Investigating Nitrates in Southeast MN Streams

September 5, 2019

Minnesota Pollution Control Agency

J. Watkins, G. Johnson, K. Ahmad, N. Rasmussen, A. Streitz, B. Beyerl, J. Roebuck

With slides from Statewide Nitrogen Study (D. Wall, W. Anderson et al)

Minnesota Geological Survey, U of MN, MN DNR

Presentation Outline

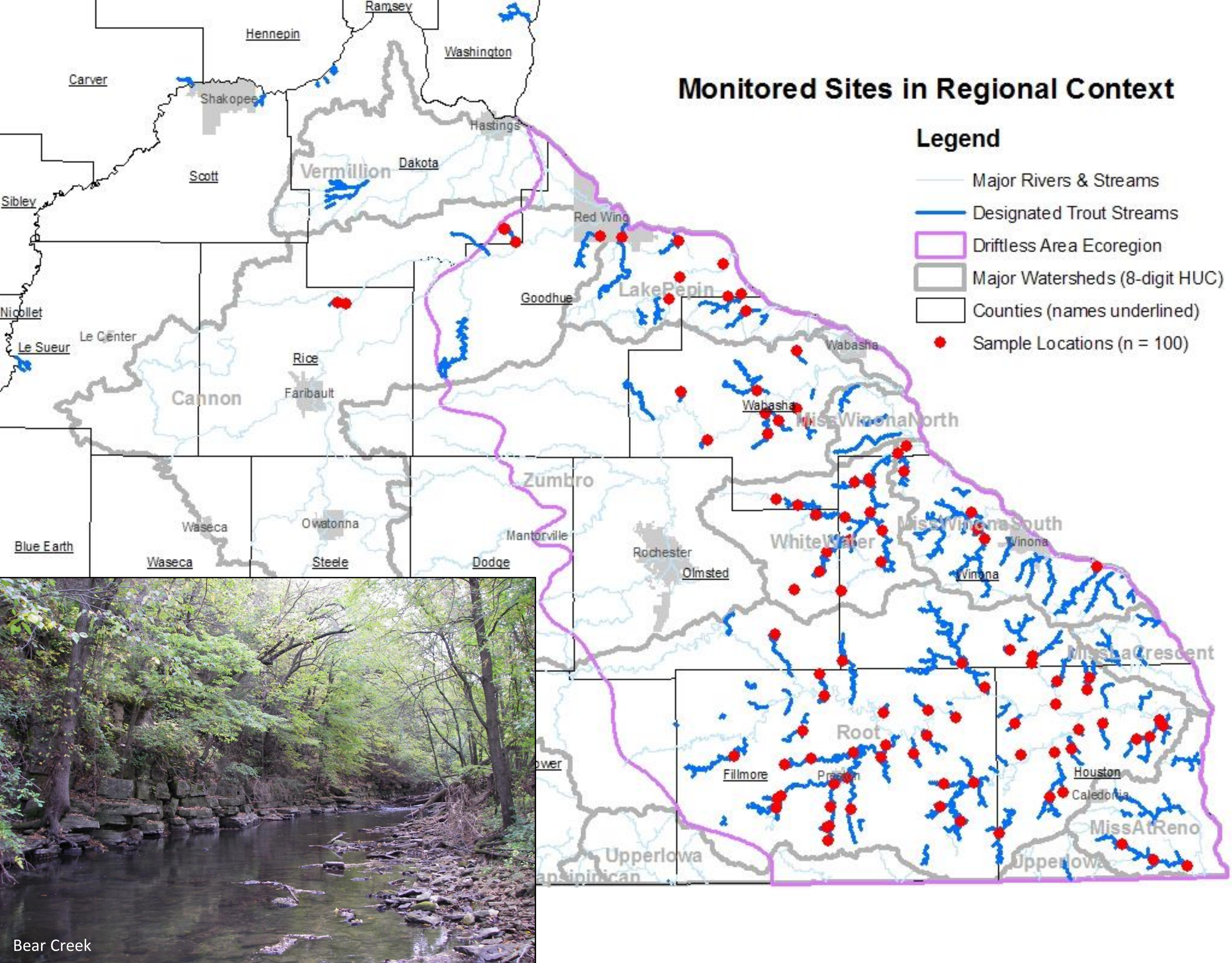
- Background regarding SE MN, nitrates
- Sources, link to land use, pollutant transport
- Planning: goals, tools, prioritization, strategies
  - Minnesota’s Nutrient Reduction Strategy

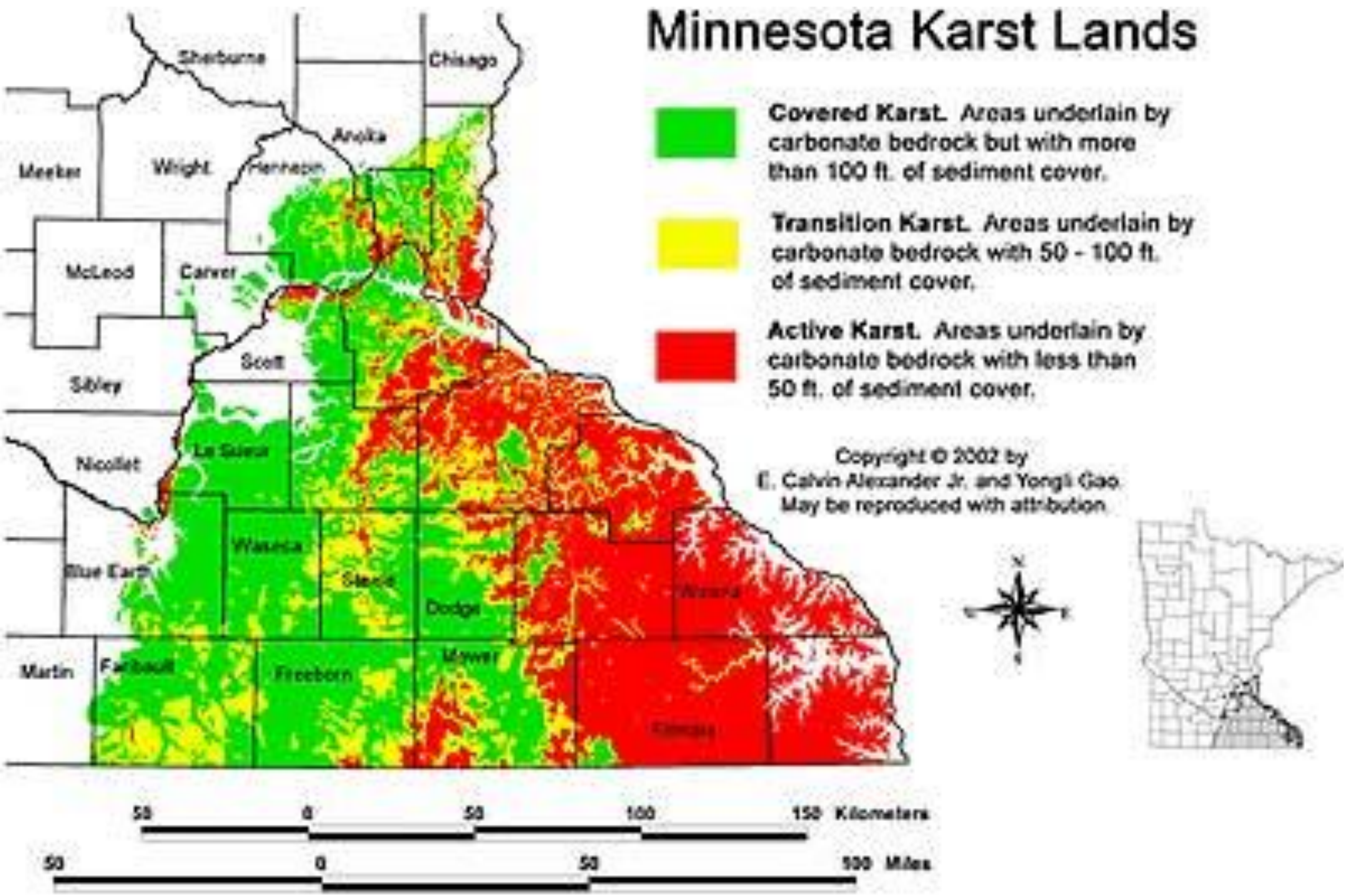
- Optional: SE MN Lysimeter Network
  - Expectations and a means of measuring change

Background

- Southeast Minnesota
- Nitrate Concerns

Monitored Sites in Regional Context

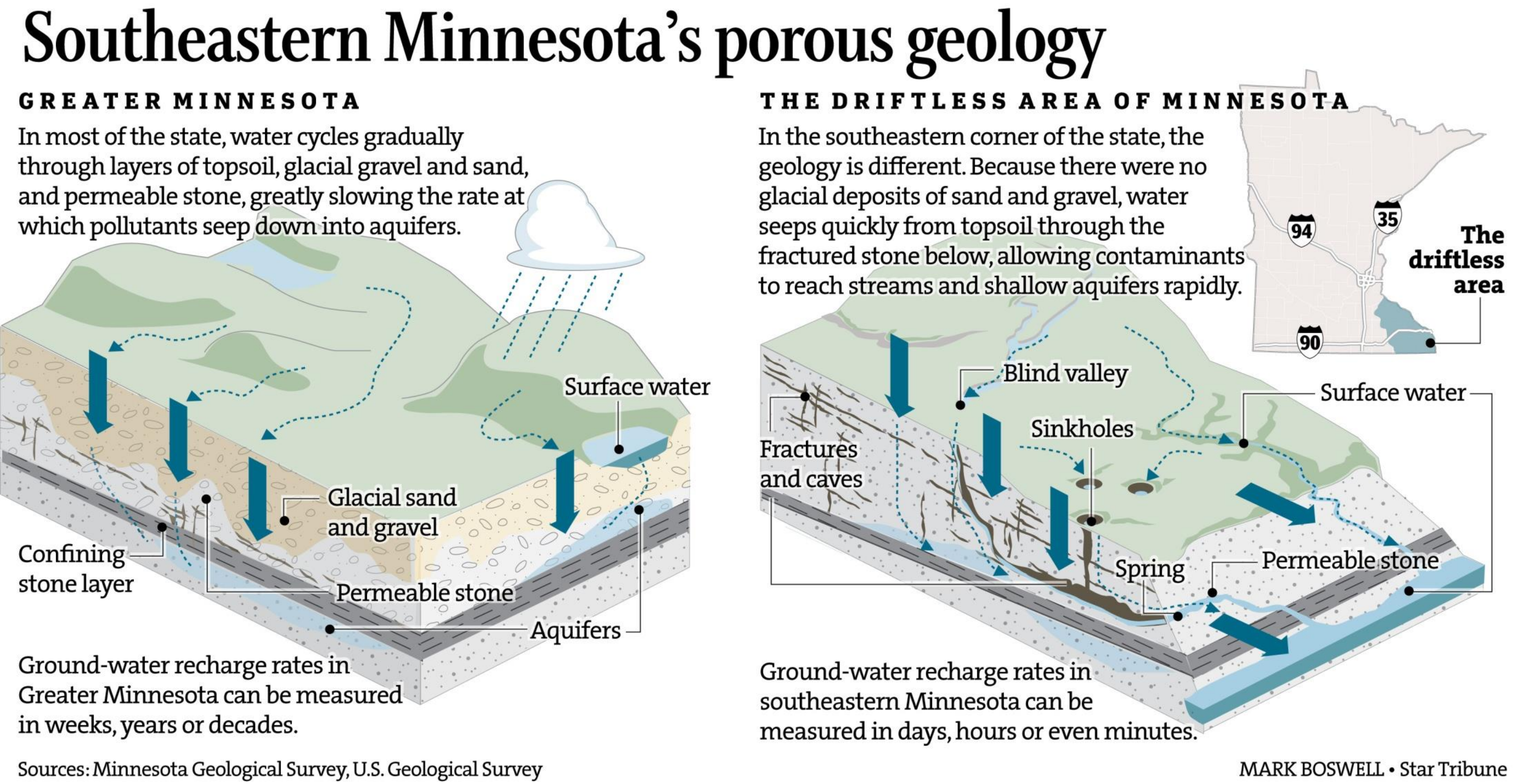




Source: E. Calvin Alexander, University of Minnesota

The landscape of southeast Minnesota is defined by coldwater **trout streams** and **karst topography**, which is characterized by integrated drainage and largely shaped by the dissolving action of water on limestone (MPCA).

Emphasize: movement through soils



Credit: Mark Boswell (printed in Star Tribune, January 30, 2011)

