Getting to Ag-Water Quality Solutions

2015 Great Lakes Restoration Conference

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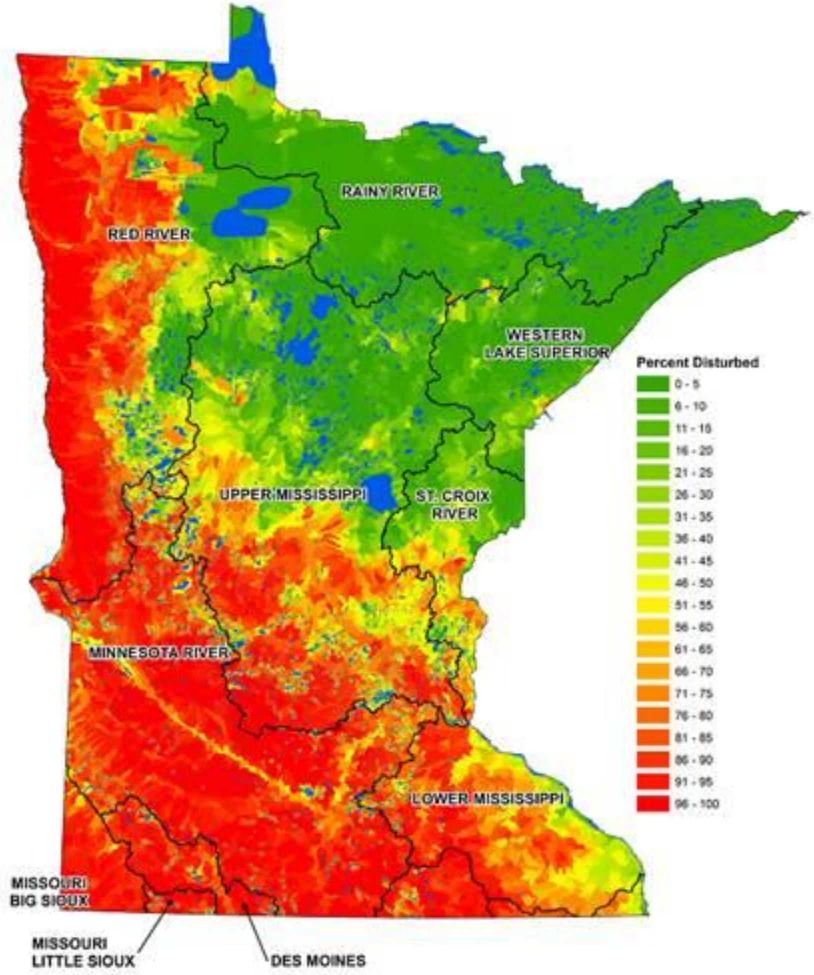
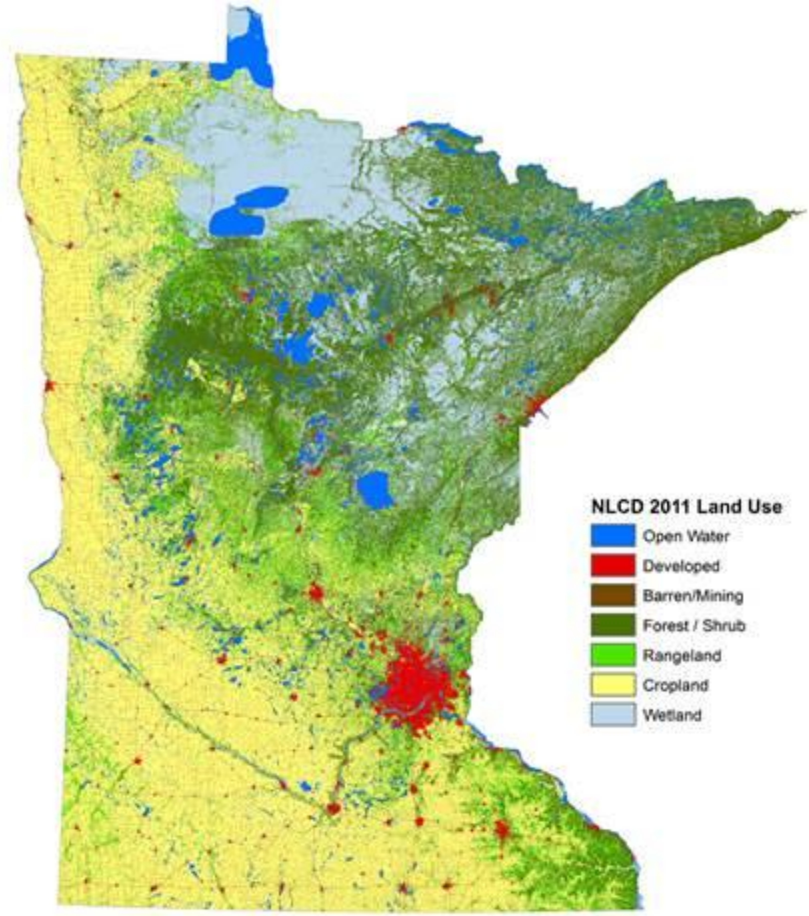
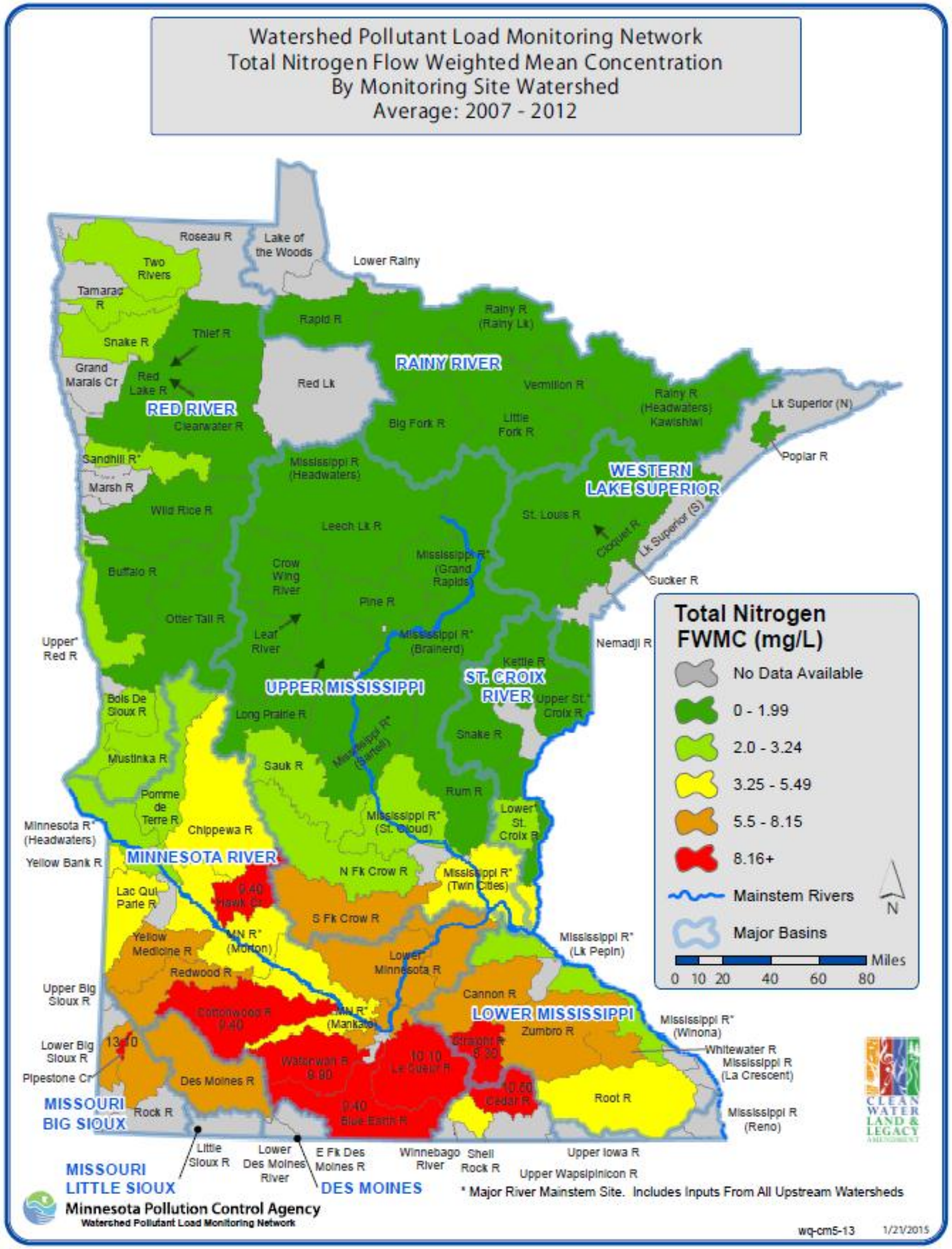


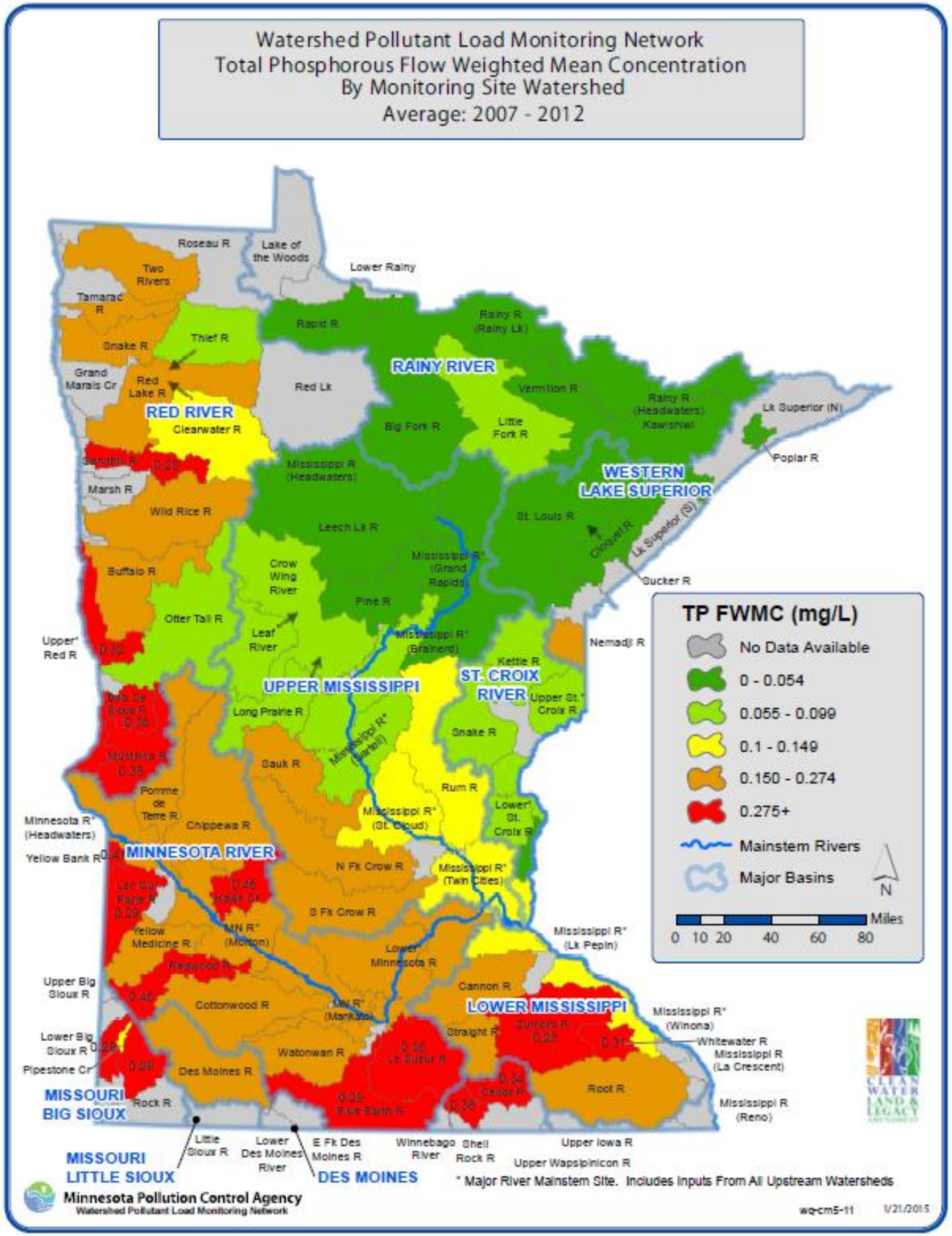


Courtesy MPCA

Nitrogen

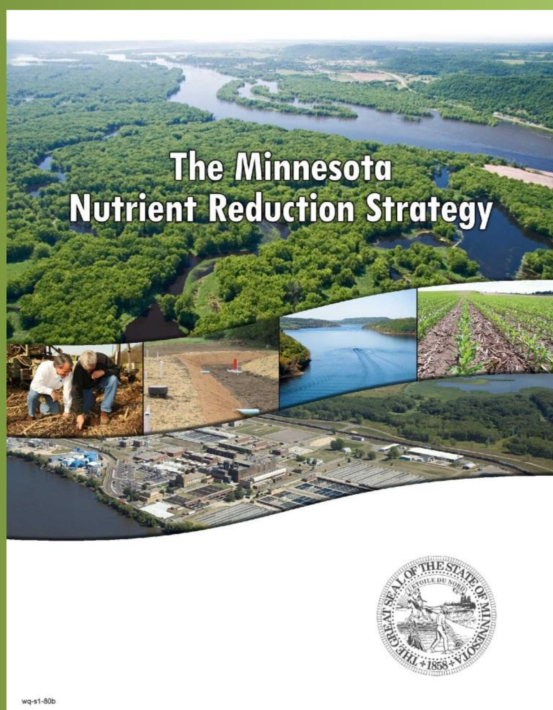

Watershed Pollutant Load Monitoring Network
Total Nitrogen Flow Weighted Mean Concentration
By Monitoring Site Watershed
Average: 2007 - 2012
RED RIVER
RAINY RIVER
WESTERN LAKE SUPERIOR
UPPER MISSISSIPPI
ST. CROIX RIVER
MINNESOTA RIVER
LOWER MISSISSIPPI
MISSOURI BIG SIOUX
MISSOURI LITTLE SIOUX
DES MOINES
Total Nitrogen FWMC (mg/L)
No Data Available
0 - 1.99
2.0 - 3.24
3.25 - 5.49
5.5 - 8.15
8.16+
Mainstem Rivers
Major Basins
Miles
0 10 20 40 60 80
N
* Major River Mainstem Site. Includes Inputs From All Upstream Watersheds
Minnesota Pollution Control Agency
Watershed Pollutant Load Monitoring Network
wq-cm5-13
1/21/2015

