board sensors

Remote sensing

Computer simulation
Problems with canopy sensing for determining rate

95% sufficiency index threshold

Site 1

Site 2

Avoid
Opportunities for Improving N Use Efficiency in U.S. Agriculture

The 4 Rs +

- Right Time – N is used most efficiently when its availability is synchronized with crop demand
- Right Rate – match the amount of N fertilizer applied to the crop need
- Right Place – place N where available to crops but shielded from environmental loss
- Right Source – optimize N availability and risk of loss
Fall Cover “Catch” Crop

Row crop

Avoid
Fall Rye Cover Crop - Results

- NO₃ concentration (mg/L)
- Date
- Soybean
- Corn
- Cover crop established

Avoid
Cover Crops and Perennials
Fall planted rye vs. no cover crop
• N loss reduction: -20 to 90%
• Expected long term reduction: 50%
Model simulations of the nitrate load reduction possible if a rye cover crop is implemented on all suitable corn acres within the 5 major cornbelt states. Total annual nitrate reductions to surface waters would be 49.2 million kg-N at a cost of $3.87–$5.65/kg-N removed.
Control

• Drainage water management
Controlled Drainage or Drainage Water Management (DWM)

The outlet is raised after harvest to reduce nitrate delivery during winter.

The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.

The outlet is raised after planting to potentially store water for crops.
Nitrate Loading Comparison

$y = 1.97x$

$R^2 = 0.58$

Sands and Helmers, unpub.
Model simulations of the nitrate load reduction possible if Drainage Water Management is implemented on all suitable corn acres within the Midwest. Total annual nitrate reductions to surface waters would be 82.1 million kg-N at a cost of $2.68/kg-N removed.
Average crop yield for DWM vs. free drainage
Trap

• Wetlands
• Denitrification bioreactors
• Saturate riparian buffers
- 83 wetlands completed
- Removing $10^6$ lbs of NO$_3$-N/yr
- = 0.2% of annual IA loss
Potential $\text{NO}_3^-$ Removal by Wetlands in the Upper Mississippi and Ohio River Basins

Requires 200,000 – 400,000 ha of wetlands for 30% reduction

Crumpton et al., 2006
Trap – Denitrification Bioreactors
Tile drainage water under a conventional and bioreactor system

Nitrate concentration in tile drainage have been reduced by more than 65% over the past 8 yr.
Trap – Riparian buffers

Midwest dominated by artificial subsurface drainage (tile) network
Saturated riparian buffers
Putting it all together
IOWA NUTRIENT REDUCTION STRATEGY
A science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico

Prepared by:
Iowa Department of Agriculture and Land Stewardship
Iowa Department of Natural Resources
Iowa State University College of Agriculture and Life Sciences
November 2012
## Nitrogen Reduction Practices

<table>
<thead>
<tr>
<th>Nitrogen Management</th>
<th>Practice</th>
<th>% Nitrate-N Reduction [Average (Std. Dev.)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Timing (Fall to spring)</td>
<td>6 (25)</td>
</tr>
<tr>
<td></td>
<td>Source (Liquid swine compared to commercial)</td>
<td>4 (11)</td>
</tr>
<tr>
<td></td>
<td>Nitrogen Application Rate</td>
<td>Depends on starting point</td>
</tr>
<tr>
<td></td>
<td>Nitrification Inhibitor</td>
<td>9 (19)</td>
</tr>
<tr>
<td></td>
<td>Cover Crops (Rye)</td>
<td>31 (29)</td>
</tr>
<tr>
<td>Land Use</td>
<td>Perennial – Land retirement</td>
<td>85 (9)</td>
</tr>
<tr>
<td></td>
<td>Living Mulches</td>
<td>41 (16)</td>
</tr>
<tr>
<td></td>
<td>Extended Rotations</td>
<td>42 (12)</td>
</tr>
<tr>
<td>Edge-of-Field</td>
<td>Drainage Water Mgmt.</td>
<td>33 (32)*</td>
</tr>
<tr>
<td></td>
<td>Shallow Drainage</td>
<td>32 (15)*</td>
</tr>
<tr>
<td></td>
<td>Wetlands</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Bioreactors</td>
<td>43 (21)</td>
</tr>
<tr>
<td></td>
<td>Buffers</td>
<td>91 (20)**</td>
</tr>
</tbody>
</table>
Iowa Water Quality & Cost Assessment Case Study

- Cedar River Watershed
- 2006 TMDL for NO$_3$
- Requiring a 35% reduction

James Baker, John Sawyer, Matt Helmers, Antonio Mallorino, Mike Duffy, Bill Crumpton, Sunday Tim, Dan Jaynes, Jack Riessen, Marty Adkins, Rick Robinson, Dean Lemke
Cost effective adoption of NO$_3$ BMPs

- Drainage water management
- 20% N rate reduction on cont. corn
- Constructed wetlands
- 20% N rate reduction on corn-soybean
- Rye cover crops
- No fall N application

Cost ($ per kg N removed)

Nitrogen Reduction (kg N yr$^{-1}$)
FINAL WORDS

• N management is not easy. We have practices for reducing N losses to surface waters, but need more
  Avoid                     Control                     Trap

• Will take years (decades) for widespread implementation of these practices given current voluntary adoption and funding levels

• Voluntary adoption of conservation practices may get replaced by mandatory requirements

• A voluntary but not optional mindset may work best to delay future legislation.

Thank You

dan.jaynes@ars.usda.gov