Photo: Jeff Green, MN DNR

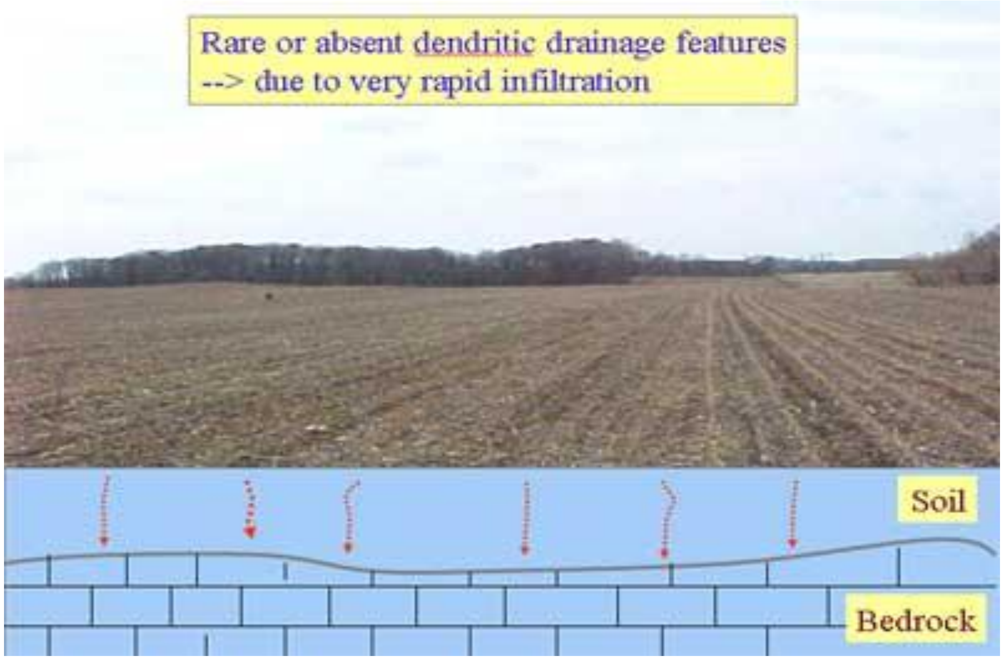
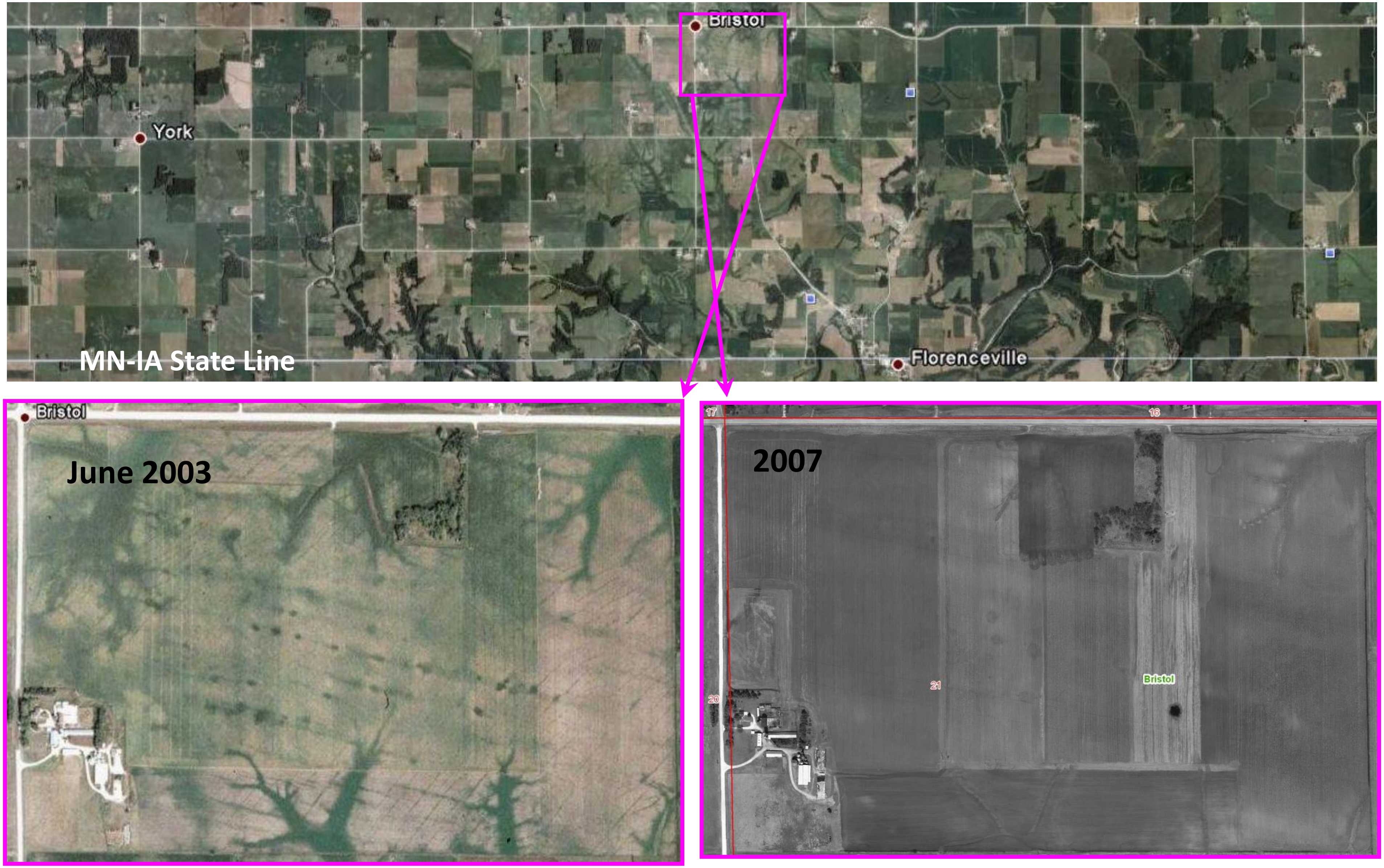
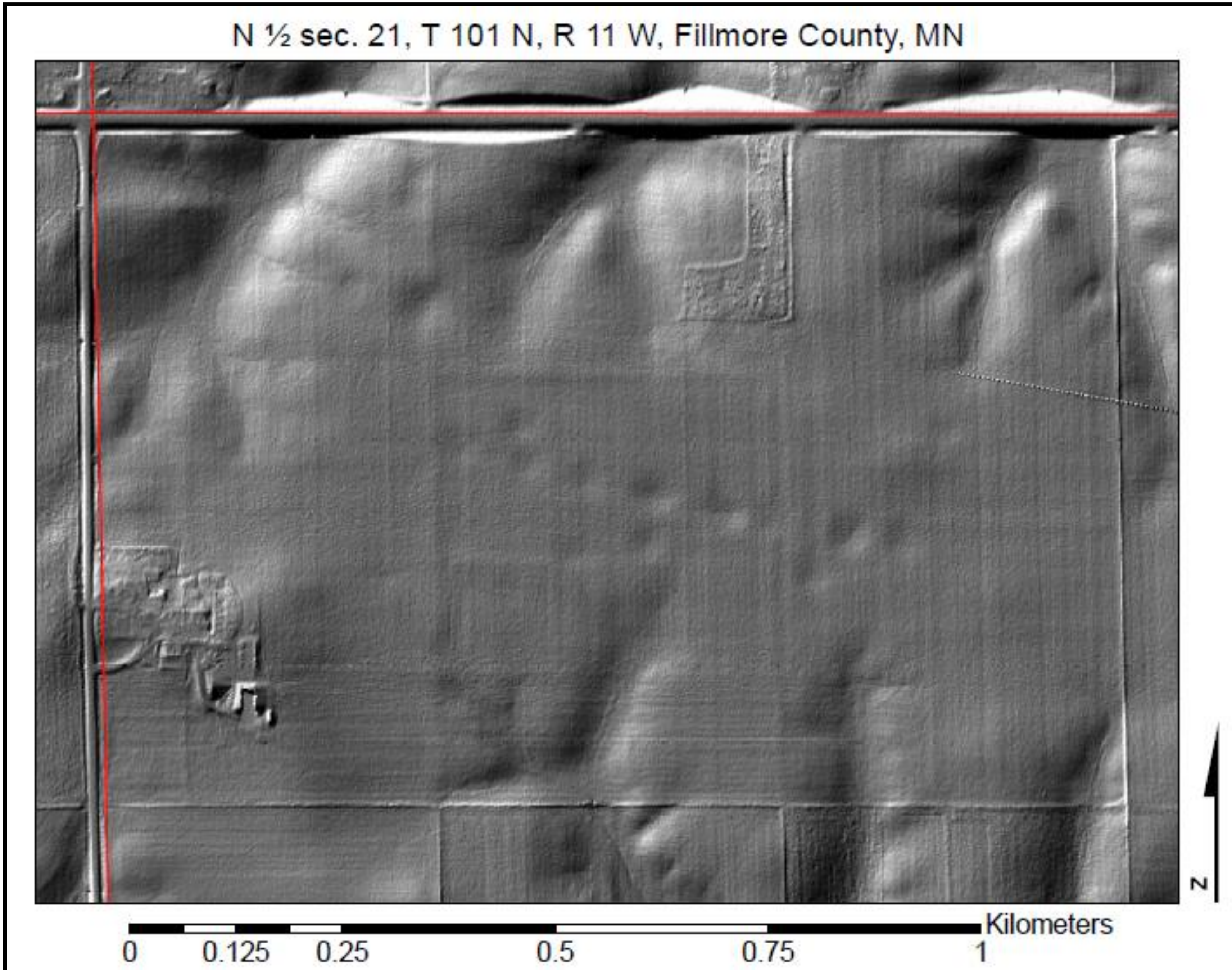


Figure from MPCA web page, 2011

From “The Impact of Karst on Agriculture,” presentation by E. Calvin Alexander




N ½ sec. 21, T 101 N, R 11 W, Fillmore County, MN
Kilometers
0
0.125
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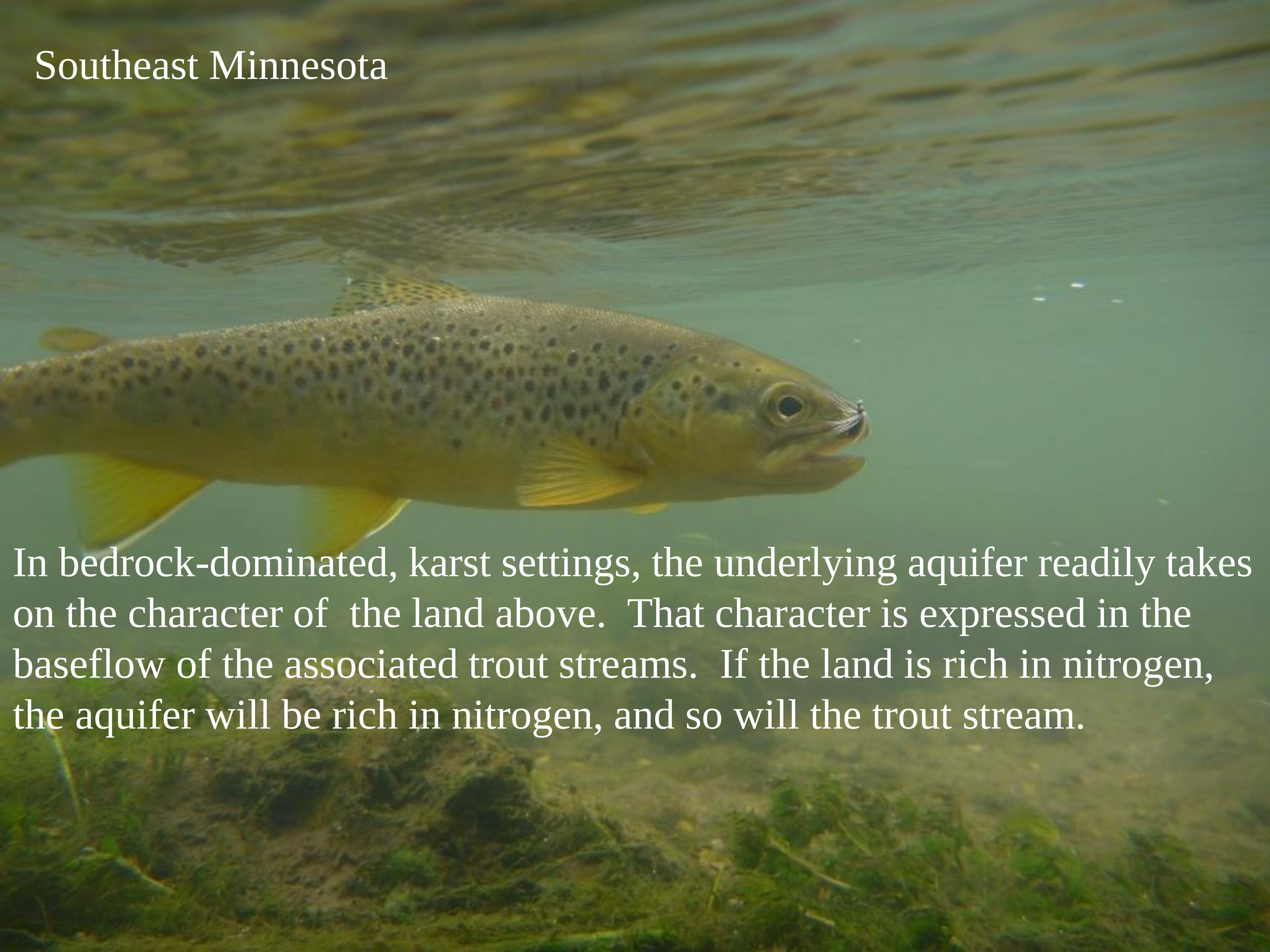
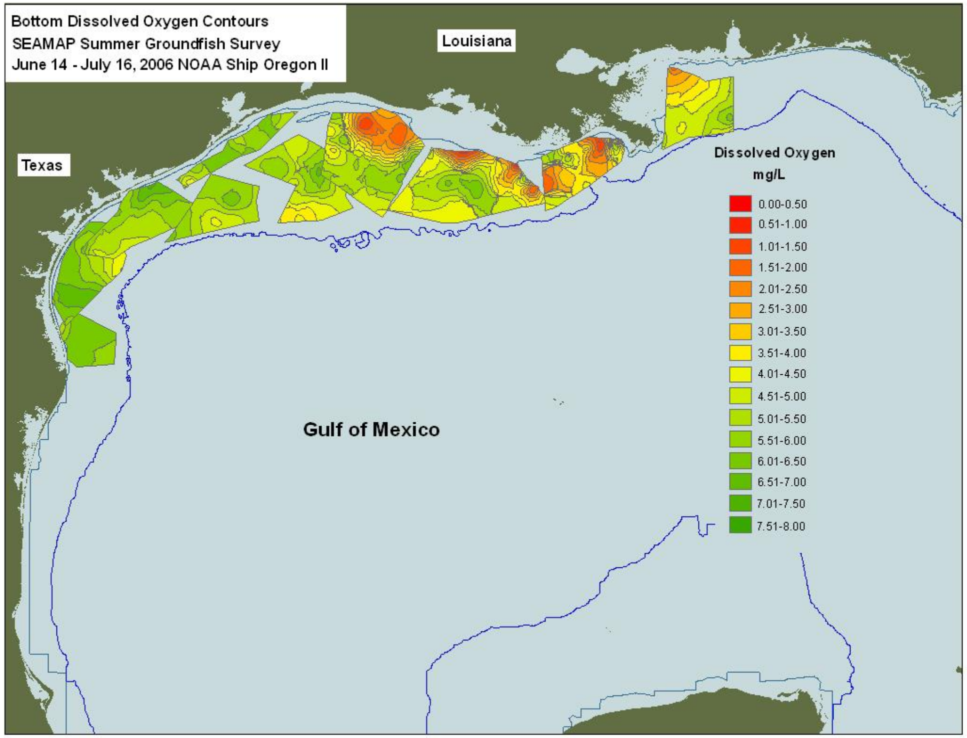
0.75
1
N



Southeast Minnesota

In bedrock-dominated, karst settings, the underlying aquifer readily takes on the character of the land above. That character is expressed in the baseflow of the associated trout streams. If the land is rich in nitrogen, the aquifer will be rich in nitrogen, and so will the trout stream.



<u>Nitrate pollution is a multi-faceted concern:</u>

- Loading of excess nutrients
- Drinking water
- Aquatic life stressor

StarTribune

Date: Sunday, January 30, 2011
Location: MINNEAPOLIS, MN
Circulation (DMA): 504,617 (15)
Type (Frequency): Newspaper (S)
Page: A1,A10
Keyword: Minnesota Pollution Control Agency

POISON ON TAP

• Minnesota's voluntary guidelines on reducing farm runoff aren't working fast enough, critics say.

By JOSEPHINE MARCOTTY
marcotty@startribune.com
LEWISTON, MINN.

Here in the heart of southeast Minnesota farm country, everyone knows you don't drink the water.

"It's just not safe," Linda Liebfried said one recent afternoon as she watched over a couple of toddlers,

tion: agriculture.

Water continues on A10 ►

Unless farm runoff is vastly reduced — and soon — environmentalists say the state may never reclaim its heritage as the land of sky-blue waters.