Phosphorus



Watershed Pollutant Load Monitoring Network
Total Phosphorous Flow Weighted Mean Concentration
By Monitoring Site Watershed
Average: 2007 - 2012
TP FWMC (mg/L)
No Data Available
0 - 0.054
0.055 - 0.099
0.1 - 0.149
0.150 - 0.274
0.275+
Mainstem Rivers
Major Basins
N
Miles
0 10 20 40 60 80
RED RIVER
RAINY RIVER
WESTERN LAKE SUPERIOR
UPPER MISSISSIPPI
ST. CROIX RIVER
MINNESOTA RIVER
LOWER MISSISSIPPI
MISSOURI BIG SIOUX
MISSOURI LITTLE SIOUX
DES MOINES
Roseau R
Lake of the Woods
Lower Rainy
Two Rivers
Tamarac R
Thief R
Rapid R
Rainy R (Rainy Lk)
Snake R
Grand Marais Cr
Red Lake R
Red Lk
Vermilion R
Rainy R (Headwaters) Kawishiwi
Lk Superior (N)
Clearwater R
Big Fork R
Little Fork R
Poplar R
Marsh R
Wild Rice R
Mississippi R (Headwaters)
Leech Lk R
St. Louis R
Cloquet R
Lk Superior (S)
Sucker R
Buffalo R
Crow Wing River
Mississippi R* (Grand Rapids)
Pine R
Otter Tail R
Leaf River
Upper* Red R
Mississippi R* (Brainerd)
Nemadji R
Kettle R
Upper St. Croix R
Long Prairie R
Snake R
Sauk R
Rum R
Pomme de Terre R
Chippewa R
Minnesota R* (Headwaters)
Yellow Bank R
Lower* St. Croix R
Mississippi R* (St. Cloud)
N Fk Crow R
Mississippi R* (Twin Cities)
Lac Qui Parle R
Hawk Cr
S Fk Crow R
Yellow Medicine R
MN R* (Morton)
Mississippi R* (Lk Pepin)
Lower Minnesota R
Redwood R
Upper Big Sioux R
Cottonwood R
MN R* (Mankato)
Cannon R
Mississippi R* (Winona)
Zumbro R
Straight R
Whitewater R
Lower Big Sioux R
Watonwan R
Le Sueur R
Mississippi R (La Crescent)
Pipestone Cr
Des Moines R
Cedar R
Root R
Rock R
Blue Earth R
Mississippi R (Reno)
Little Sioux R
Lower Des Moines River
E Fk Des Moines R
Winnebago River
Shell Rock R
Upper Iowa R
Upper Wapsipinicon R
* Major River Mainstem Site. Includes Inputs From All Upstream Watersheds
Minnesota Pollution Control Agency
Watershed Pollutant Load Monitoring Network
wq-cm5-11
1/21/2015

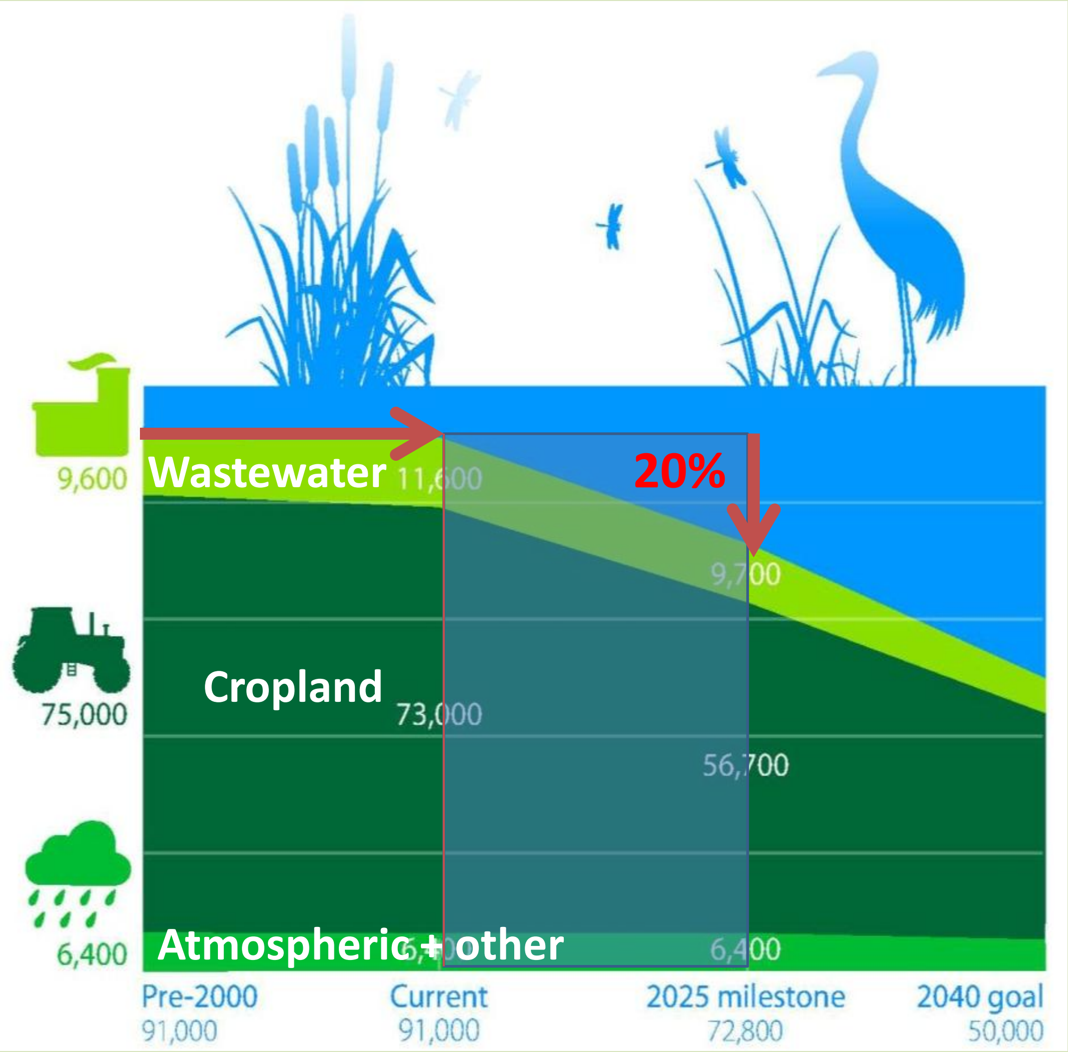
Minnesota's Nutrient Reduction Strategy

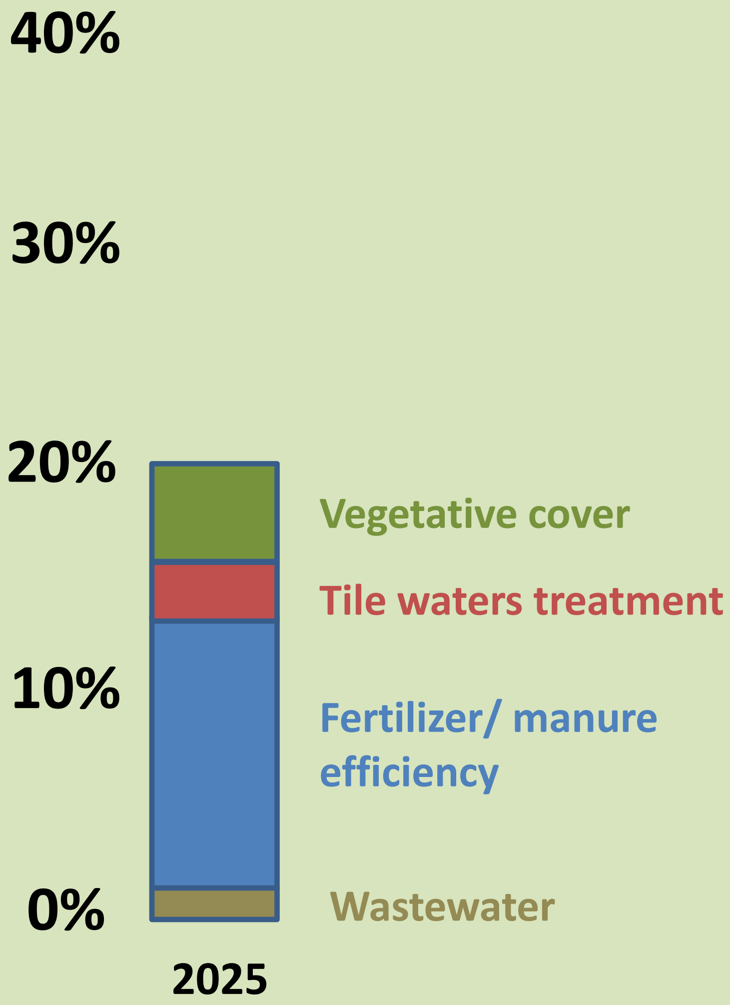


Water Quality Needs

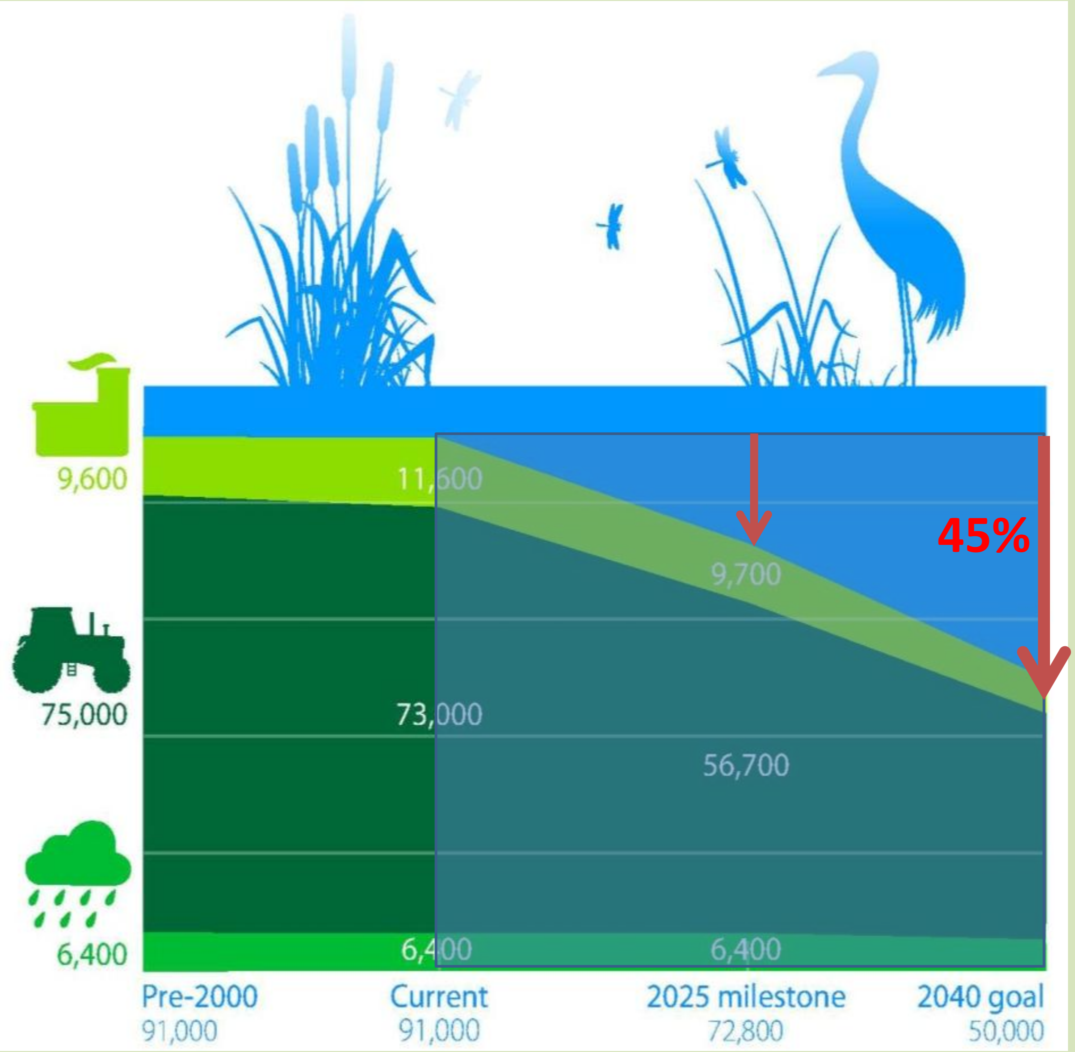
- 45% nitrogen reduction in Mississippi River
- 40-50% phosphorus reduction in hundreds of Minnesota lakes and rivers