"There are no mechanisms to curtail the huge loading of pollution, nutrients and sediment from agricultural runoff," said Whitney Clark, executive direc-

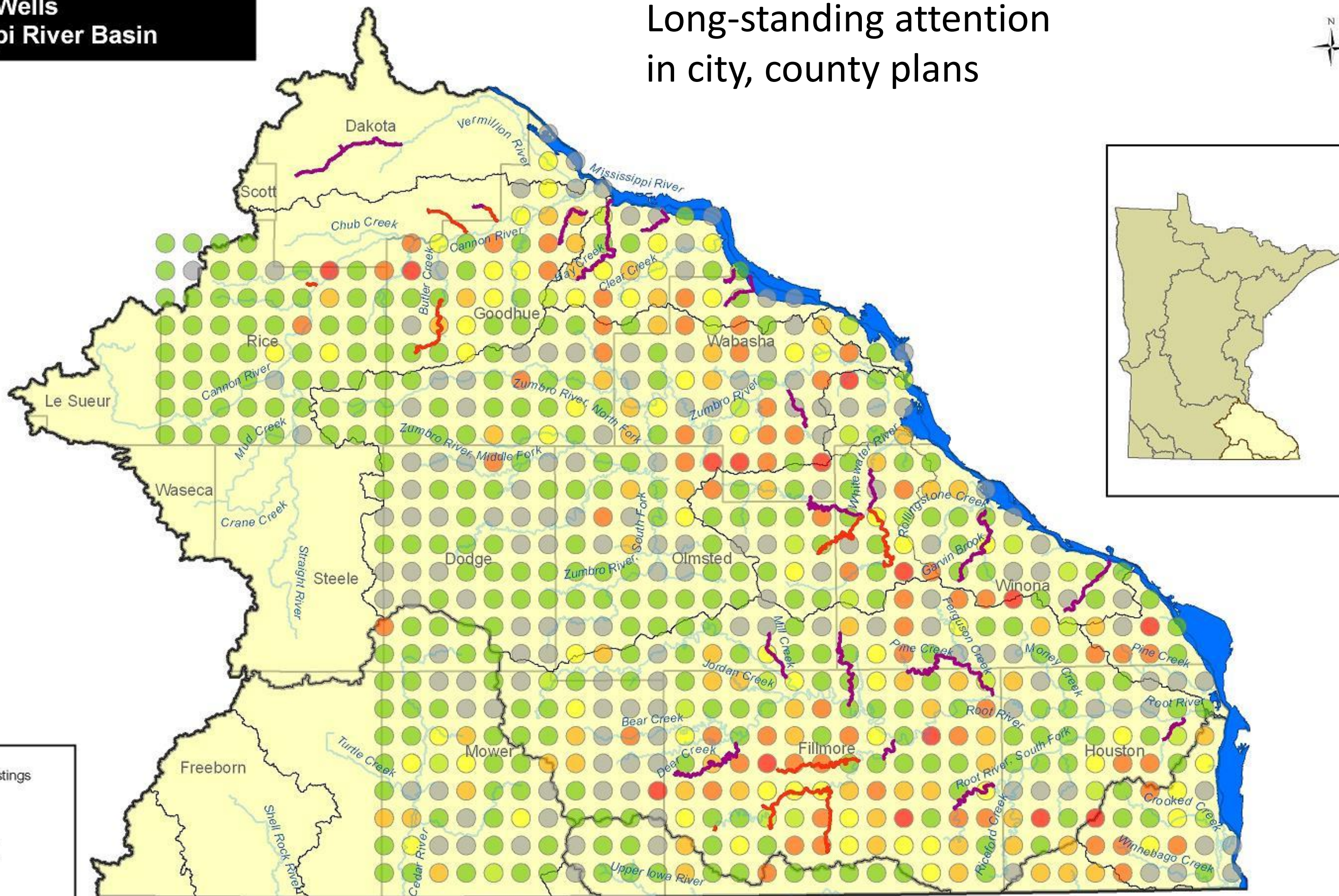
impaired, and with nearly half of the state's land mass devoted to crops, the vast amount of chemical runoff that comes from agriculture is a major factor. Unless agriculture moves faster, they say, the $80 million a year in clean-water funds that will flow from the 2008 Legacy Amendment water could be wasted.

Because time is running out.

Earlier this month Deborah Swackhamer, a University of Minnesota water quality expert, presented the Legislature with a 150-page, 25-year plan to clean up the state's waters. One of the primary recommendations: new laws that would require farmers to adhere to limits on pollution because the voluntary guidelines they are expected to follow now are not working fast enough.

Nitrate Impairment and Unimpairment
NO3 Monitoring Wells
Lower Mississippi River Basin

Long-standing attention in city, county plans



Projection: UTM Zone 15N
Datum: NAD 1983
Scale = 1:1,000,000

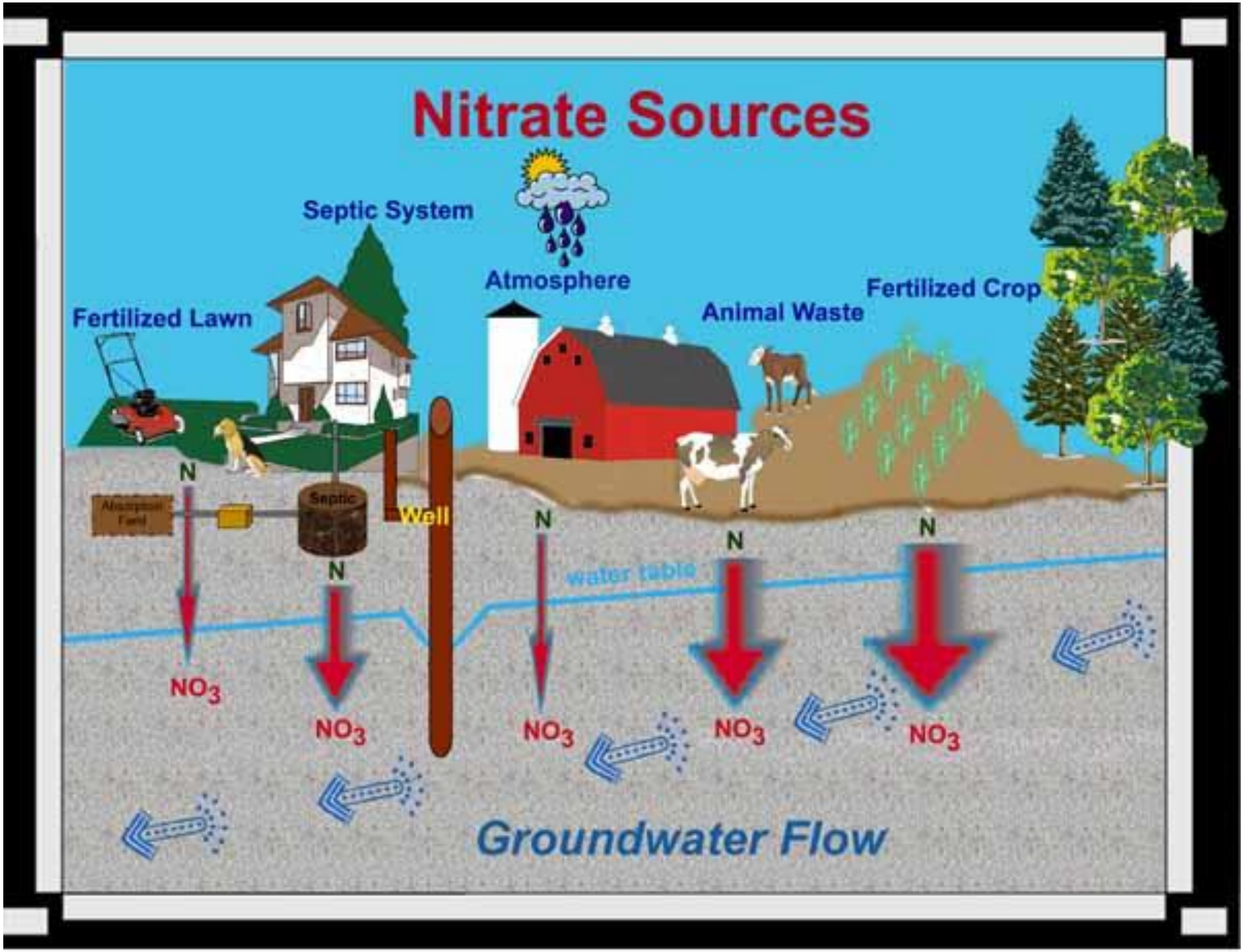
Map does not exceed the accuracy of the source data.

Minnesota Pollution Control Agency

Watershed	# of Listings	Length (miles)
Cannon River	4	20.87
Root River	6	23.84
Whitewater River	2	41.46
TOTAL	12	86.17

Watershed	# Unimpaired	Length (miles)
Cannon	2	9.86
Mississippi River - Lake Pepin	10	75.54
Mississippi River - Winona	2	25.81
Root River	8	74.81
Whitewater River	3	17.49
Zumbro River	1	6.56
TOTAL	26	210.07

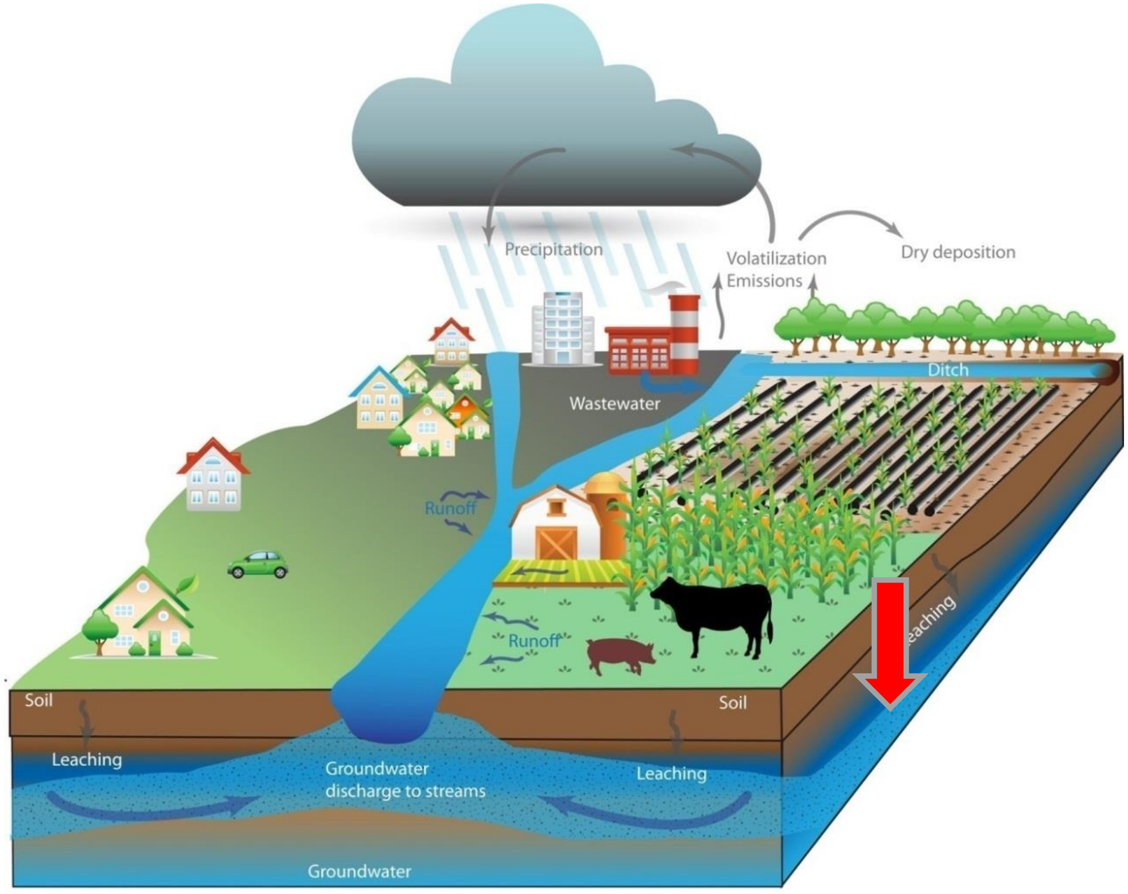
Sources & Transport



- Portage County WI website

Cropland Groundwater

- Travel time to streams
  - from minutes to centuries
- 30% of statewide Nitrogen (N)
- Lower Mississippi
  - 58% of all N
- Minnesota River
  - 16% of all N
- Uncertainties with groundwater N estimates



Baseflow
vs
Stormflow

Root River Project

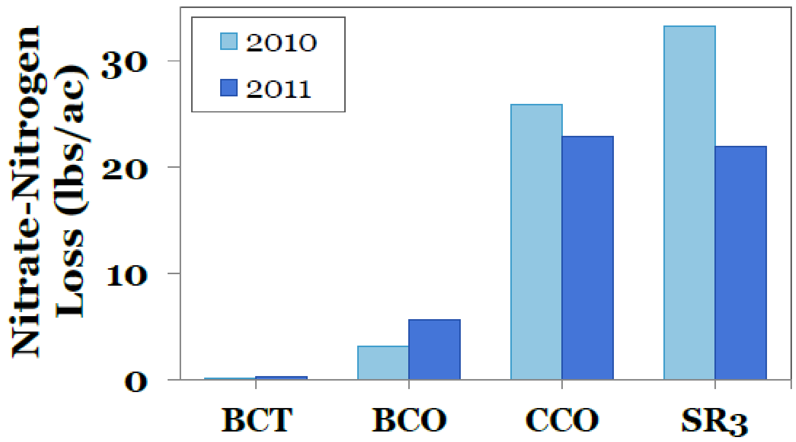


Figure 11. Sub-watershed annual nitrate-nitrogen loss.