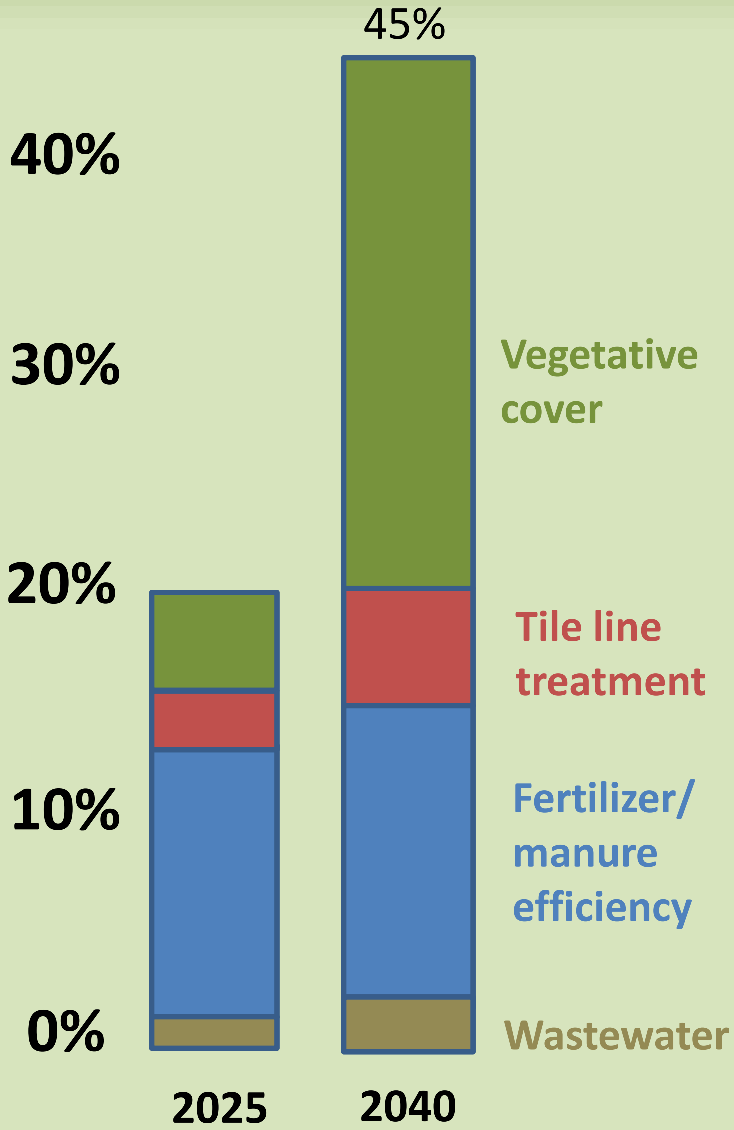
Mississippi River Nitrogen Loads





Mississippi River Nitrogen Loads





Getting to Ag Water Quality Solutions: Nonpoint Source Nitrogen Reduction Plan for Minnesota Surface Waters

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William Lazarus
Department of Applied Economics
University of Minnesota

David Wall
Minnesota Pollution Control Agency

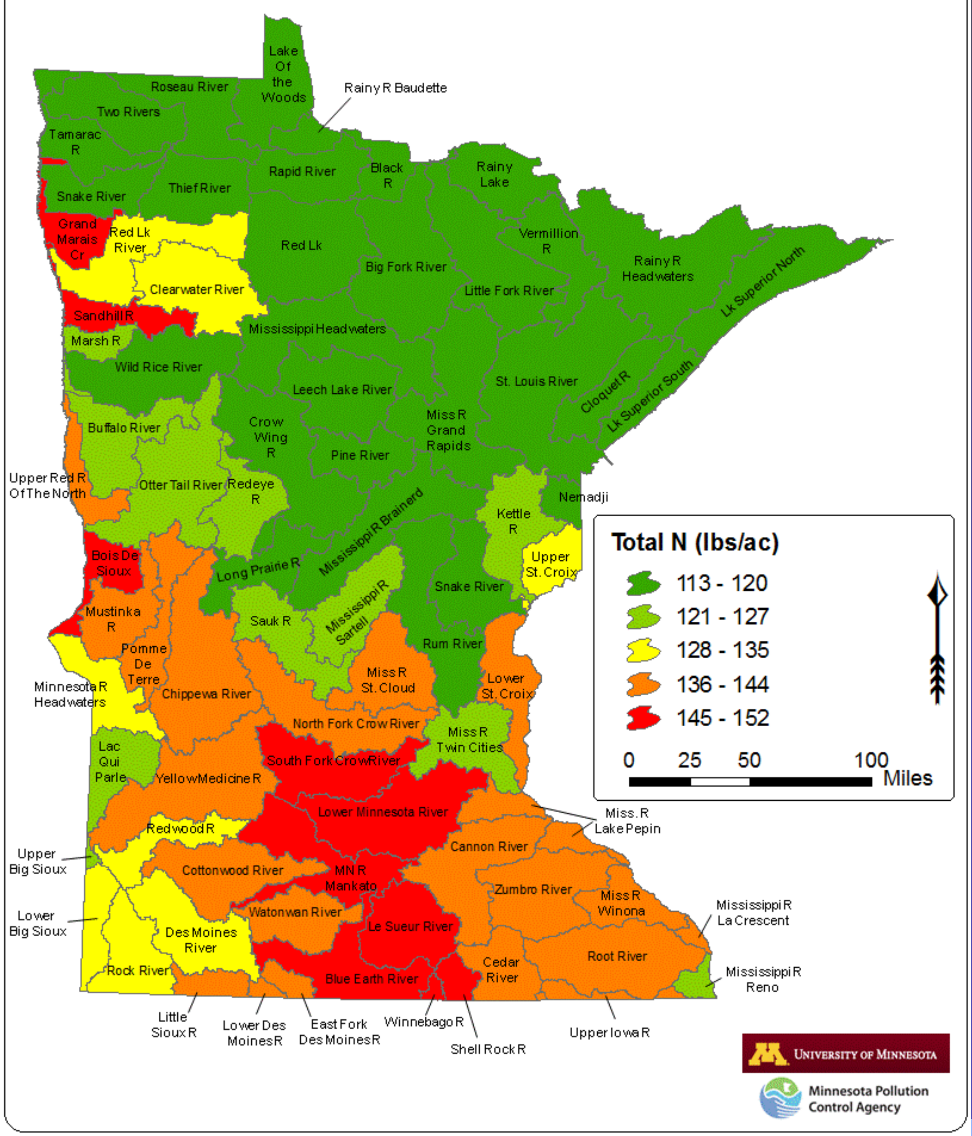
GOALS

- Assess nonpoint source nitrogen contributions to Minnesota rivers from a) the primary land use sources, and b) the primary hydrologic pathways under dry, average and wet climatic conditions
- Determine the watersheds which contribute the most nitrogen to the Mississippi River, and combination of land uses and hydrologic factors having the greatest influences on the elevated nitrogen
- What BMPs and goals for nitrogen reductions to surface waters are effective and economically feasible?

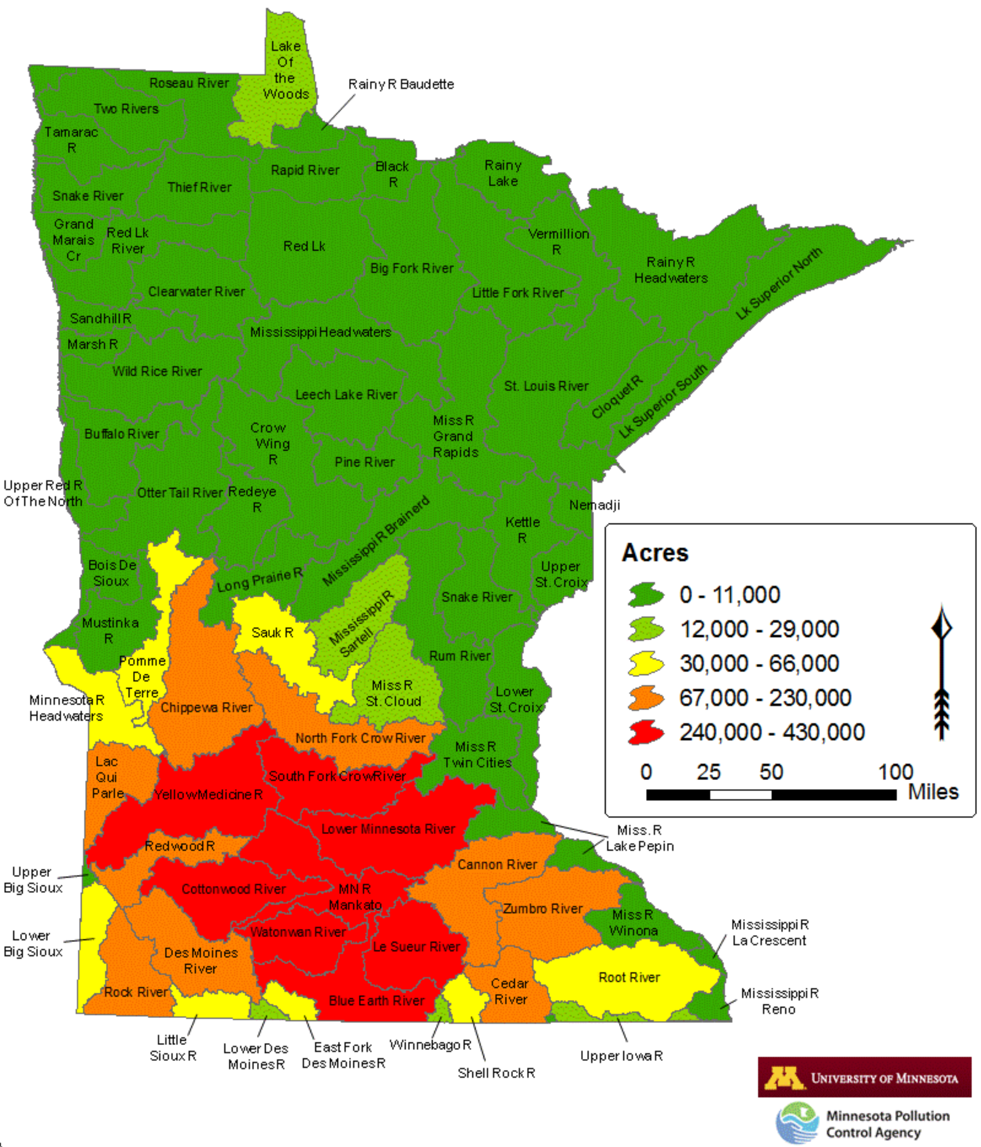
Baseline N Loss to Surface Waters

- Estimated nonpoint source nitrogen contributions to Minnesota rivers from agricultural, forest, and urban sources through drainage, groundwater discharge or runoff under dry, average and wet climatic conditions
  - Agricultural N loss estimates were based on precipitation, N inputs to system (e.g. fertilizer, manure, soil mineralization), N concentrations and discharges in numerous field and plot experiments conducted over many decades at different locations in Minnesota
  - Forest and Urban N loss estimates were based on export coefficients derived from an extensive literature review
- Point source losses were estimated based on an extensive permit database

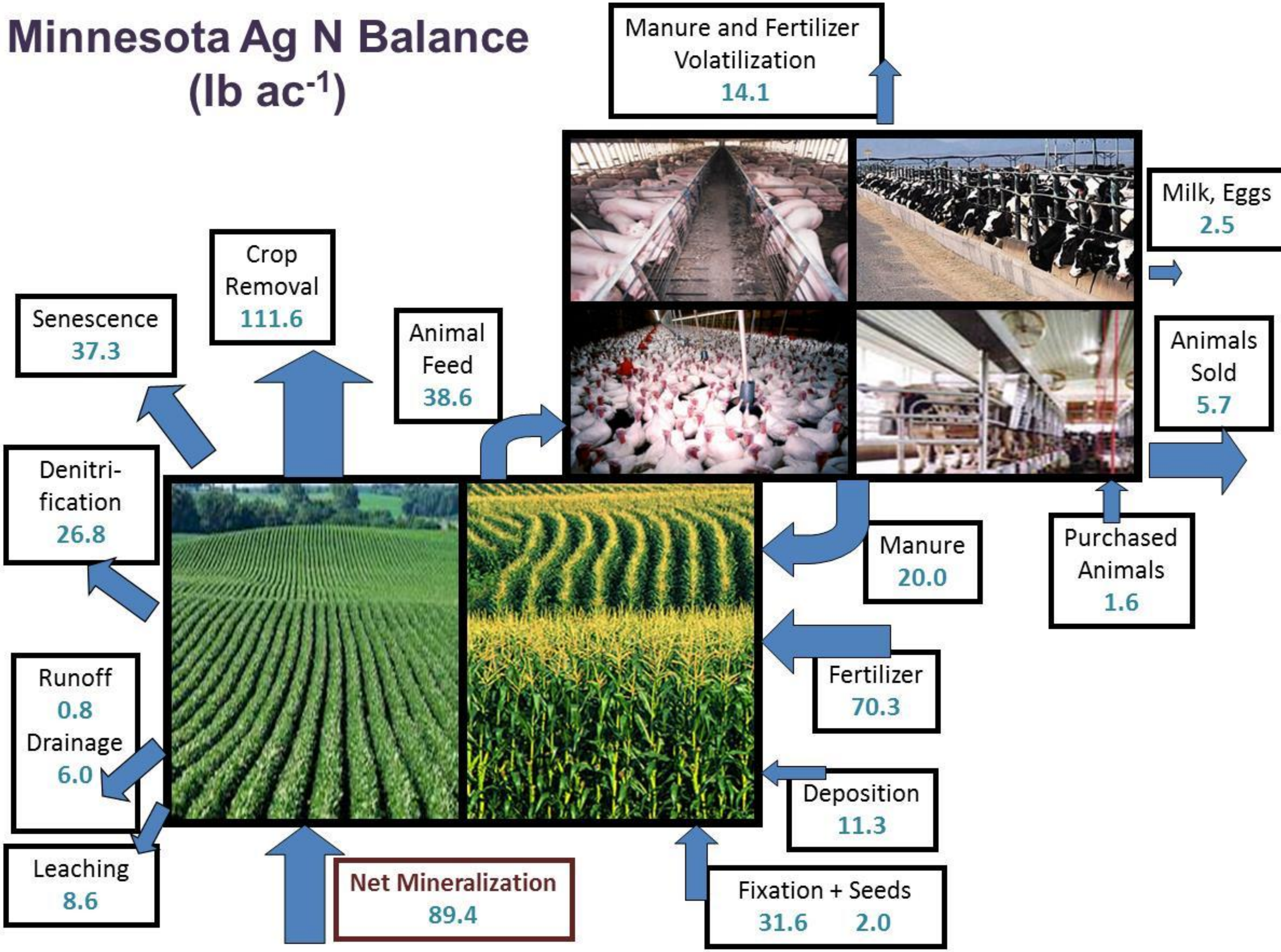
N Rate applied to Corn from Fertilizer



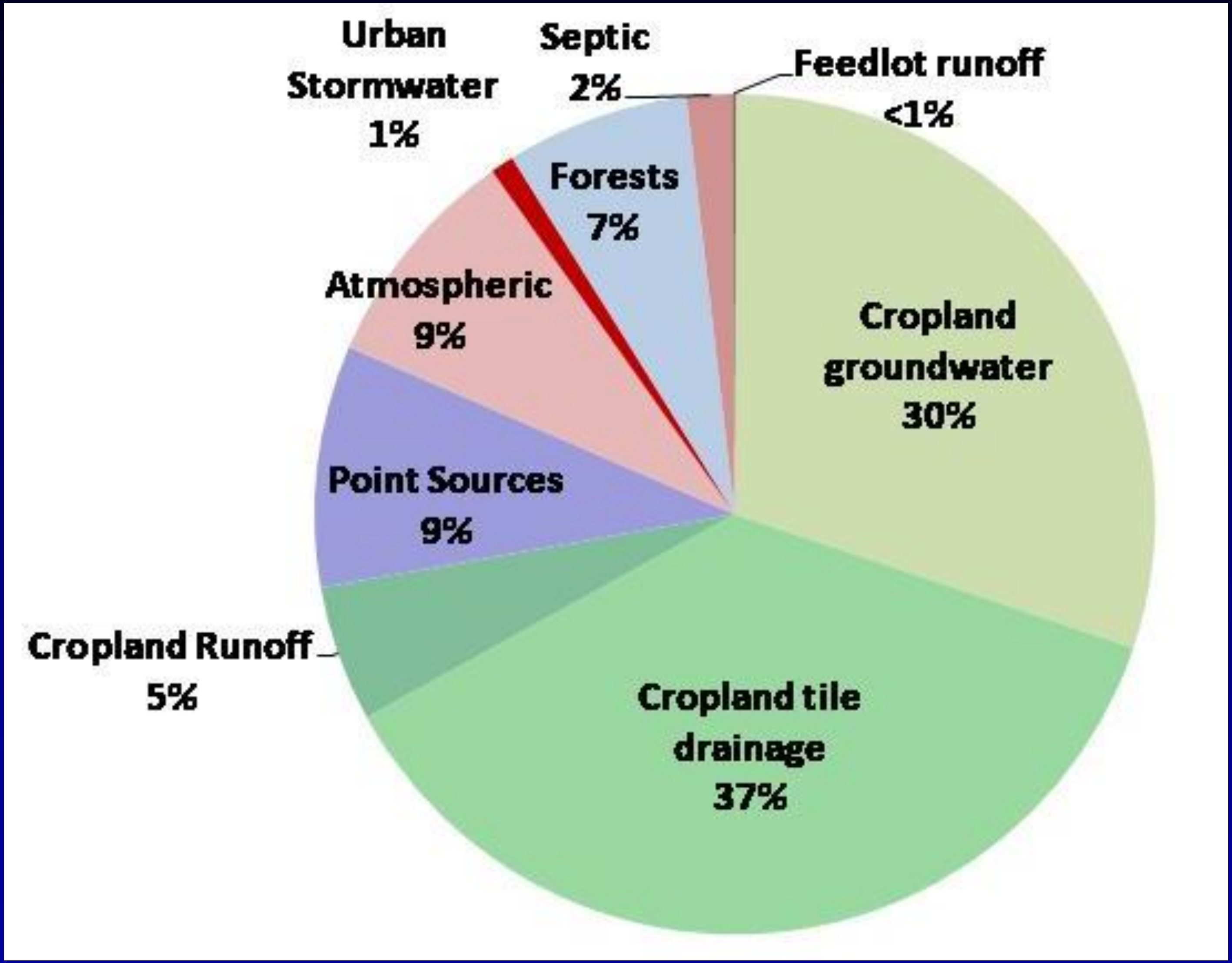
Total Acres Likely Tile Drained



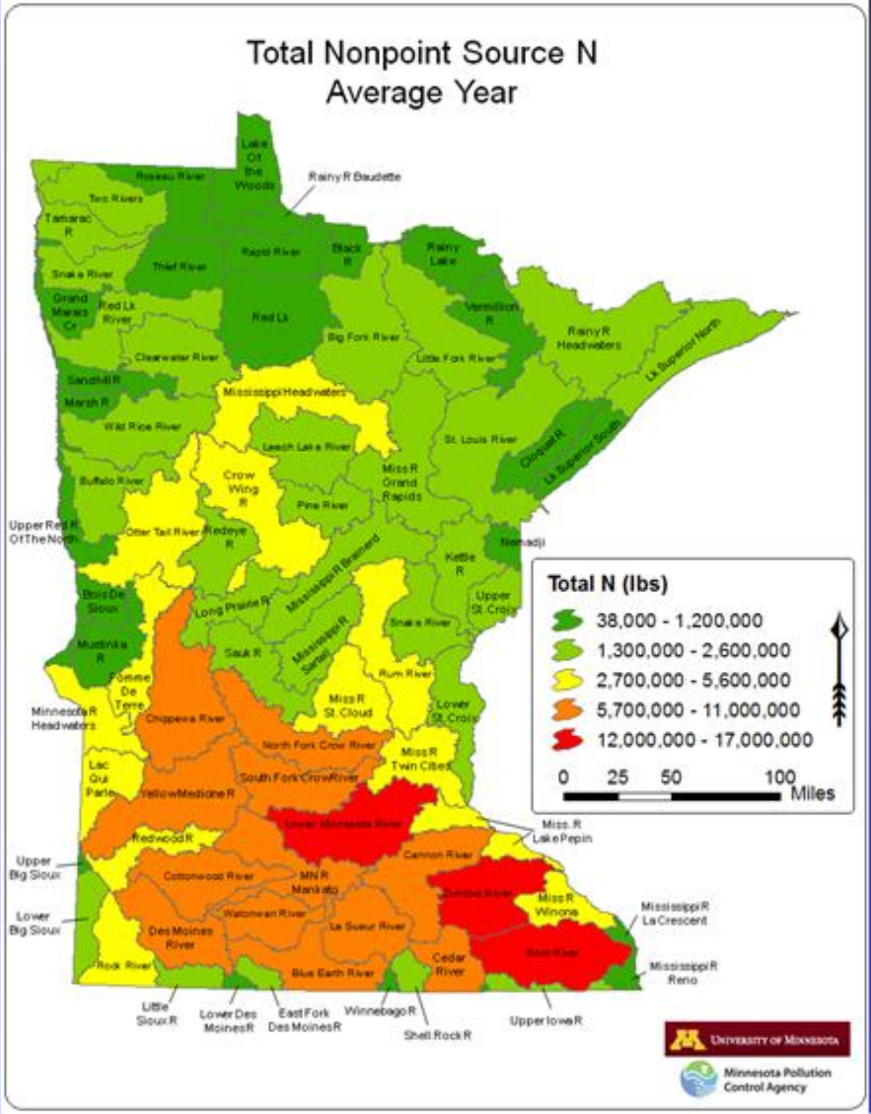
Minnesota Ag N Balance
(lb ac^{-1})