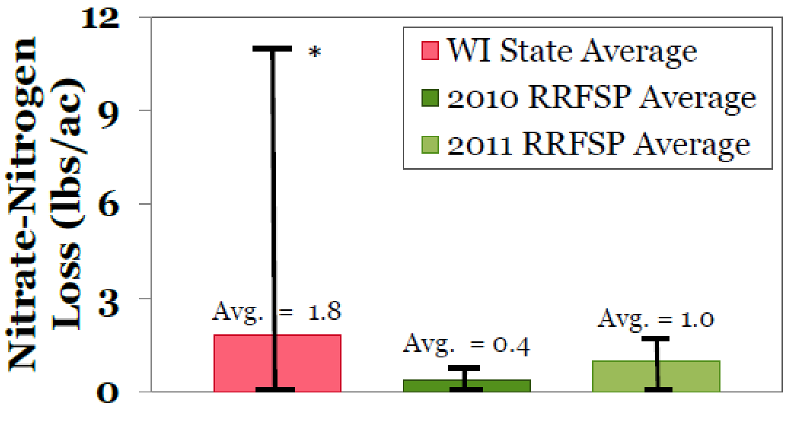
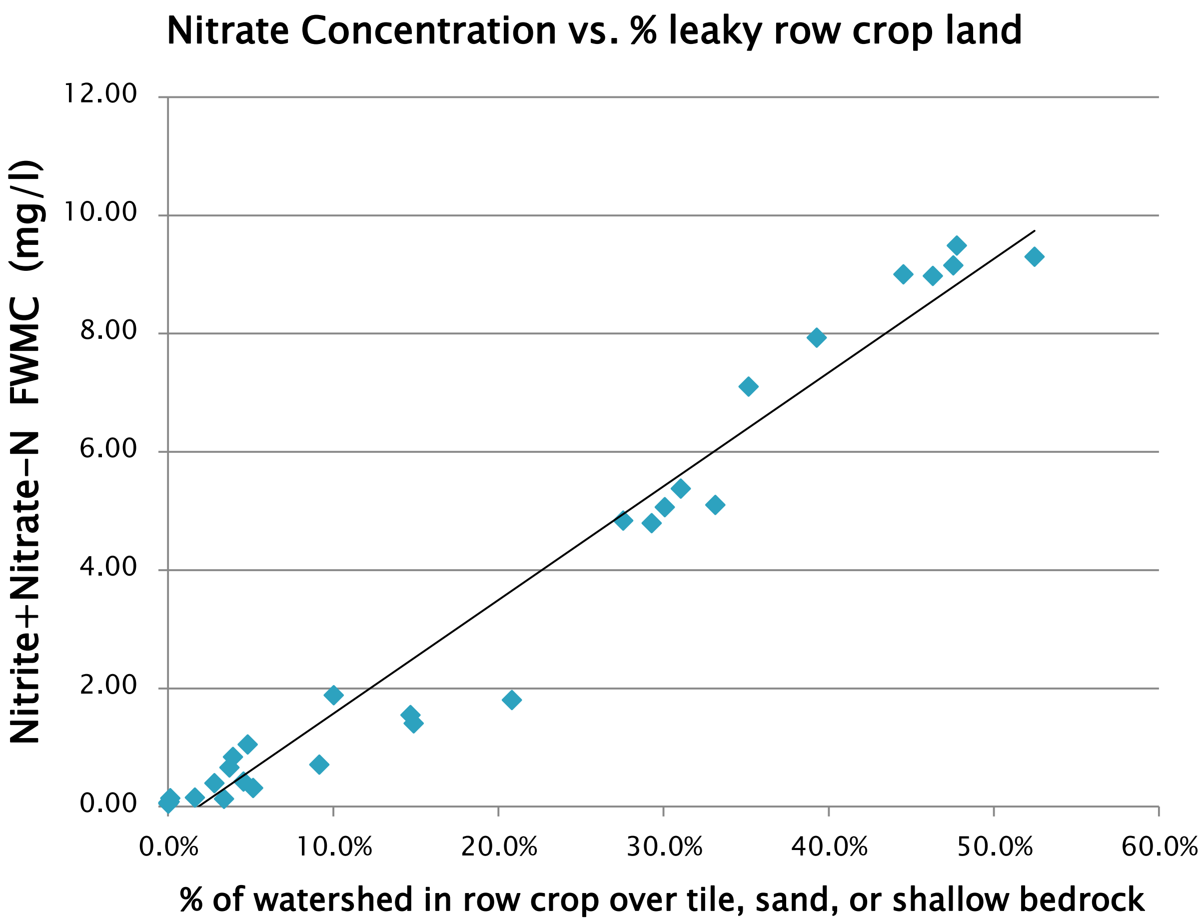
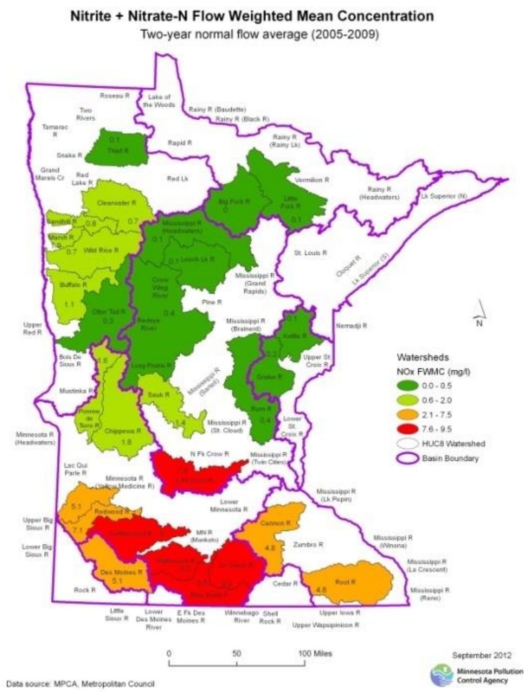


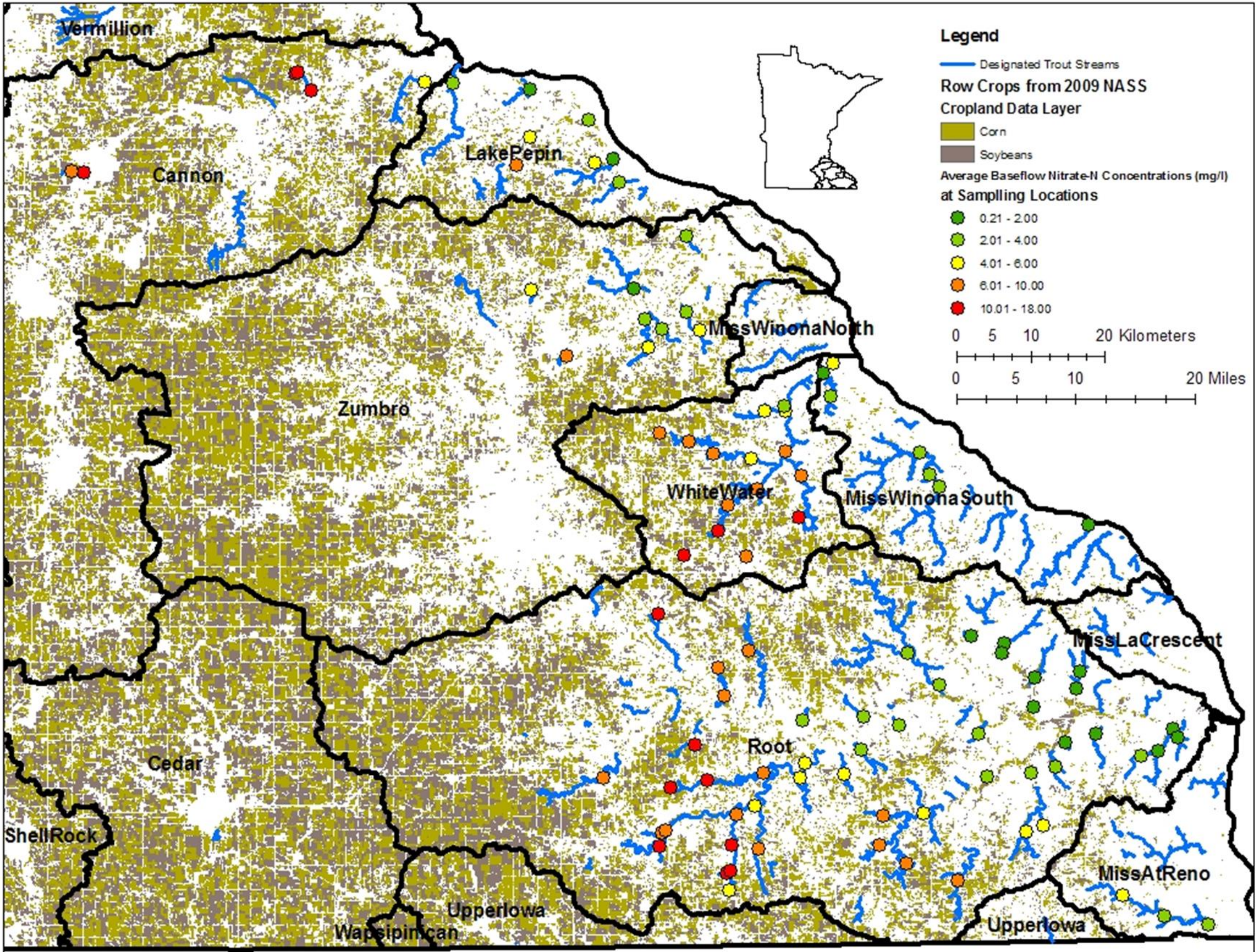
Figure 12. Edge-of-field annual nitrate-nitrogen loss for RRFSP compared with Wisconsin state averages.

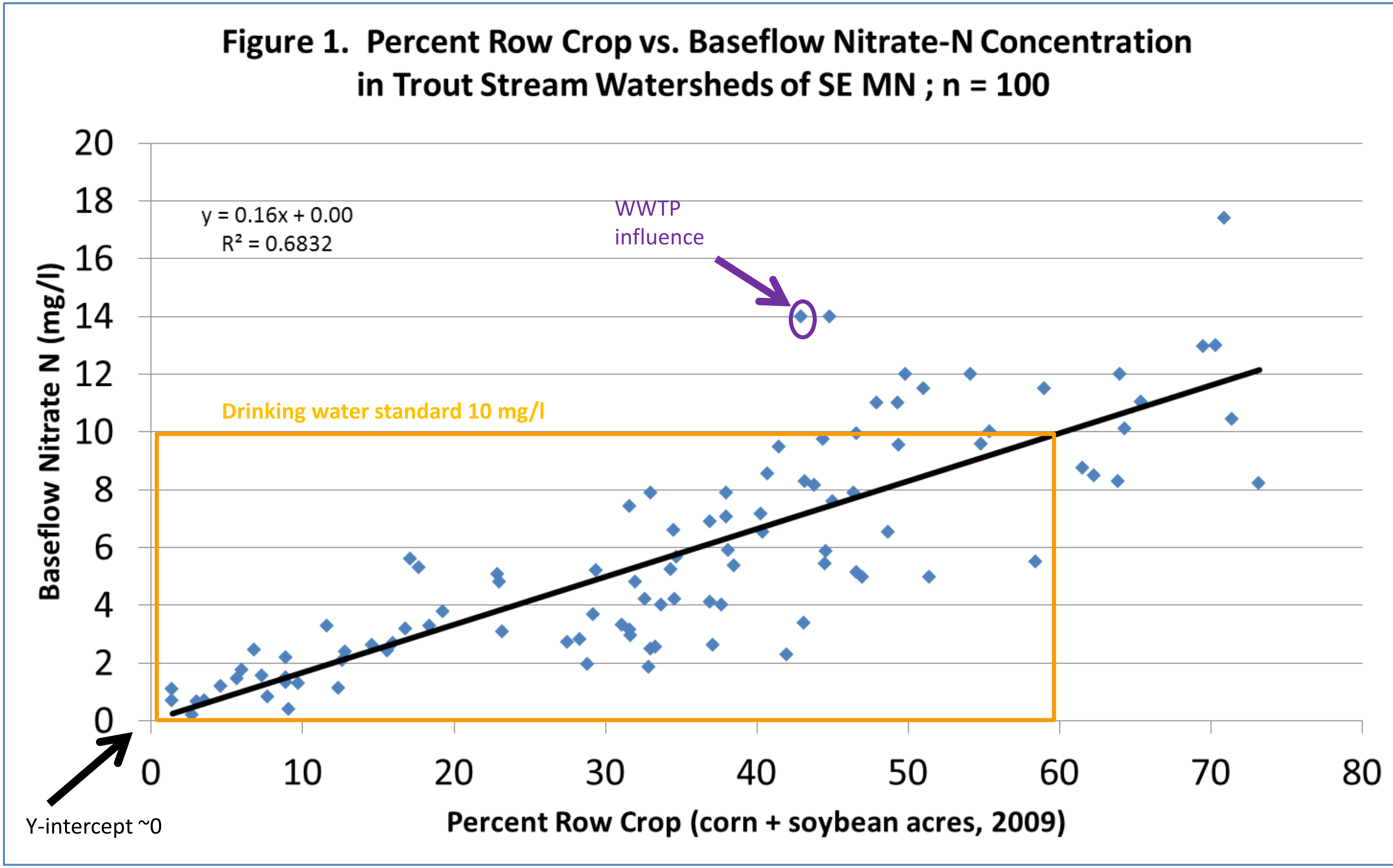
Stream Nitrate vs Land Use

Row crops over tile, sand & bedrock






Legend
Designated Trout Streams
Row Crops from 2009 NASS
Cropland Data Layer
Corn
Soybeans
Average Baseflow Nitrate-N Concentrations (mg/l)
at Samplling Locations
0.21 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 10.00
10.01 - 18.00
0 5 10 20 Kilometers
0 5 10 20 Miles
Vermillion
Cannon
LakePepin
MissWinonaNorth
Zumbro
WhiteWater
MissWinonaSouth
MissLaCrescent
Root
Cedar
ShellRock
UpperIowa
Wapsipinican
MissAtReno
UpperIowa



For detailed methods, etc. see poster.

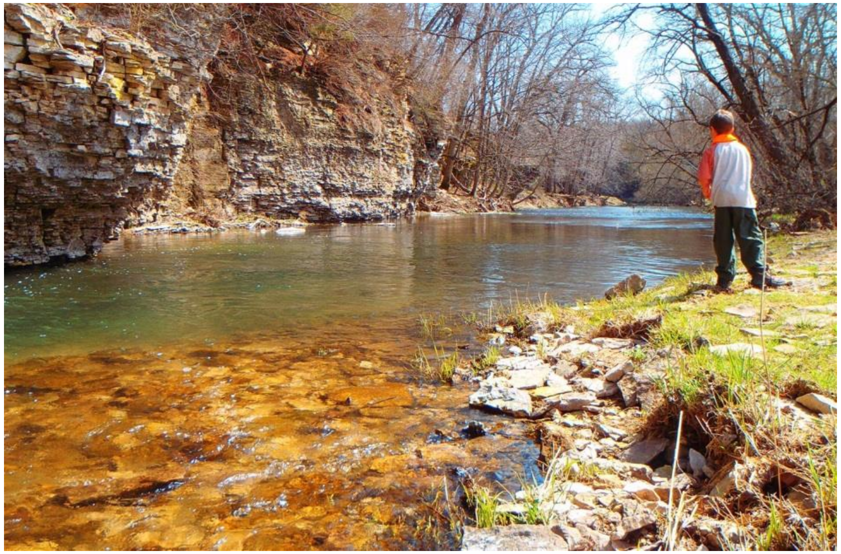
Note: these are nearly all rural watersheds.

Planning & Tools

- Goals, tools, prioritization, strategies
  - Minnesota's Nutrient Reduction Strategy

Nutrient Reduction Strategies in The Driftless Area

- Know that/why they exist
- Over of MN Strategy
- Examples of use
- Quick notes on WI, IL, IA
- Overview: you look further
- Many slides from D. Wall & W. Anderson



Mississippi River Gulf of Mexico Watershed Nutrient Task Force

In the Spotlight

- Nutrient Reduction Strategies
- Water Action Hub
- 2014 Gulf Dead Zone
- Partnership with Land Grant Universities
- HTF Reports Show Progress
- New USGS Nutrients Trends Report
- EPA N & P Website
- Success Stories

Home

Task Force
Members
Sub-basin Committees
History

Learn
Hypoxia 101
Hypoxia in the News
The MARB

Moving Forward
2008 Action Plan
Implementation
Meetings & Events

Resources
Archived Documents
Related Legislation
Additional Resources

Contact

State and Federal Nutrient Reduction Strategies

State development and implementation of nutrient reduction strategies are a major focus of the Hypoxia Task Force (HTF). The first Action Item of the 2008 Action Plan calls for HTF states to develop by 2013 "comprehensive nitrogen and phosphorus reduction strategies encompassing watersheds with significant contributions of nitrogen and phosphorus to the surface waters of the MARB, and ultimately to the Gulf of Mexico." State-level strategies allow for a more detailed basis for developing and implementing load reductions and provide a vehicle for coordinating with federal agencies and other MARB states.