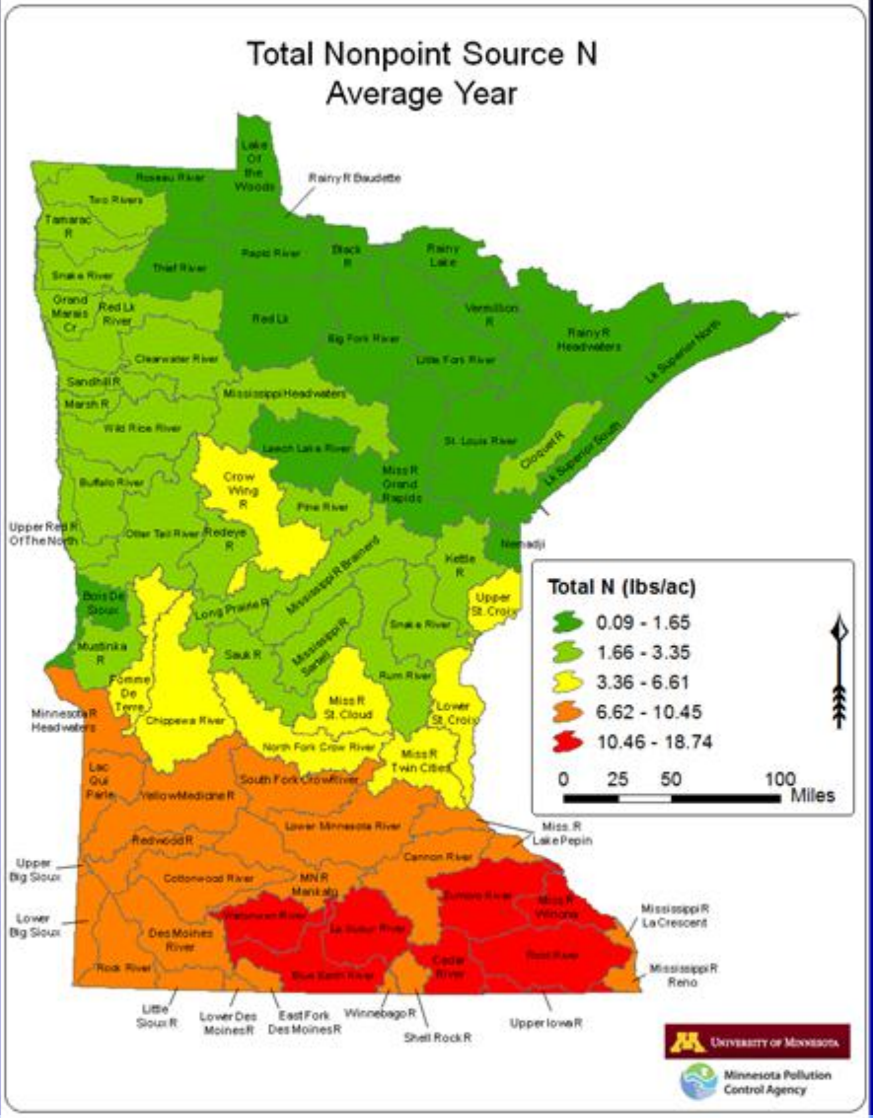


Baseline N Loadings to Surface Water

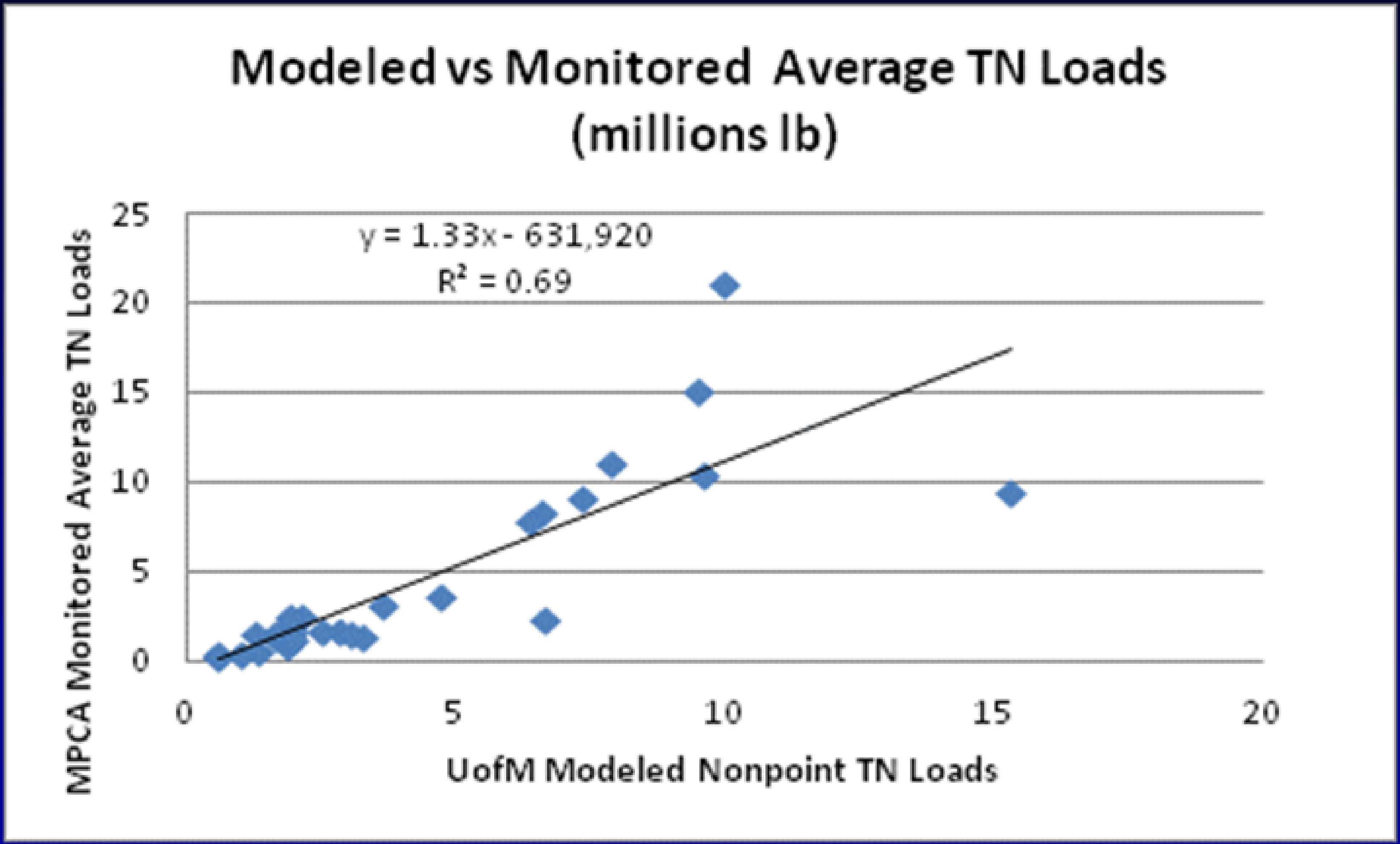


The 15 red/orange-colored watersheds generate a majority of N losses to surface waters for the state of Minnesota.

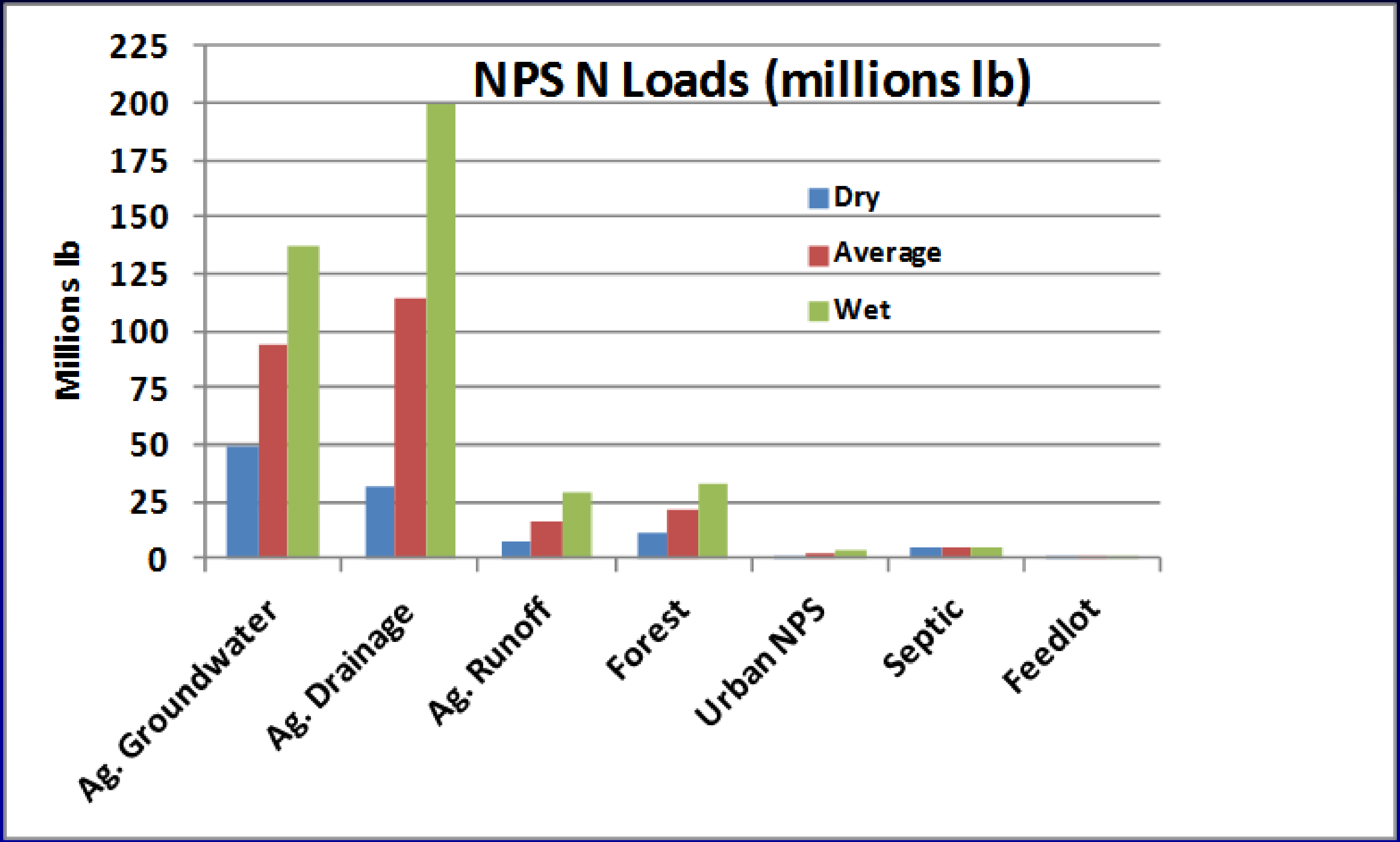




Comparison between Predicted and Measured N Loads in an Average



Effect of Climate on N Loadings



Conclusions – Nonpoint Source N Loadings to Surface Waters

- Total nonpoint source N loadings to Minnesota surface waters were estimated at 254 million lb during an average climatic year. This is about 6% of the total inputs of N on all Minnesota cropland
- Statewide, losses of N to surface water from agricultural sources represent 72% of total losses
  - Agricultural N loadings to surface waters from groundwater and drainage are about equal and each far exceed runoff losses

Watershed N Reduction Decision Tool

- How can non-point source N losses be reduced?
- What goals for nitrogen reductions to surface waters are feasible?
- The Decision Tool is an Excel spreadsheet linked to a database of Minnesota soils, landscapes, cropping systems, management practices and crop enterprise budgets
- Estimates of N reductions are based on research meta-data and BMP specific reduction coefficients
- Estimates are tied to site specific characteristics such as soil, slope, climate, and baseline farm management practices and cropping systems

N Reduction Decision Tool BMPs

- Rate and timing of N fertilizer
- Controlled drainage
- Bioreactors
- Planting cover crops
- Planting perennial grass
- Installing riparian buffer strips
- Installing wetlands

- Effects of individual BMPs as well as combinations of BMPs can be evaluated

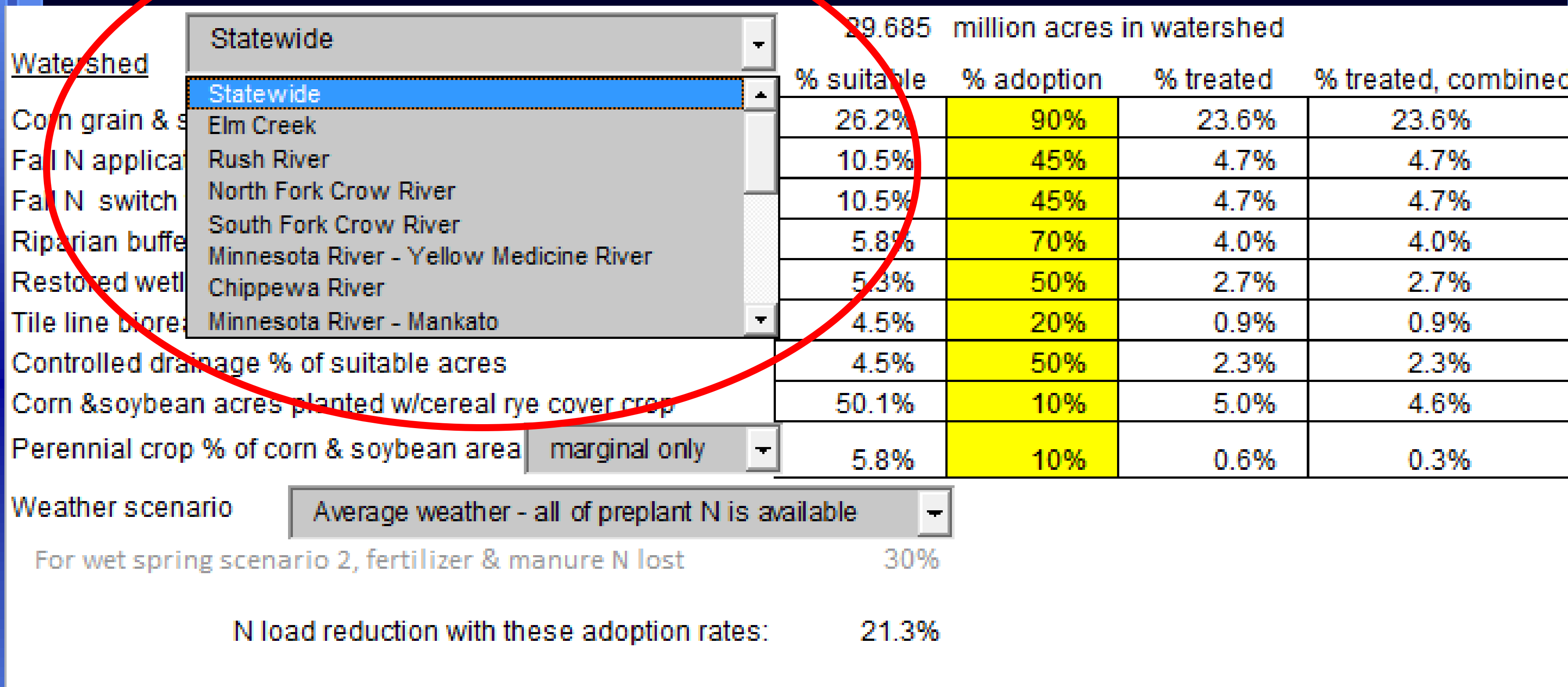
Suitable Acres for BMPs

- Fertilizer rate reductions are only possible in areas where existing application rates exceed University recommendations
- Controlled drainage and bioreactors can be installed on tile drained land with slopes of 0.5%, 1% or 2%
- Perennial grass can be planted on ag land with crop productivity ratings of 60% or less (marginal land)
- Riparian buffers can be installed on ag land within 30 m of waterways
- Wetlands can be restored on tile drained land with hydric soils and high Compound Topographic Index values

Watershed Nitrogen Reduction Planning Tool

Screen Capture Image Results

Main Input Screen: Area Selection



Main Input Screen: BMPs

Watershed: Statewide

29.685 million acres in watershed

	% suitable	% adoption	% treated	% treated, combined
Corn grain & silage acres receiving the target N rate	26.2%	90%	23.6%	23.6%
Fall N applications switched to spring, % of fall-app. acres	10.5%	45%	4.7%	4.7%
Fall N switch to split spring/sidedressing, % of fall acres	10.5%	45%	4.7%	4.7%
Riparian buffers % of suitable acres	5.8%	70%	4.0%	4.0%
Restored wetlands % of suitable acres	5.3%	50%	2.7%	2.7%
Tile line bioreactors % of suitable acres	4.5%	20%	0.9%	0.9%
Controlled drainage % of suitable acres	4.5%	50%	2.3%	2.3%
Corn &soybean acres planted w/cereal rye cover crop	50.1%	10%	5.0%	4.6%
Perennial crop % of corn & soybean area: marginal only	5.8%	10%	0.6%	0.3%

Weather scenario: Average weather - all of preplant N is available

For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%

Main Input Screen: Suitable Area

Watershed: Statewide

29.685 million acres in watershed

	% suitable	% adoption	% treated	% treated, combined
Corn grain & silage acres receiving the target N rate	26.2%	90%	23.6%	23.6%
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Controlled drainage % of suitable acres	4.5%	50%	2.3%	2.3%
Corn &soybean acres planted w/cereal rye cover crop	50.1%	10%	5.0%	4.6%
Perennial crop % of corn & soybean area: marginal only	5.8%	10%	0.6%	0.3%

Weather scenario: Average weather - all of preplant N is available

For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%

Main Input Screen: Adoption Rate

Watershed: Statewide

29.685 million acres in watershed

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Perennial crop % of corn & soybean area: marginal only	5.8%	10%	0.6%	0.3%

Weather scenario: Average weather - all of preplant N is available

For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%

Main Input Screen: Treated Area

Watershed: Statewide

29.685 million acres in watershed

	% suitable	% adoption	% treated	% treated, combined
Corn grain & silage acres receiving the target N rate	26.2%	90%	23.6%	23.6%
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Weather scenario: Average weather - all of preplant N is available

For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%

Main Input Screen: Weather Scenario

Watershed: Statewide

29.685 million acres in watershed

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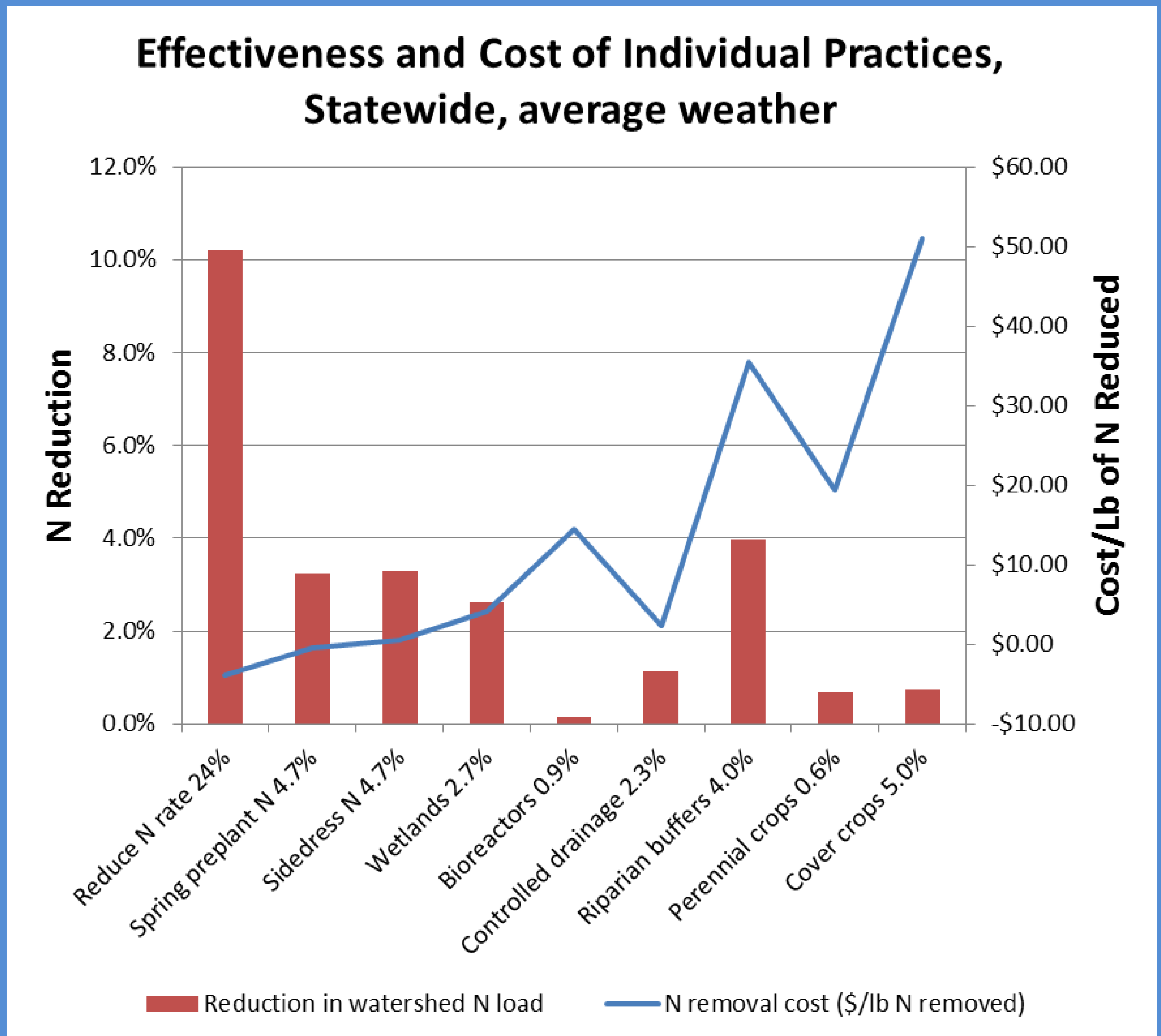
Weather scenario: Average weather - all of preplant N is available

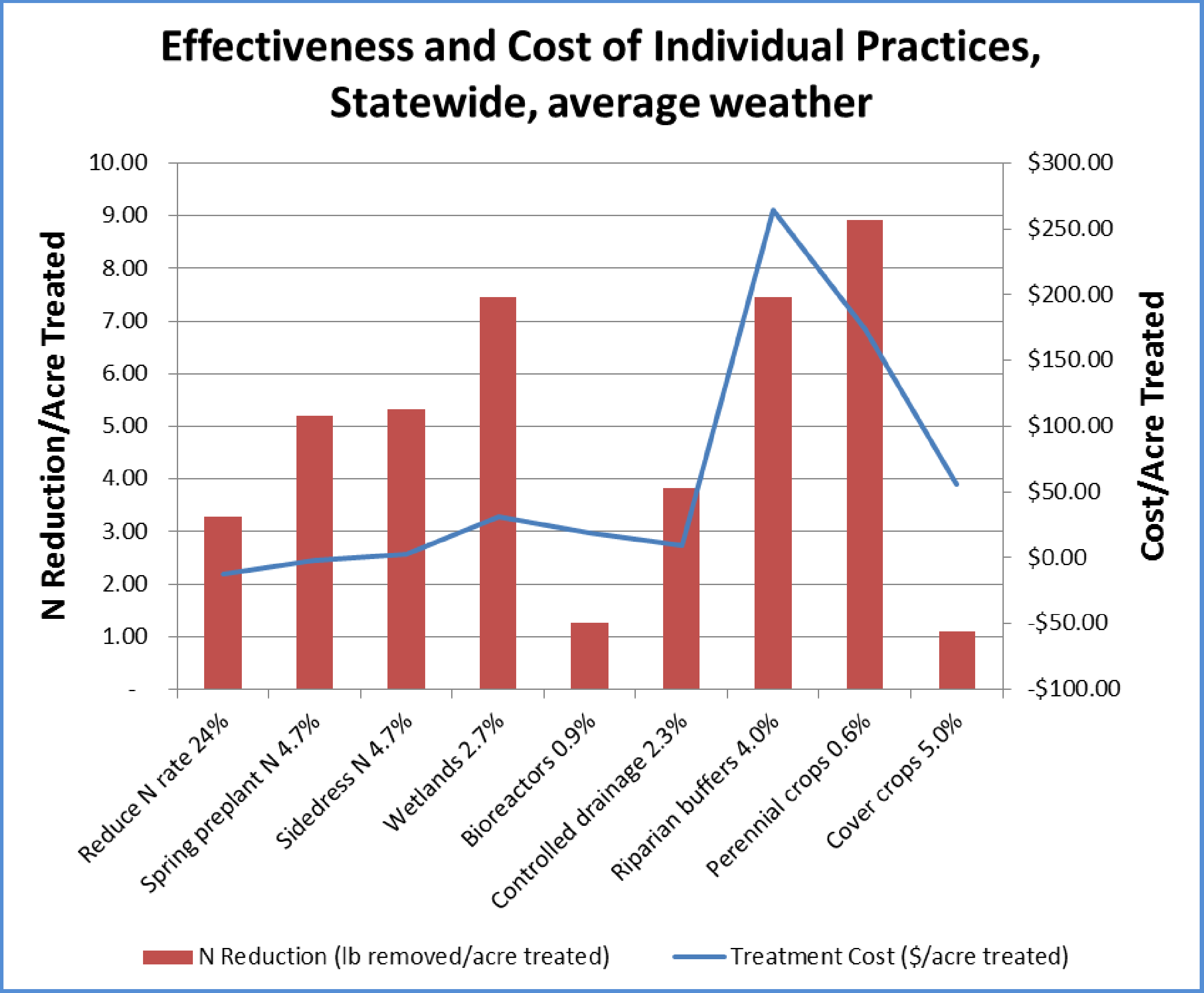
- Average weather - all of preplant N is available
- Wet year- 30% of preplant N is lost, yield reduced
- Dry year - low N leaching losses

For wet spring scena

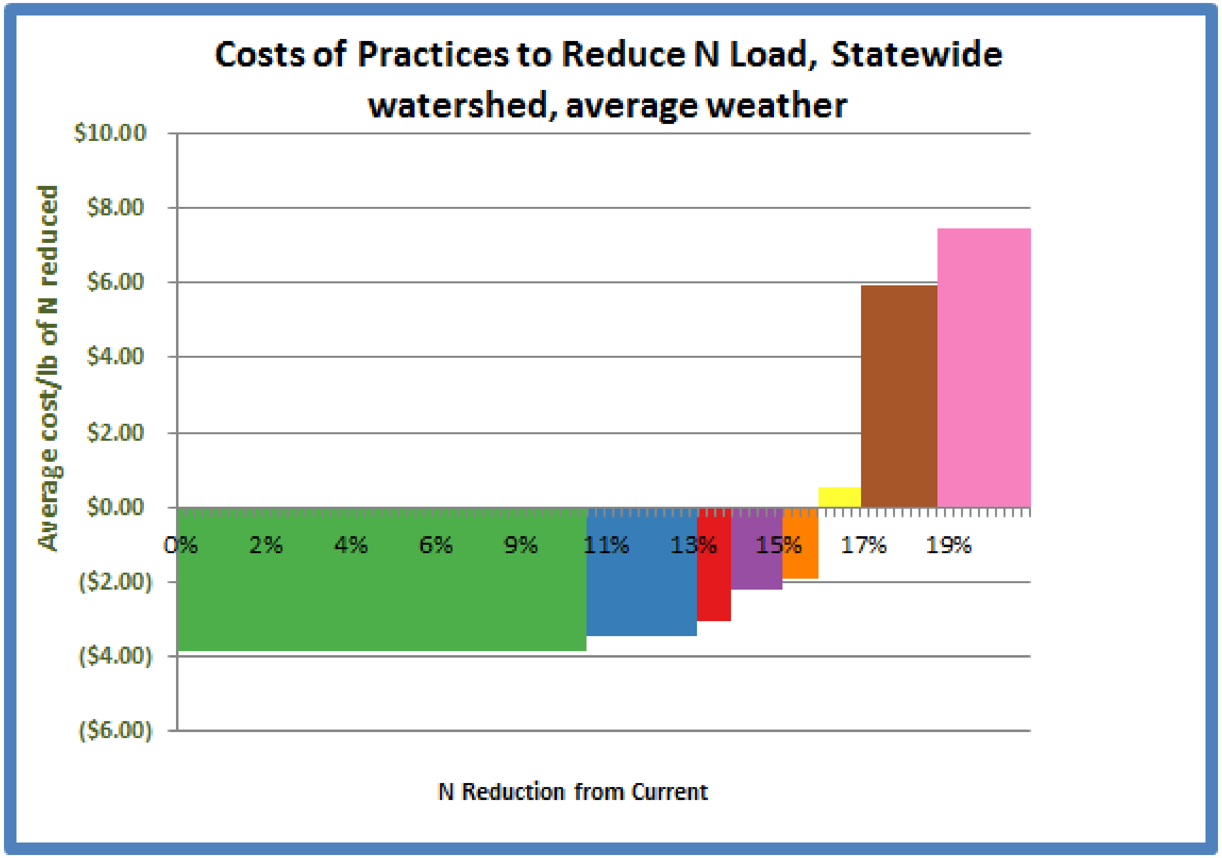
N lo



"Effectiveness" is expressed as the N load reduction compared to the baseline. "Cost" is expressed per pound of N removed.