Quick Links

Moving Forward
- 2008 Action Plan
- Implementation
- Meetings & Events

On this page
- State Nutrient Reduction Strategies
- Federal Nutrient Reduction Strategies

Having each state develop and implement its own strategy provides flexibility for tailoring the strategy's approach and components. At the same time, the HTF recognizes that all state strategies need to include certain essential components that need to be in every state strategy to achieve goals. States are generally following the framework described in a 2011 EPA memo (PDF, 6 pp, 346K).

State Nutrient Reduction Strategies

States continue to develop state nutrient reduction strategies that contain tailored methods for reducing nutrients in their state. Some states have already completed their strategies, while others continue to work on completing draft and final documents. Learn more about each state below EXIT Disclaimer.

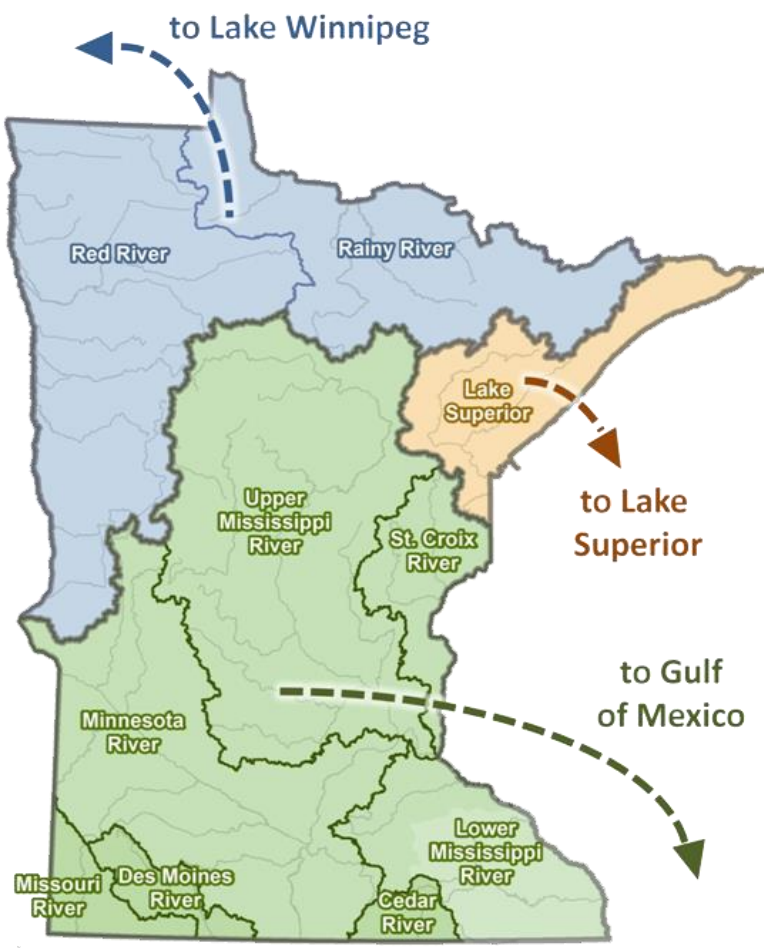
- Arkansas (43 pp, 2.7 MB)
- Indiana
- Illinois
- Iowa
- Louisiana
- Kentucky
- Minnesota
- Mississippi
- Missouri
- Ohio
- Tennessee (Coming Soon!)
- Wisconsin

- Too much phos & nitrogen
- A Call for State-Level Nutrient Reduction Strategies
- Big stakeholder efforts

How we developed a state-level nutrient reduction strategy for MN

1. **Goals - What are the needed levels of reductions?**
2. **Sources - What sources should we focus on?**
3. **Priority areas - What parts of the state are most critical for reductions?**
4. **BMPs - What level of BMP adoption is needed?**
5. **Stepping up – What changes will increase BMP adoption?**
6. **Research - What new/improved BMPs are needed to ensure long term goals achieved?**

Why we need a strategy



National Eutrophication

– Gulf of Mexico Task Force

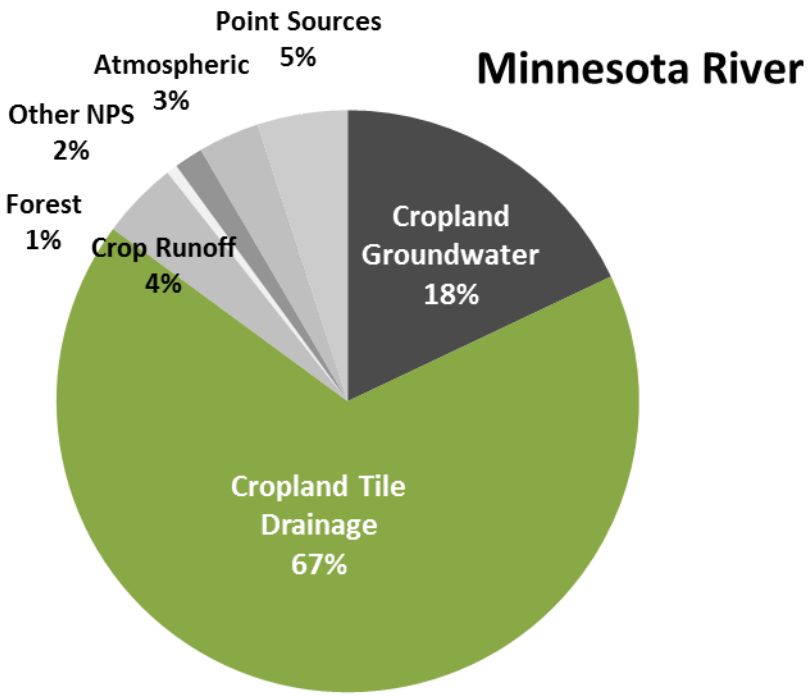
- 45% Reduction in N & P
- 12 states developing strategies

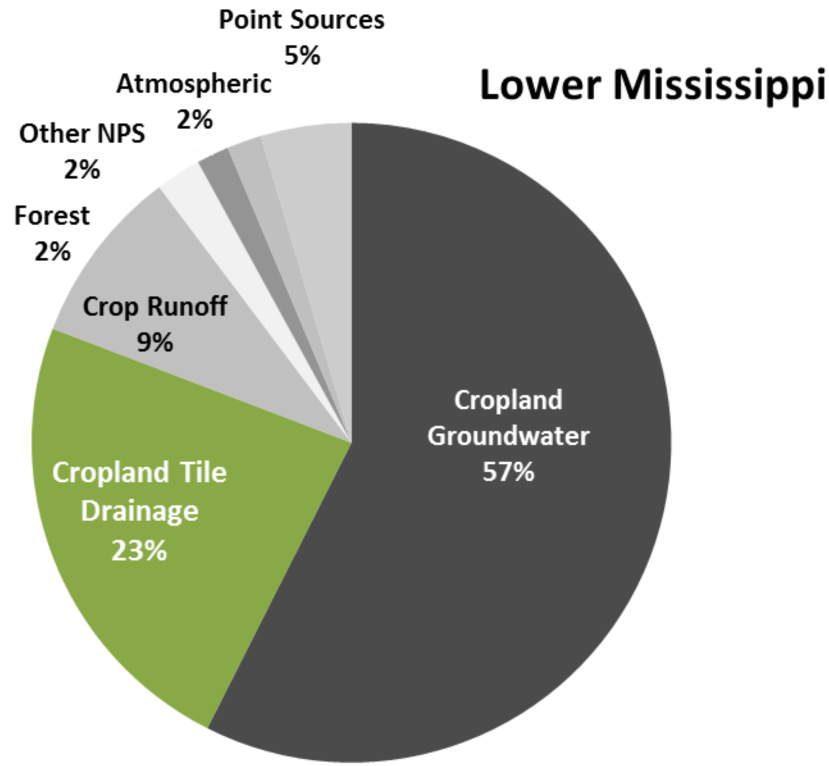
International Eutrophication

– Lake Winnipeg

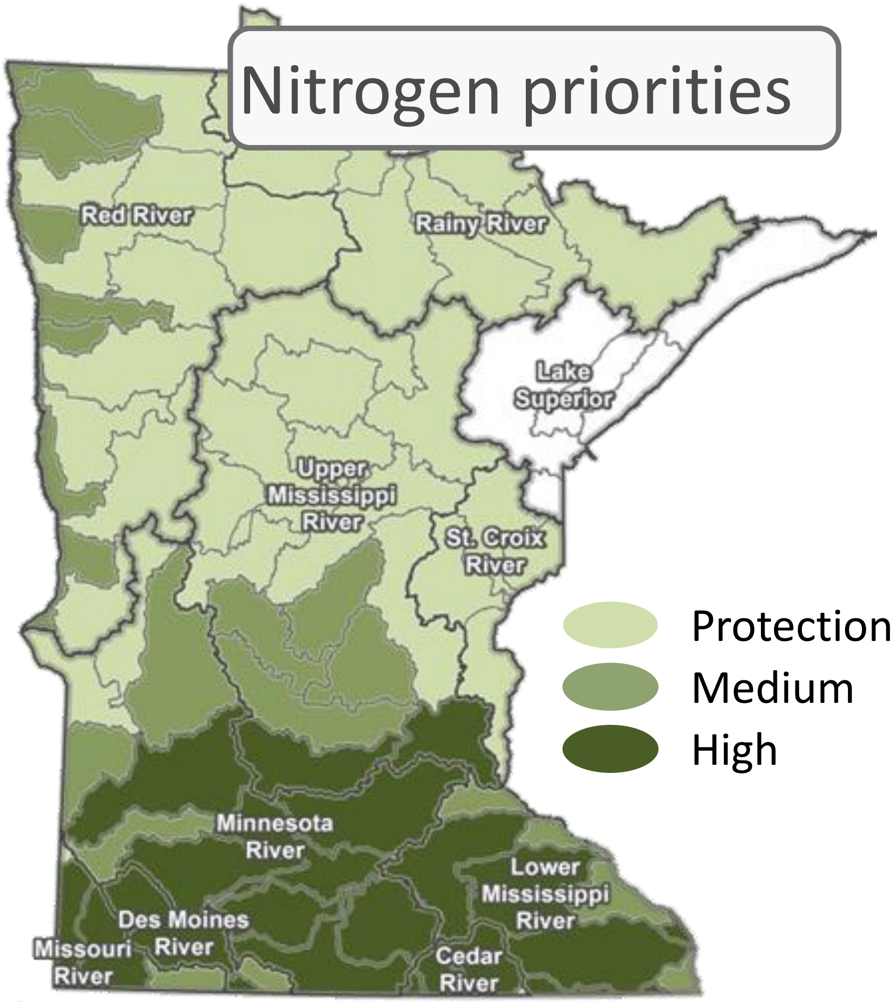
- >10% Reduction in N & P
- Goals currently being revised

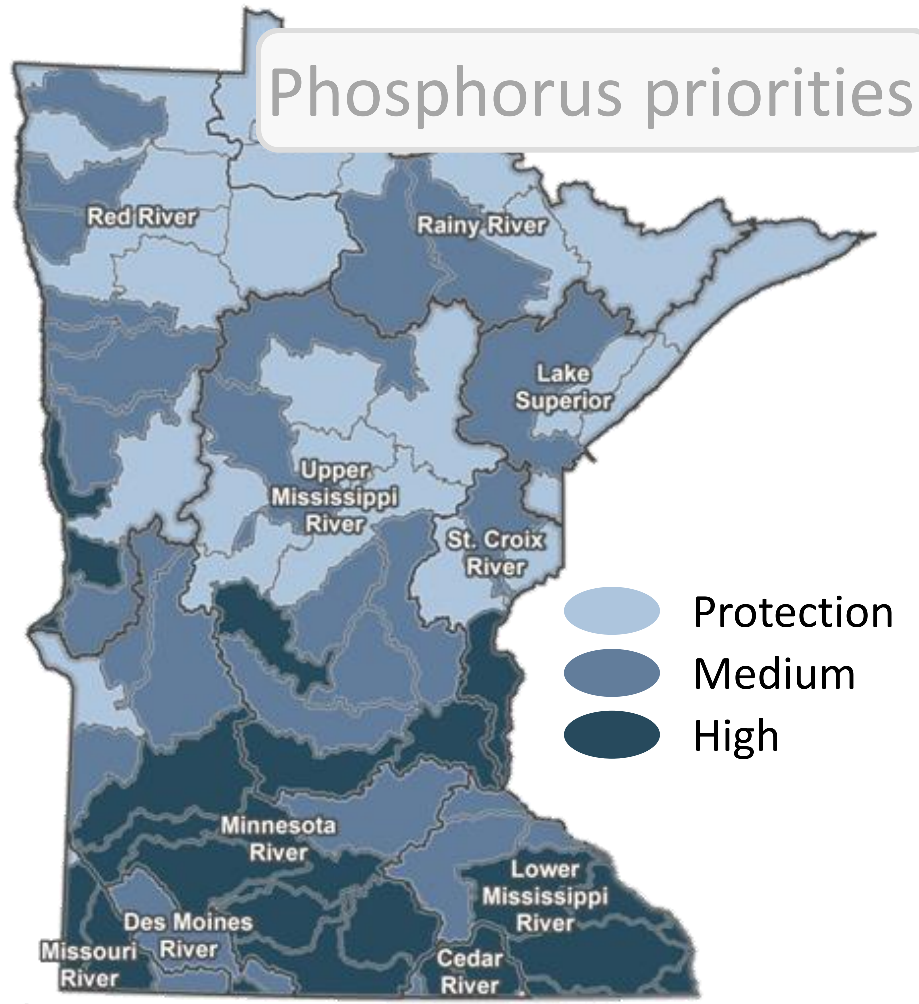
Nitrogen sources to surface waters: differences between basins





Southern Minnesota high priority

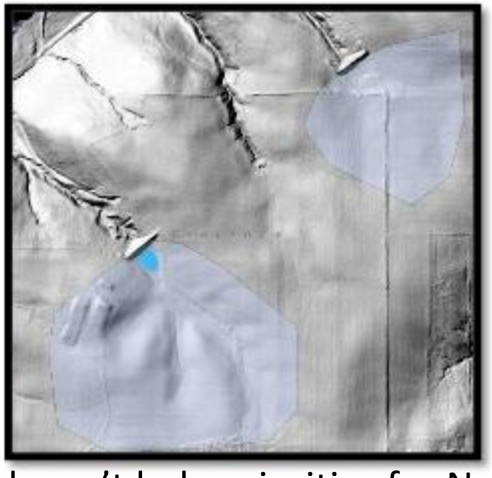




Local Prioritization

- Challenging
- Not driven by topography
- Models and GIS aren't enough

This doesn't help prioritize for N reduction



This doesn't help prioritize for N reduction

This isn't a primary tool for N reduction

Prioritizing N Reduction in SE MN*

Base Layer
(mask or domain)

- Row Crop Acres

Raster Layers
(for ModelBuilder)