"Effectiveness" is expressed as the area normalized N load reduction. "Normalized Cost" is expressed per acre.



Key to graph colors by BMP (left to right, the numbers are percent of the watershed, from above)

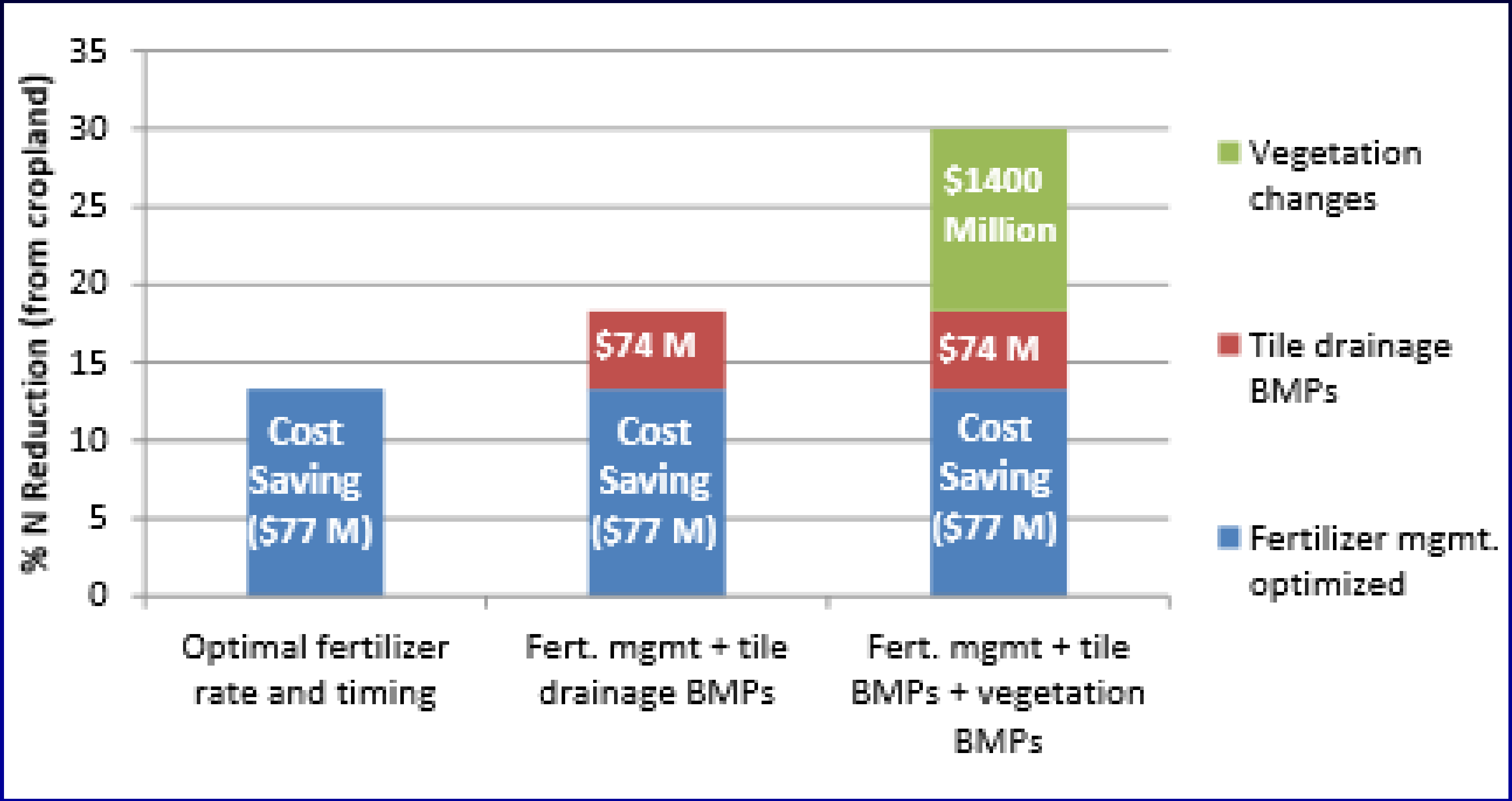
- Reduce N rate 24%
- reduce N rate 24%,spring preplant N 4.7%
- reduce N rate 24%,spring preplant N 4.7%,controlled drainage 2.3%
- reduce N rate 24%,spring preplant N 4.7%,restore wetlands 2.7%
- reduce N rate 24%,spring preplant N 4.7%,restore wetlands 2.7%,controlled drainage 2.3%
- reduce N rate 24%,sidedress N 4.7%,restore wetlands 2.7%,controlled drainage 2.3%,plant cover crops 5.0%
- reduce N rate 24%,spring preplant N 4.7%,riparian buffers 4.0%,restore wetlands 2.7%,controlled drainage 2.3%
- reduce N rate 24%,spring preplant N 4.7%,sidedress N 4.7%,riparian buffers 4.0%,restore wetlands 2.7%,bioreactors 0.9%,controlled drainage 2.3%,plant cover crops 5.0%,perennial crops 0.6%

The "Efficient Frontier" of practice combinations.

BMPs appear from left to right in order of their cost effectiveness.

Rate Reduction
Spring Application
Controlled Drainage
Wetlands
Drainage + Wetland
Cover Crops
Buffer strips
Bioreactors

N BMP Reduction Scenarios



20% Reduction Milestone

Mississippi River Nitrogen

	Source			
	Agricultural	Wastewater	Miscellaneous	Total
Baseline Load (1980–1996) Units = 1,000 metric tons (MT) per year	75.0	9.6	6.4	91
Progress Since Baseline	2	-2	0	0
Recommended Strategy Reductions				
Increasing Fertilizer Use Efficiencies on 11.2 Million Acres ▪ Recommended fertilizer rates ▪ Placement and timing of application ▪ Nitrification inhibitors	11			
Increase and Target Living Cover on 1.6 Million Acres ▪ Cover crops ▪ Perennial buffers ▪ Forage and biomass planting ▪ Perennial energy crops ▪ Conservation easements and land retirement	4.0			
Drainage Water Retention and Treatment for 0.6 Million Acres ▪ Constructed wetlands ▪ Controlled drainage ▪ Bioreactors ▪ Two stage ditches	1.3			
Wastewater Treatment		1.9		
Total Reductions	16.3 +	1.9 +	0 +	0 = Total 18.2

Milestone Target **20%** from Baseline Load = 18,200 Metric Tons Reduced

Progress Since Baseline 0 **+** **Additional Reductions** 18,200 **=** **Milestone** 18,200 MT Reduced = **20%** by **2025**

1,000 kg = 1 MT

University of Minnesota

Department of APPLIED ECONOMICS

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WILLIAM F. LAZARUS

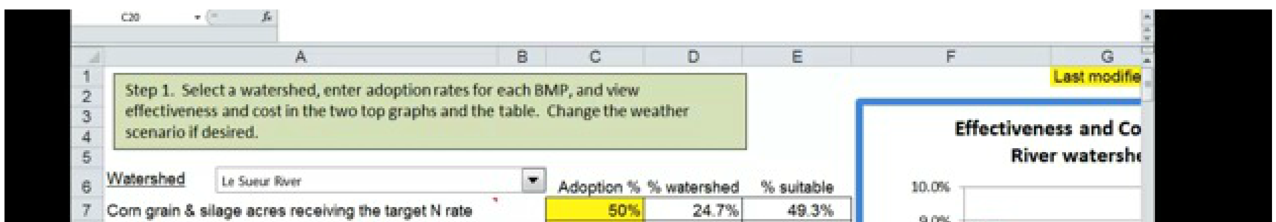
Activities, Projects, and Interests

MITIGATING AGRICULTURE'S IMPACT ON WATER AND AIR QUALITY

- Watershed Nitrogen Reduction Planning Tool - Overview Paper (pdf), NBMP.xlsm spreadsheet, and two tutorial videos. Note: This is a watershed-scale tool intended for an audience of local water resource managers, not a farm-level decision tool. Click here to link to the Minnesota Pollution Control Agency's recent study of nitrogen in surface waters and ways to reduce it. Click here to view their June press conference discussing the study. The videos shown below were recorded in May 2012. A number of small changes have been made in the spreadsheet since then, so you will see that the actual spreadsheet now looks slightly different from what is shown in the videos but they still provide a general overview of how it is organized.

INSTRUCTIONAL VIDEOS ON USING THE WATERSHED NITROGEN REDUCTION PLANNING TOOL SPREADSHEET:

Part 1



Spreadsheet: z.umn.edu\nbmp

Documentation: z.umn.edu\nbmpdoc

Conclusions

- An N Reduction Planning Tool was developed for Minnesota
- The Tool estimates reductions in N losses to surface waters for combinations of agricultural BMPs based on the area suitable for implementation of these BMPs
- Users can specify which BMPs to evaluate and the rate of adoption of these BMPs
- The Tool estimates the costs associated with the selected BMPs and their economic impact on crop yield
- The most cost-effective BMPs include optimal N rates, fall to spring/preplant timing, controlled drainage and wetlands
- Costs increase substantially with BMPs that take cropland out of production (riparian buffers and perennial crops)

Thank you!

Questions?

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David Mulla mulla003@umn.edu

Spreadsheet: z.umn.edu\nbmp

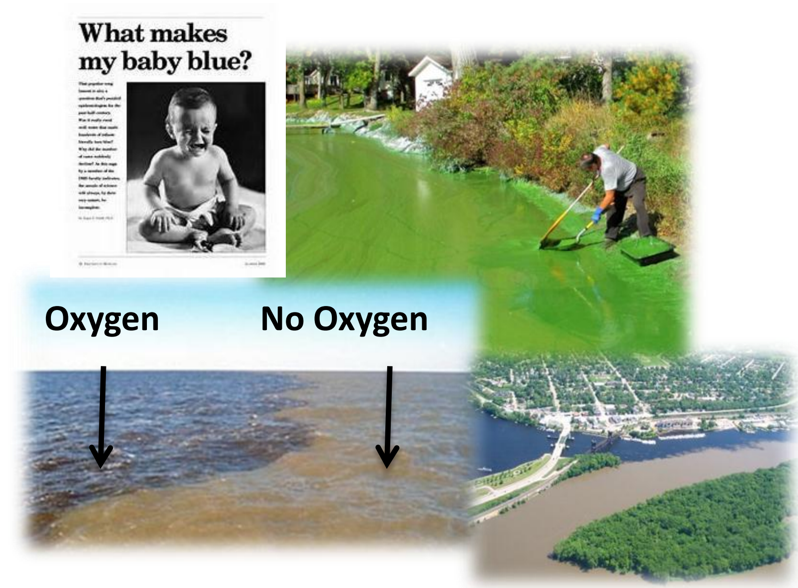
Documentation: z.umn.edu\nbmpdoc

Making Good long-term Choices

So, will it be bachelor #1, bachelor #2 or #3

Shawn Schottler, St. Croix Watershed Research Station, Science Museum of MN

What do we want--or not want?