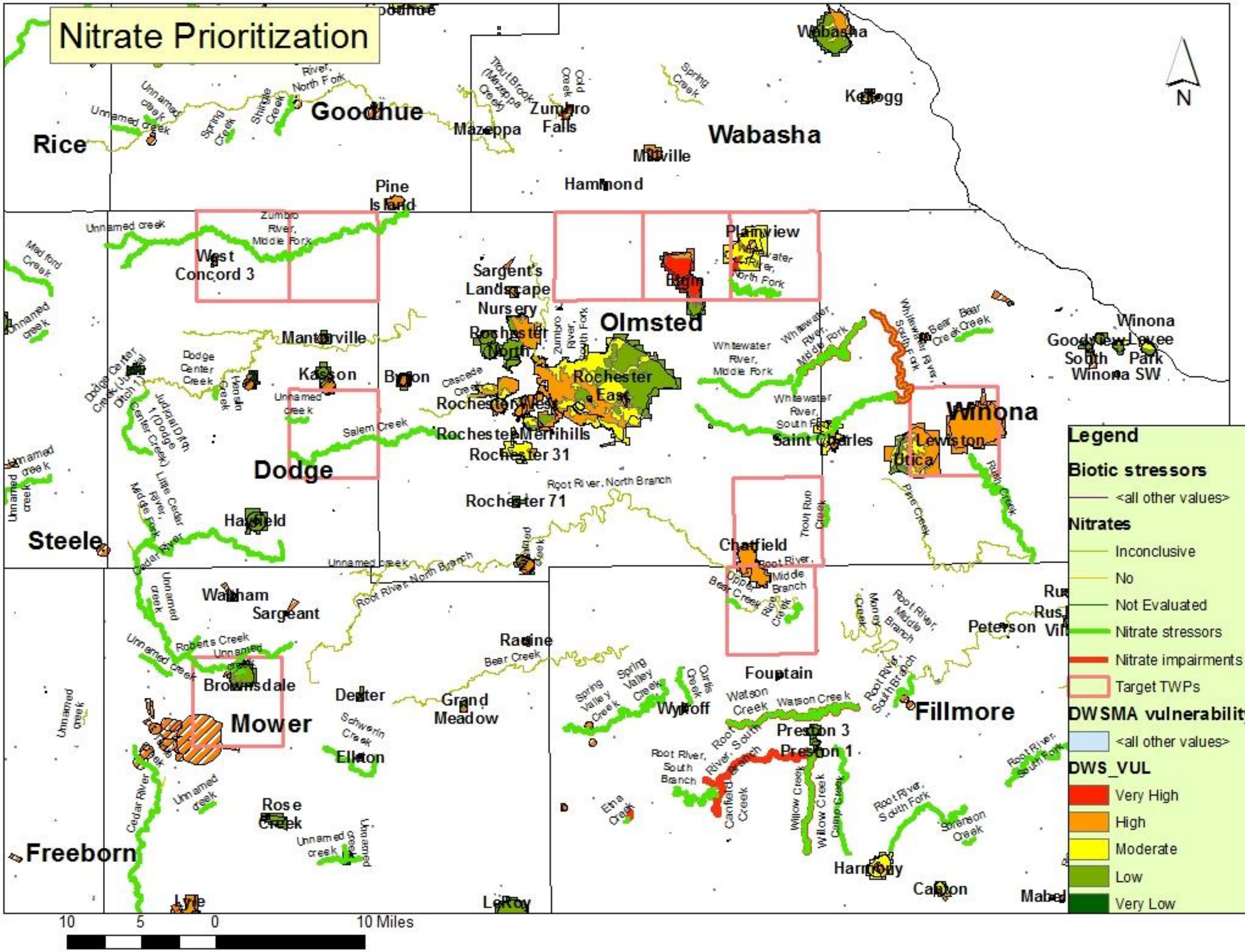
- Human health: DWSMA vulnerability
- Aquatic life: N stressor and impairment watersheds
- State directive: Areas of fastest groundwater response (from MGS)

Shapefile Overlays

- Nitrogen Fertilizer Mngmnt Plan Priority TWPs
- Volunteer Well Monitoring Network Points
- Significant Recreation Value Areas (e.g. state parks)

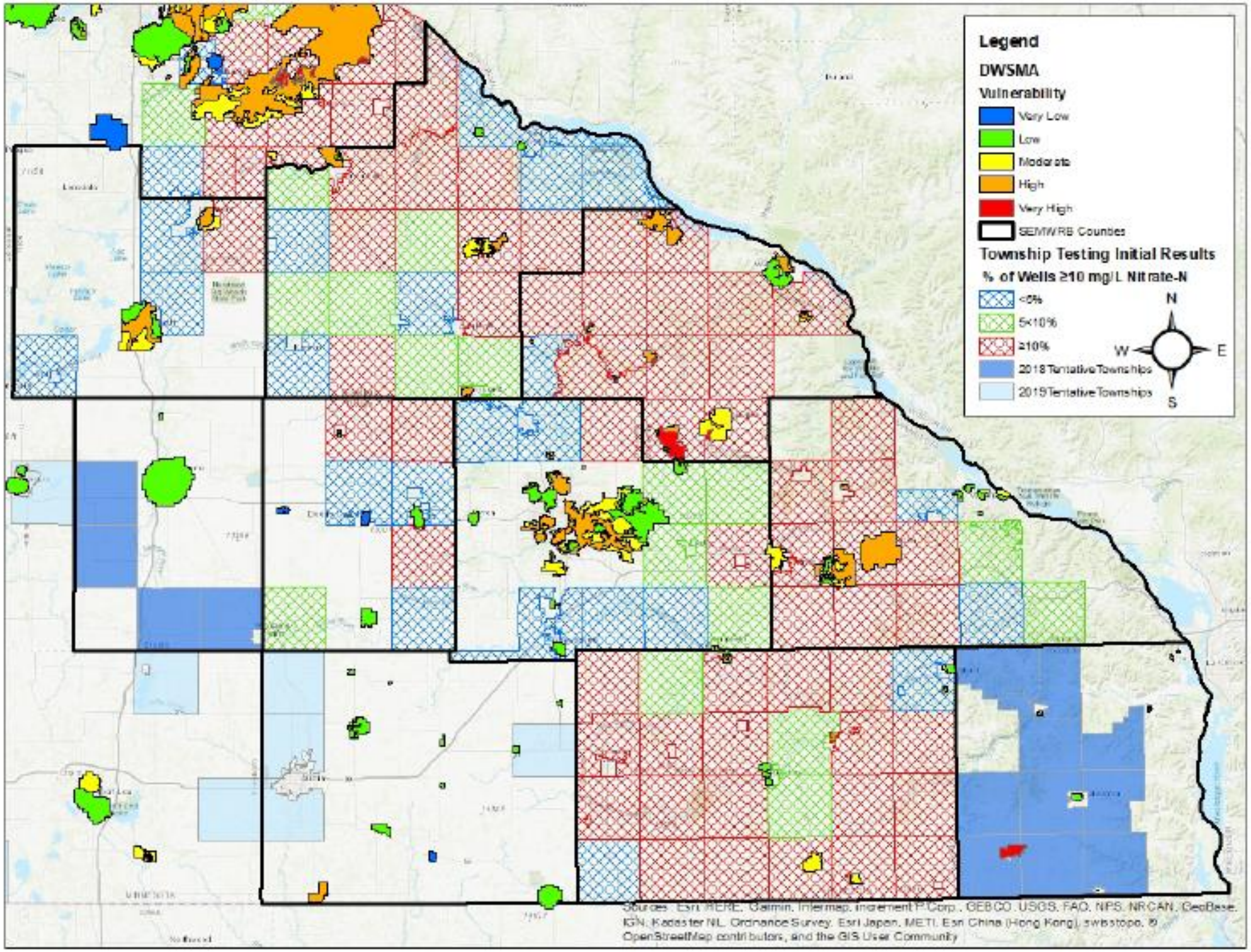
*Not "official" approach

Just some group thinking



Nitrate Prioritization
N
Rice
Goodhue
Wabasha
Olmsted
Dodge
Steele
Winona
Mower
Freeborn
Fillmore
Mazeppa
Zumbro Falls
Millville
Hammond
Kellogg
Wabasha
Pine Island
West Concord 3
Plainview
Elgin
Sargent's Landscape Nursery
Rochester North
Rochester East
Rochester West
Rochester Merrihills
Rochester 31
Rochester 71
Mantorville
Kasson
Byron
Hayfield
Saint Charles
Lewiston
Utica
Goodview Levee
South Park
Winona SW
Winona
Chatfield
Waltham
Sargeant
Racine
Brownsdale
Dexter
Grand Meadow
Elkton
Rose Creek
Lyle
LeRoy
Fountain
Wykoff
Preston 3
Preston 1
Peterson
Harmony
Canton
Mabel
Legend
Biotic stressors
<all other values>
Nitrates
Inconclusive
No
Not Evaluated
Nitrate stressors
Nitrate impairments
Target TWPs
DWSMA vulnerability
<all other values>
DWS_VUL
Very High
High
Moderate
Low
Very Low
10 5 0 10 Miles

Application Image



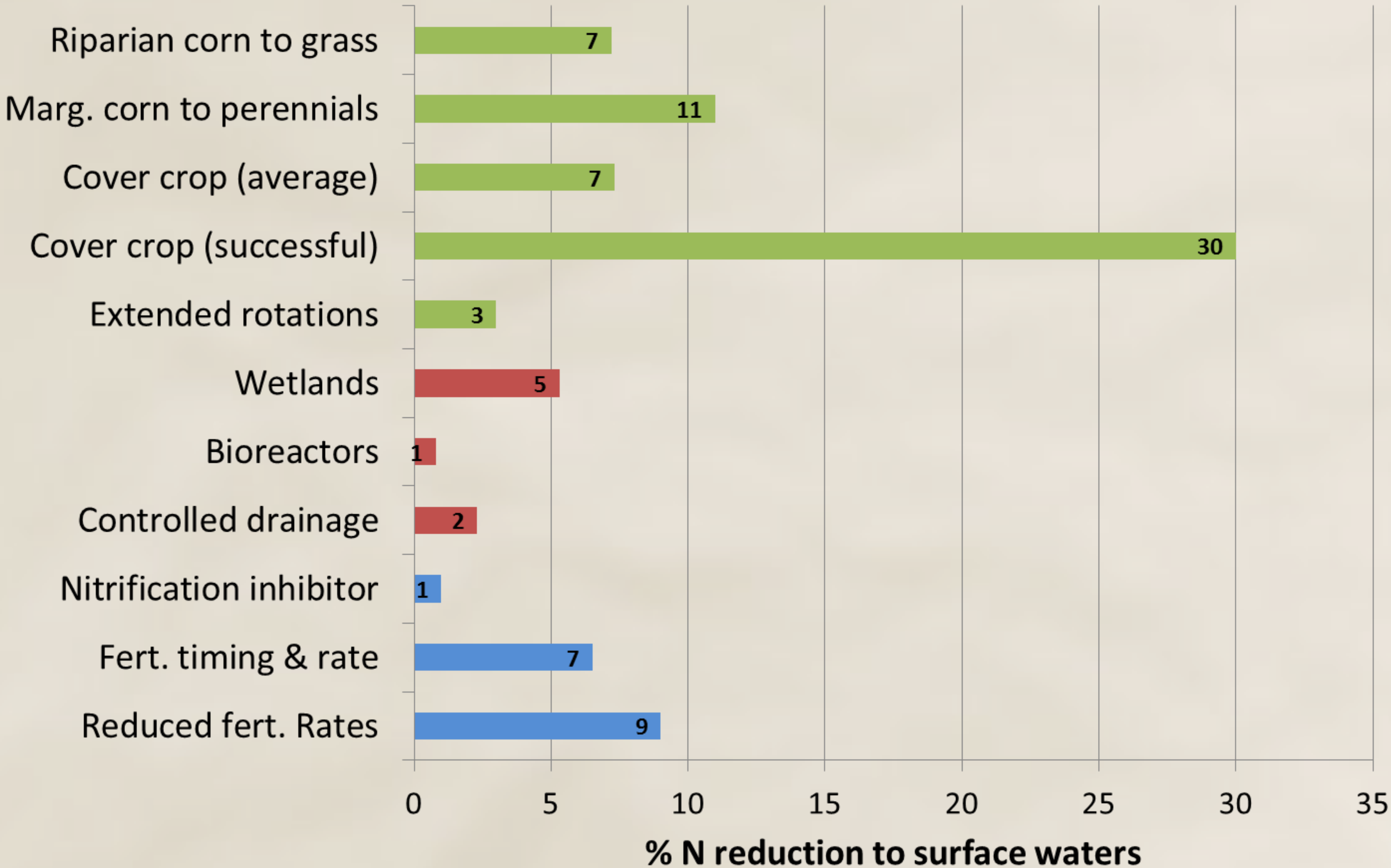
Nonpoint Source Strategies

Phosphorus BMPs	**Acres**
1. Crop residue increases	7 million
2. Banding & soil P mgmt	2 million
3. Living vegetative cover	1 million

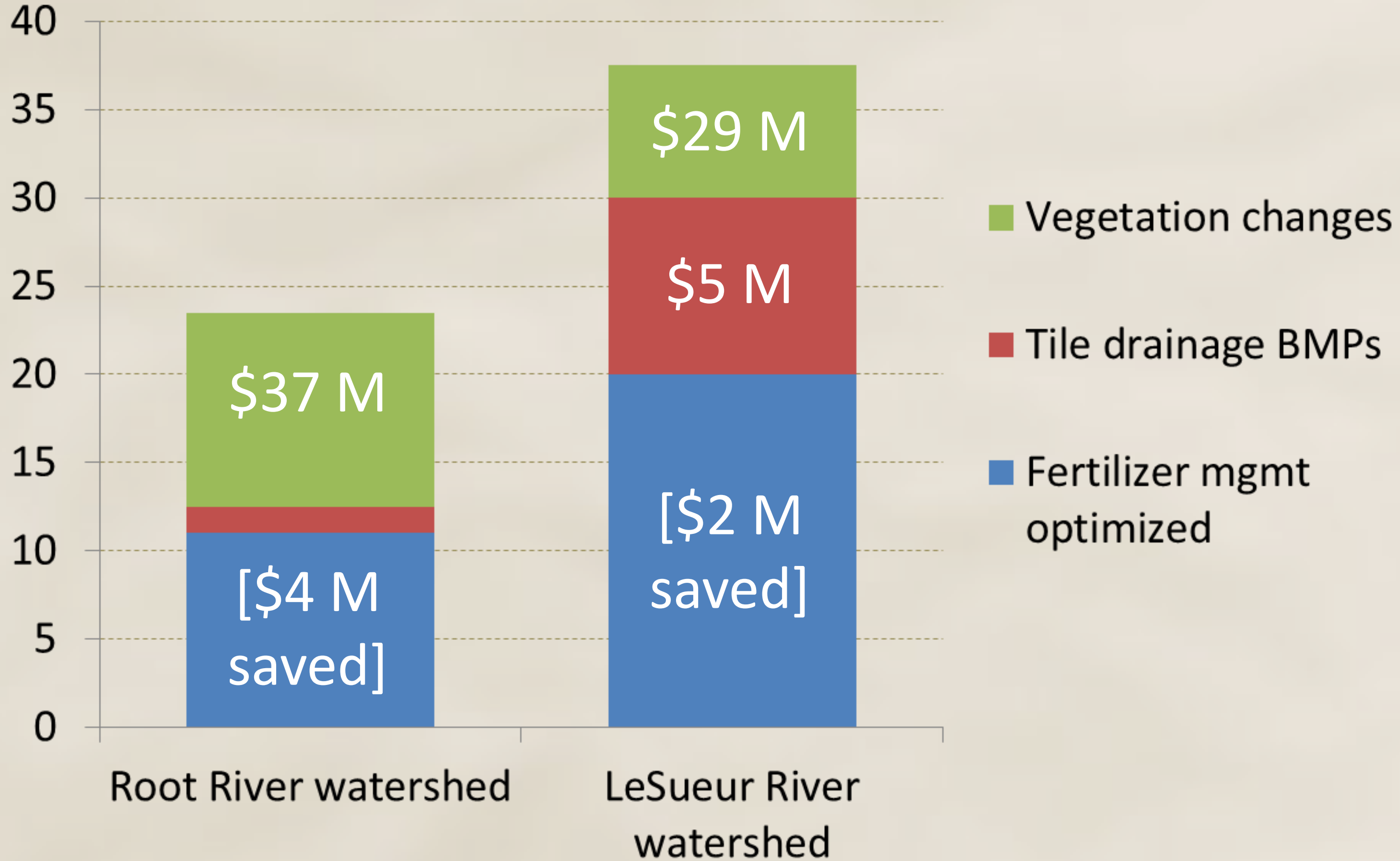
Cropland Nitrogen BMPs	**Acres**
1. Rate & timing optimized	11 million
2. Drainage water retention & management	1 million
3. Living vegetative cover	1 million

Statewide % N reduction to surface waters

If BMPs used on all land suitable for the BMPs



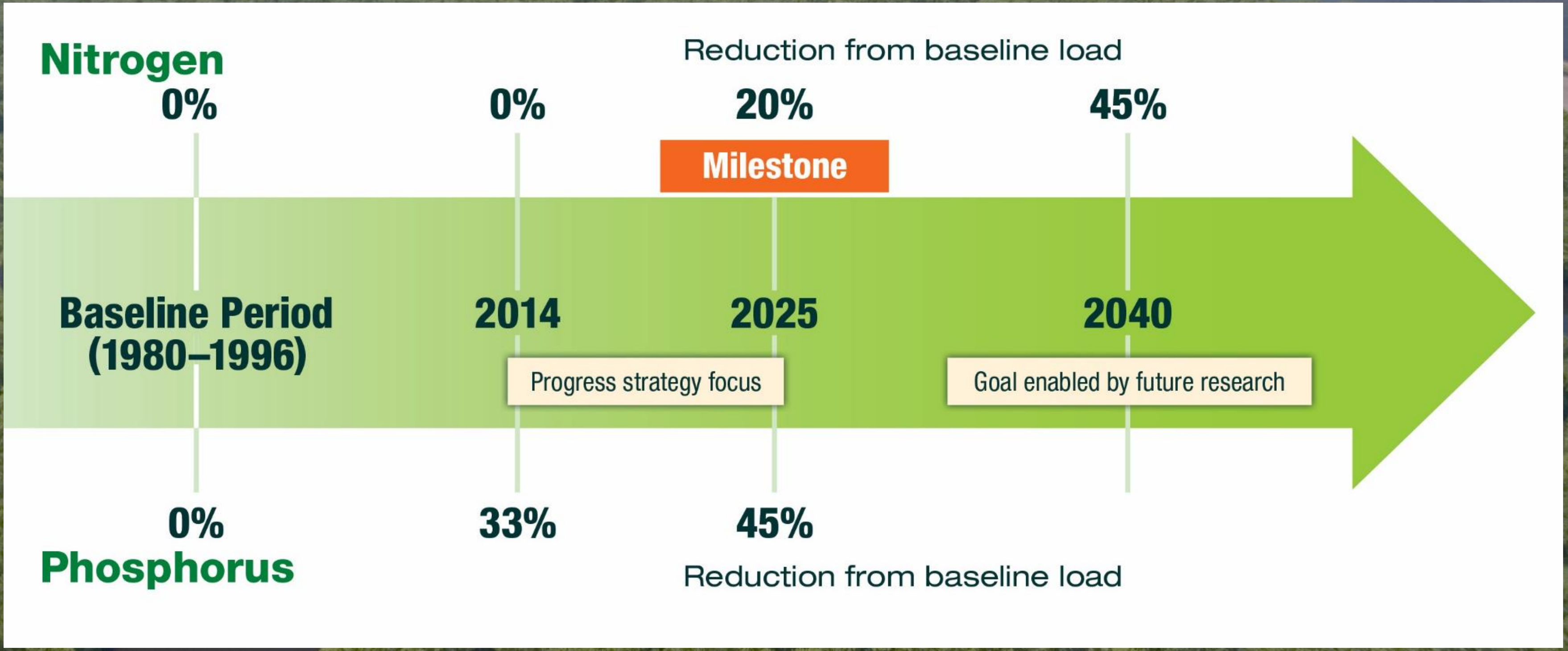
Nitrogen reduction potential and costs vary by watershed



Generally agree with locally-conceived scenarios.

www.pca.state.mn.us/nutrientreduction

Mississippi River progress and goals



Research recommendations

- Cover crop establishment and genetics
- Markets and technologies for perennials
- Fertilizer use efficiency
  - Precision and split applications
  - Remote sensing tools
- Further research on tile drainage treatment
- BMPs with multiple benefits
- Watershed NBMP tool for N/P/sed

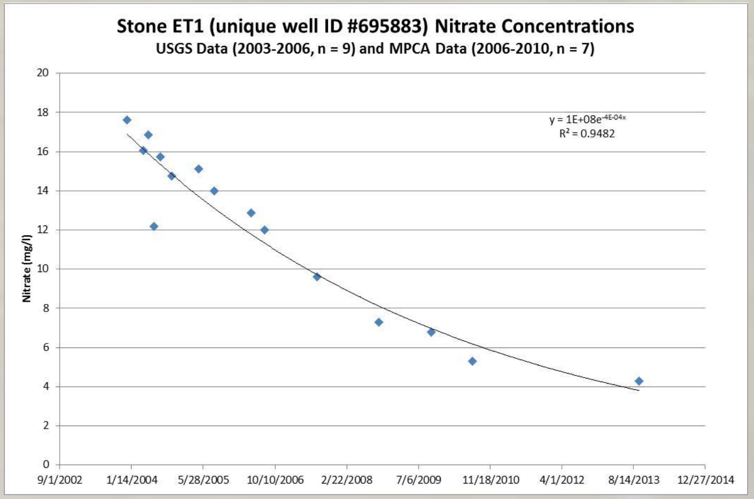
Thank you. Questions & Discussion.

Could cover lysimeter network if time and interest.

Expectations

When might we see change?

- Depends on where we look:
  - On the land
  - Under the root zone
  - In the springs and trout streams



Geologic controls on groundwater and surface water flow in southeastern Minnesota and its impact on nitrate concentrations in streams

Anthony C. Runkel, Julia R. Steenberg, Robert G. Tipping, Andrew J. Retzler

Minnesota Geological Survey OpenFile Report 14-02

UNIVERSITY OF MINNESOTA

CLEAN WATER LAND & LEGACY AMENDMENT

November 18, 2013

Mississippi River Lake Pepin

Watershed Restoration and Protection Strategy Report

March 2015

CLEAN WATER LAND & LEGACY AMENDMENT

wq-iw9-15n

Given that the primary transport mechanism for loading nitrate to the trout streams of the MRLP watershed is "ag groundwater" (i.e., leaching loss from agricultural lands to groundwater, which comprises the majority of trout stream base flow; see Figure 7), it follows that the response time of nitrate concentrations to changes in land use practices will likely vary in different hydrogeological settings (MGS 2013). Studies outside of southeastern Minnesota have concluded that some hydrogeological systems function in a manner whereby changes in base flow nitrate concentrations lag changes in land use practices by decades (e.g., Tesoriero et al. 2013). The most significantly lagged response in southeastern Minnesota should be expected in the deep valleys incised into the Prairie du Chien Plateau, where significant baseflow is derived from deep, siliciclastic-dominated bedrock sources with one or more overlying aquitards (MGS 2013).

MRLP Watershed Nitrogen Summary

- Geographic source: cultivated acres.
- There are many complicating agronomic variables (e.g., soils, manure and fertilizer management).
- While phosphorus is typically bound to soil and transported via runoff, nitrates are water soluble.
- Main transport mechanism: leaching to groundwater, subsequent discharge to trout streams. Lag time between land surface and point of measure in trout stream can be significant.

Southeastern Minnesota Soil Water Monitoring Network

Collaborative effort between MPCA, Fillmore SWCD, MN Dept. of Ag, and Winona State University

Toby Dogwiler
Director, Southeastern Minnesota Water Resources Center
Professor, Department of Geoscience

WINONA STATE UNIVERSITY

SOUTHEASTERN MINNESOTA Water Resources Center WINONA STATE UNIVERSITY

Kuehner 5/18/11
Bernau 6/6/11
Dogwiler 8/31/11

Southeastern Minnesota Soil Water Monitoring Network

- Purpose: develop a long-term network of soil water nitrate monitoring over a variety of representative land use cover types and nutrient management practices.

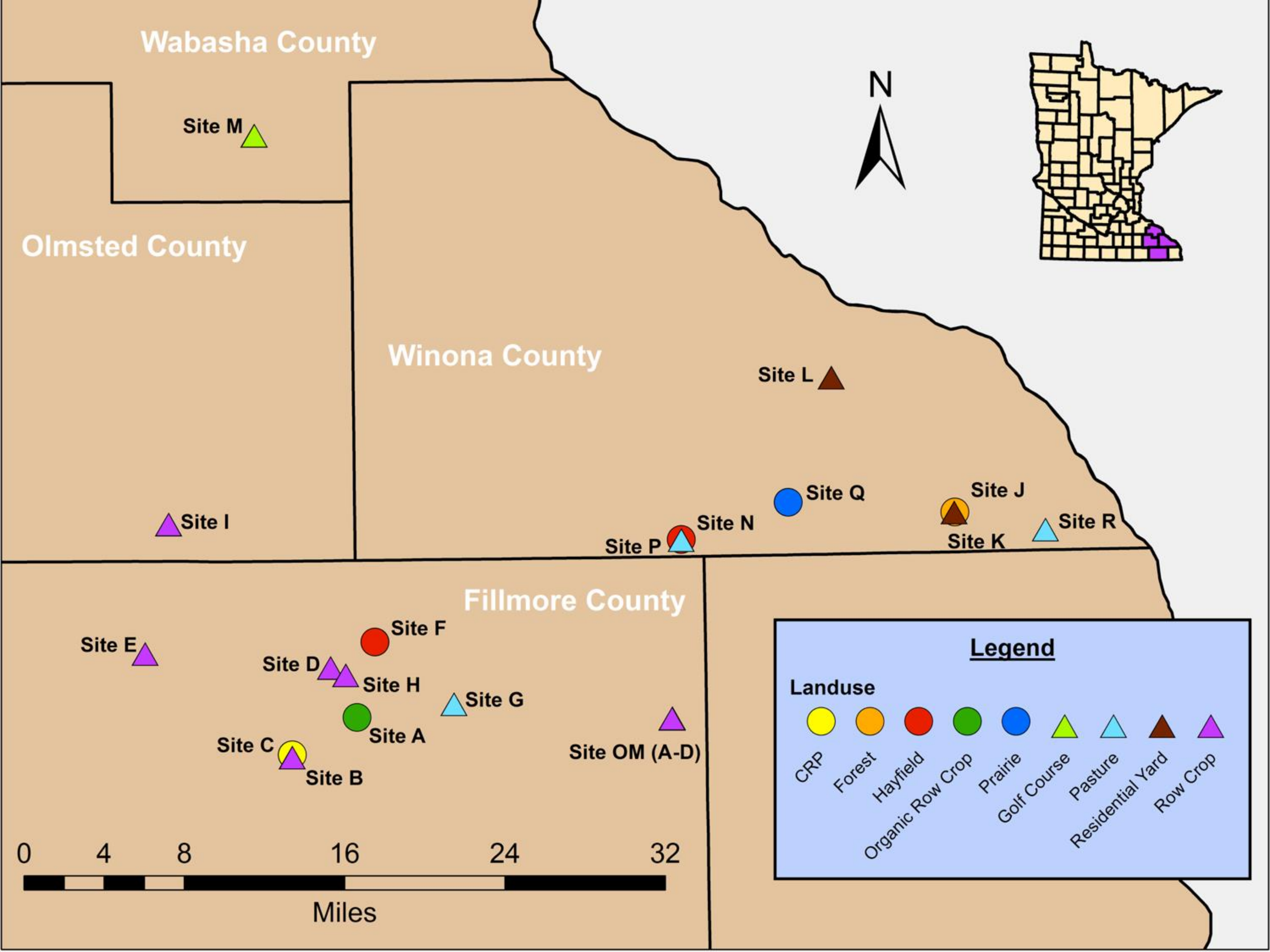
- Information will be used for demonstration and educational purposes.

"Nitrate-N concentrations in the soil water at 5' (below the root zone) provide a good basis upon which to compare the environmental risks associated with various N management systems."

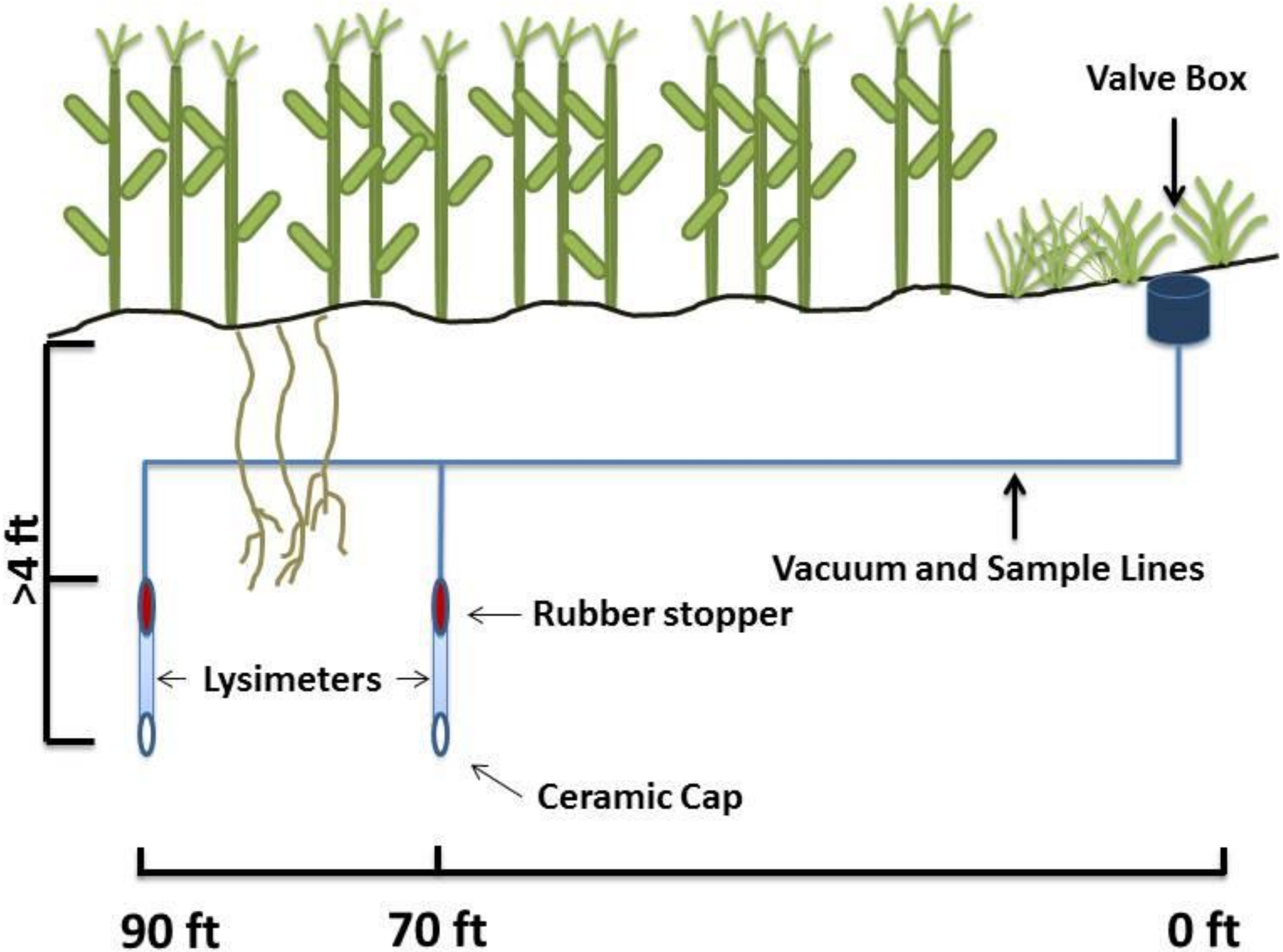
– Randall et al

Network Details

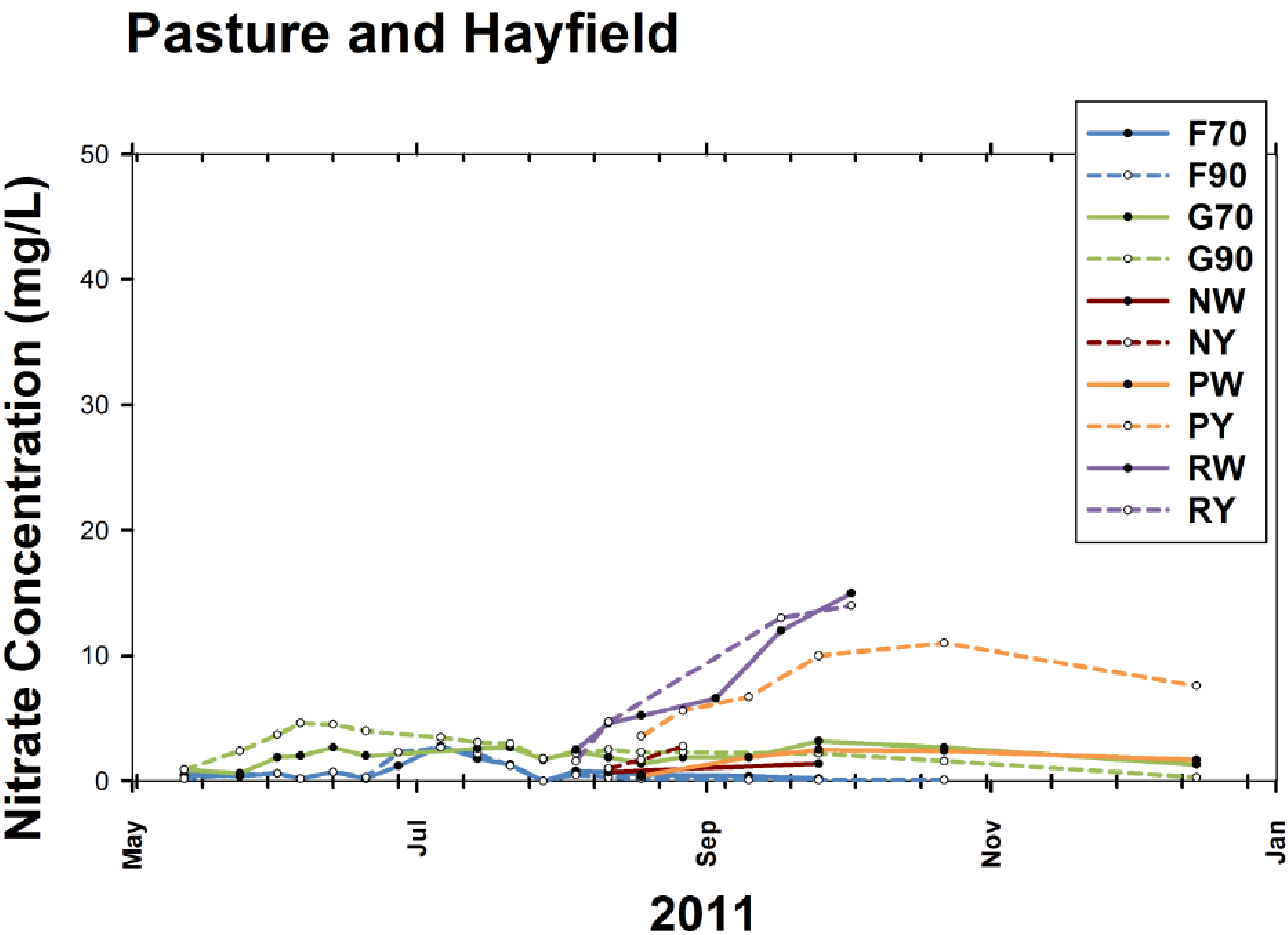
- ~50 lysimeters installed at ~17 different sites (WSU: 42 lysimeters at 14 sites)
- Installed in April – July 2011
- May install additional sites
- Variety of representative…
  - Row-crop, Pasture, Hay, Alfalfa, CRP, Prairie, Golf Course, Yard



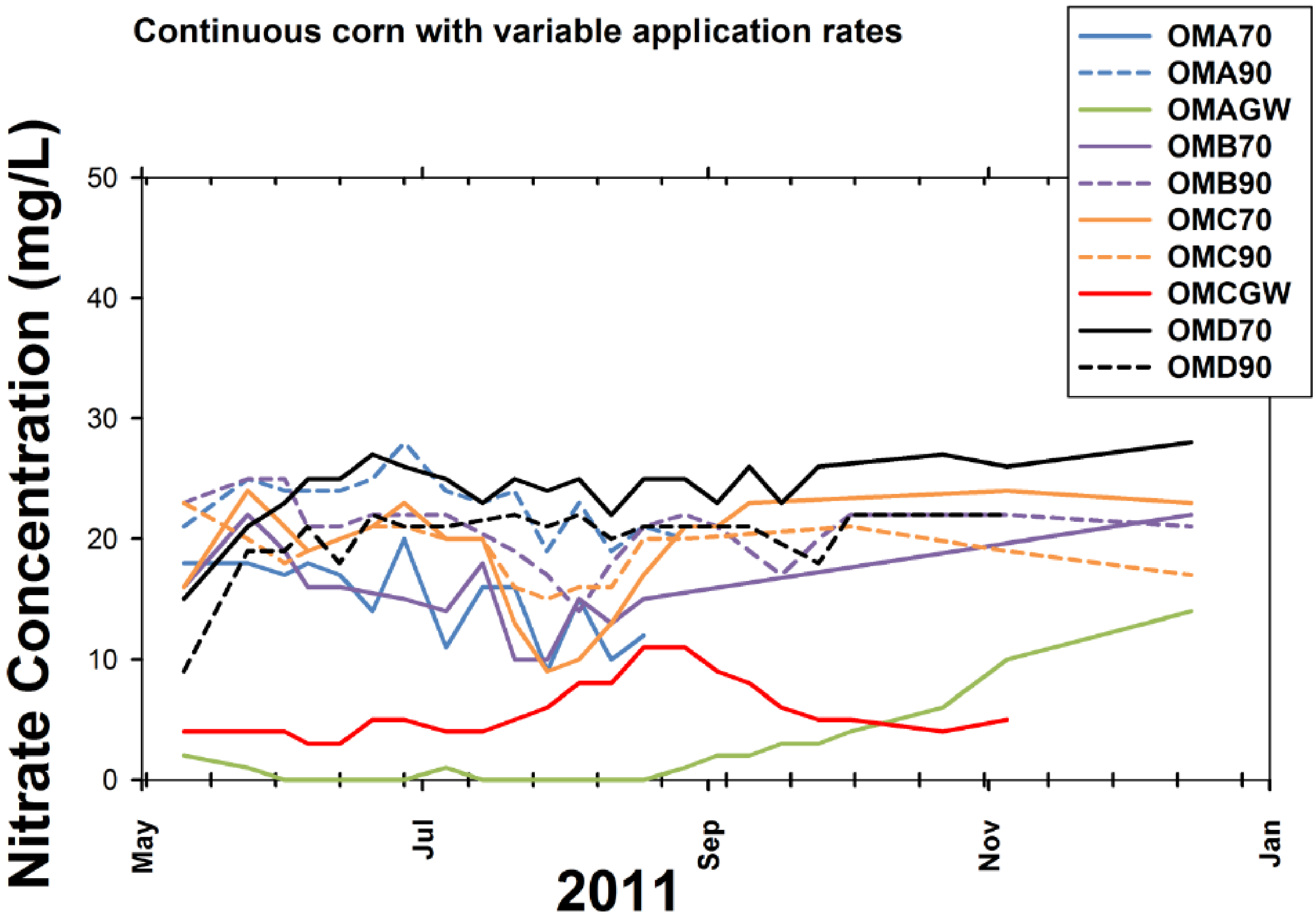
Wabasha County
Olmsted County
Winona County
Fillmore County
N
Site M
Site L
Site Q
Site J
Site N
Site R
Site I
Site P
Site K
Site F
Site E
Site D
Site H
Site G
Site A
Site C
Site B
Site OM (A-D)
Legend
Landuse
CRP
Forest
Hayfield
Organic Row Crop
Prairie
Golf Course
Pasture
Residential Yard
Row Crop
0
4
8
16
24
32
Miles



Valve Box
Vacuum and Sample Lines
>4 ft
Rubber stopper
Lysimeters
Ceramic Cap
90 ft
70 ft
0 ft

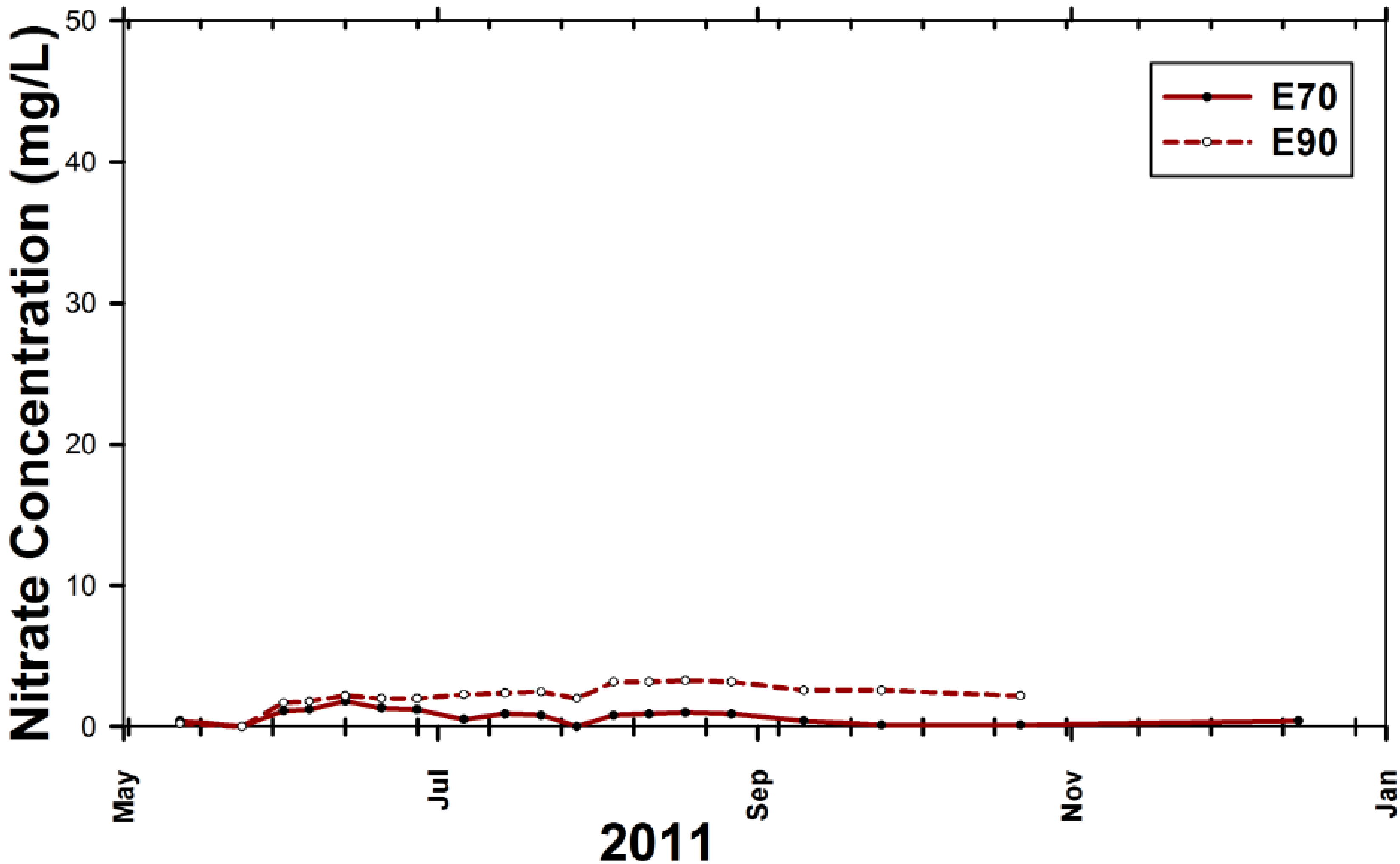


Pasture and Hayfield
Nitrate Concentration (mg/L)
0
10
20
30
40
50
May
Jul
Sep
Nov
Jan
2011
F70
F90
G70
G90
NW
NY
PW
PY
RW
RY



Continuous corn with variable application rates
OMA70
OMA90
OMAGW
OMB70
OMB90
OMC70
OMC90
OMCGW
OMD70
OMD90
Nitrate Concentration (mg/L)
0
10
20
30
40
50
May
Jul
Sep
Nov
Jan
2011

Corn field with winter rye cover crop



In Closing

- Many variables
- Not a quick fix

- Goals
- There has been a good amount of study
  - And so we have good information
- Strategies

- Technical work and plans support funding ideas
  - Consideration: clean water $$ competitive
  - Consideration: leadership, FLC, SWCDs, others

Thank you. Questions & Discussion.