- Safe Drinking Water
- Fewer/smaller noxious algal blooms
- Reduced Hypoxia
- Better Aquatic Habitat

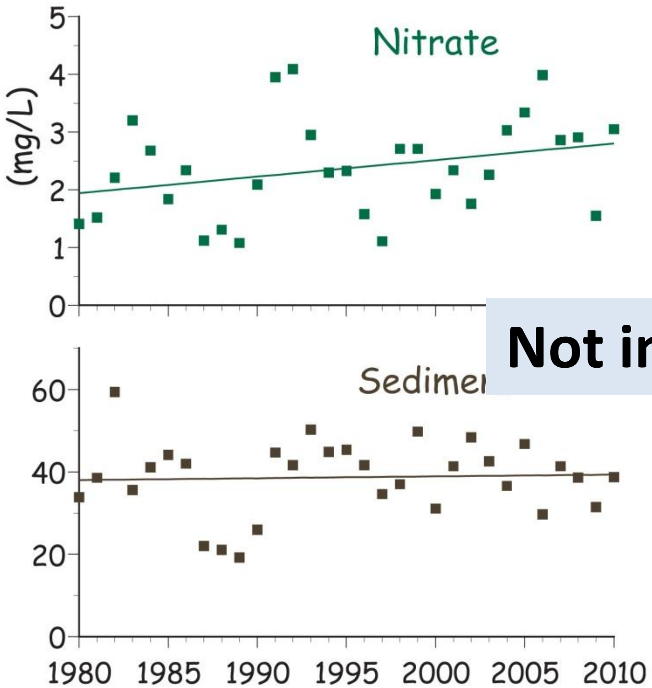
Less Nitrate, Phosphorus, Turbidity (soil loss)

- Game species
- Non-game species
- Pollinators
- Quality of life, ecosystems services

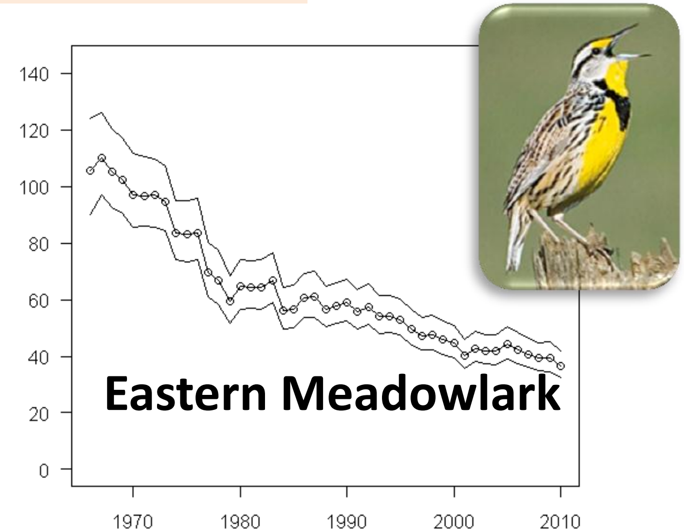
More and Better Habitat

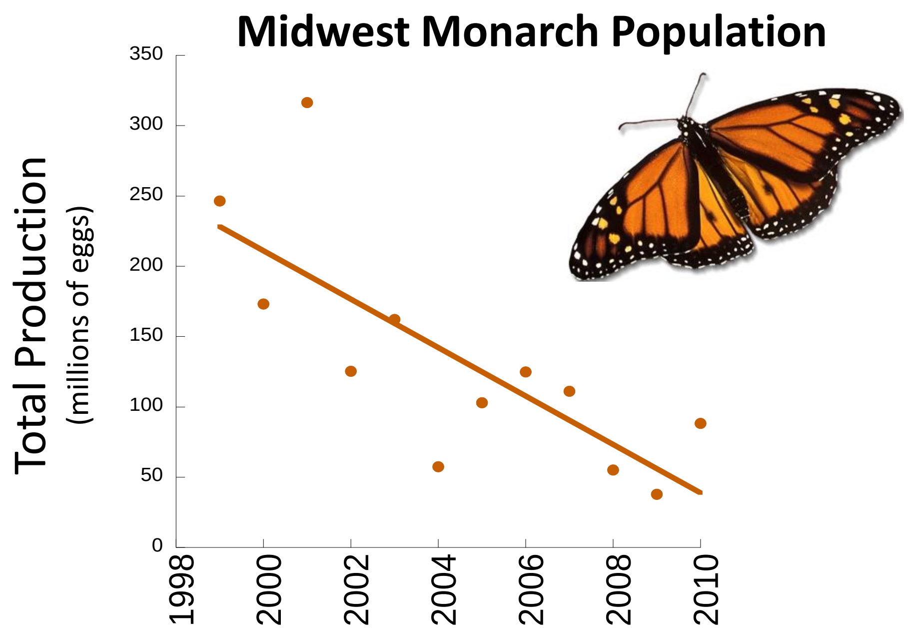
Trends—After Much Effort and $

Mississippi River at Prescott 1980–2010



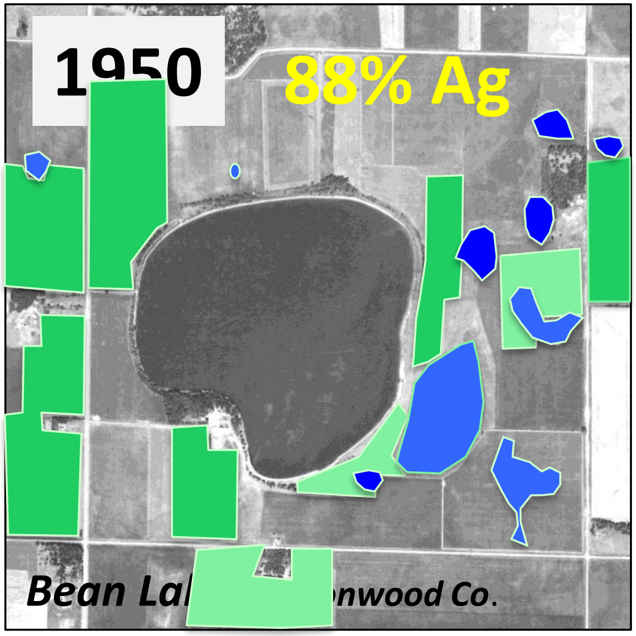
Not improving

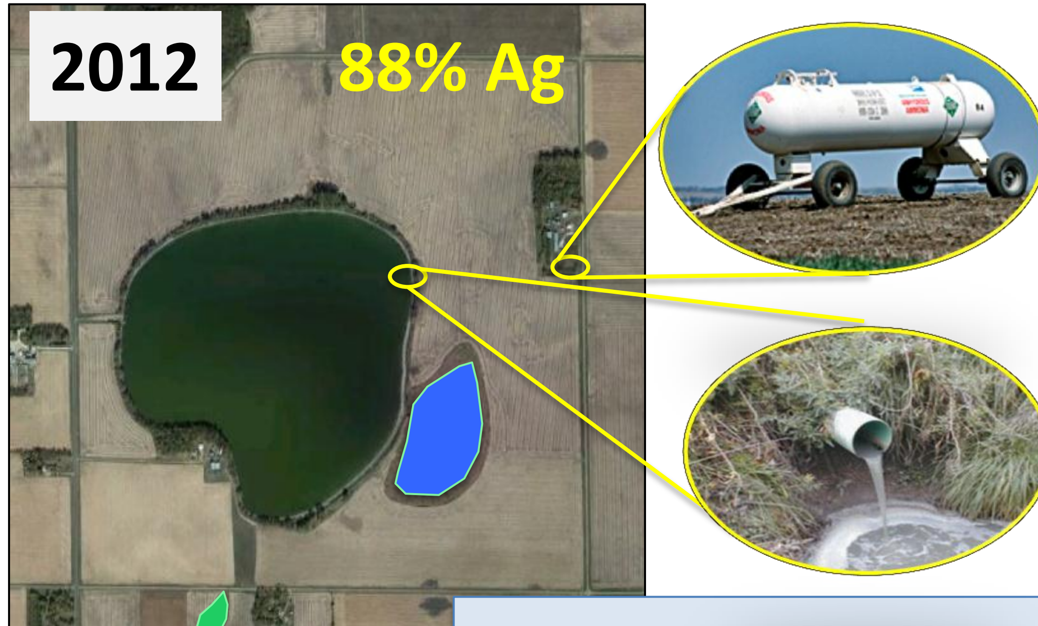


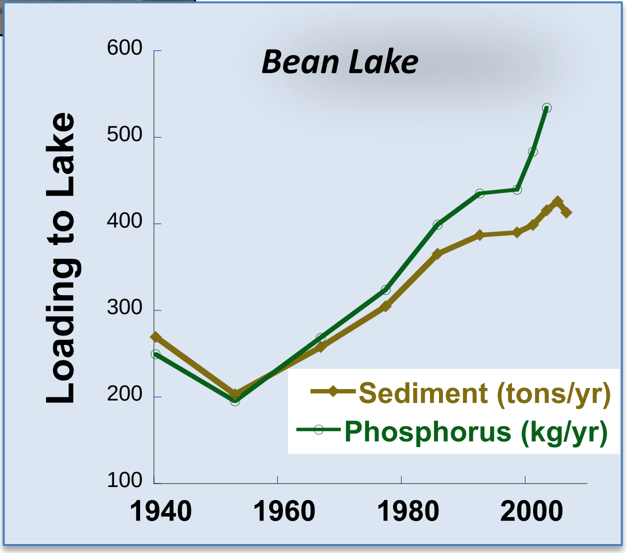


Pleasants and Oberhauser, 2012

Decades of Changes: Ag then, ag now…but very different

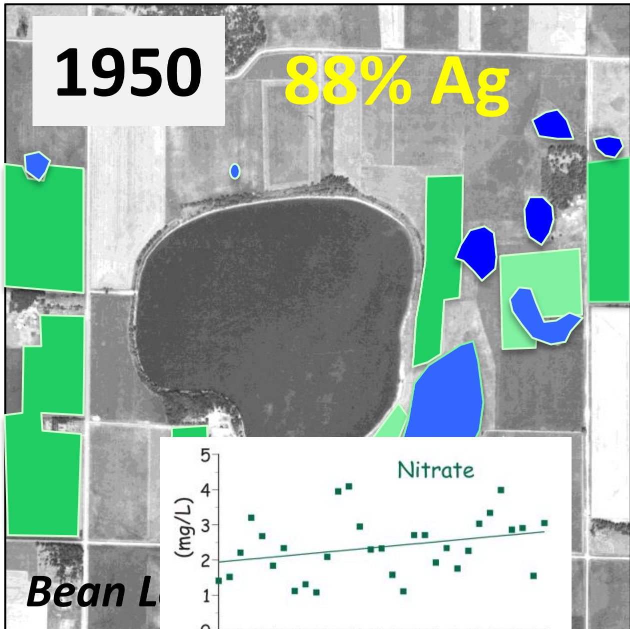


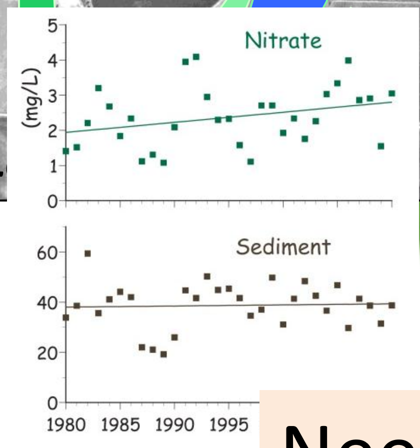


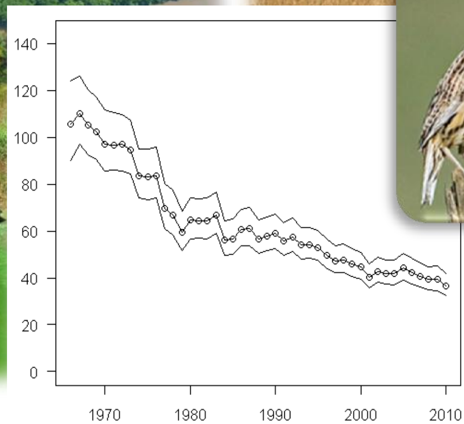


- **Loss of wetlands and depressions**
- **Addition of artificial drainage-**
  routing water, sed and nutrients to SW
- **Loss of alfalfa, hay pasture**
- **Addition of row-crops..**
  …and associated addition of nutrients

Linked by a Common Denominator



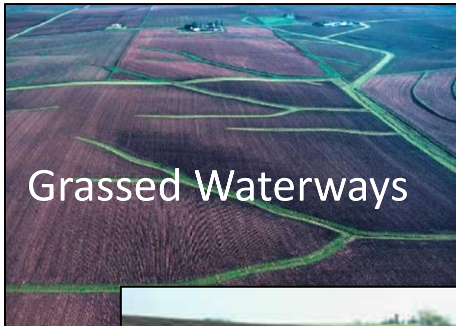




Need more perennials /crop diversity on a <u>landscape scale</u>

What is perennial vegetation

Best Management Practices (BMP)



Perennial Crops

Retired Lands/Restorations

Making Choices: Why is the landscape the way it is?

Grass Buffer

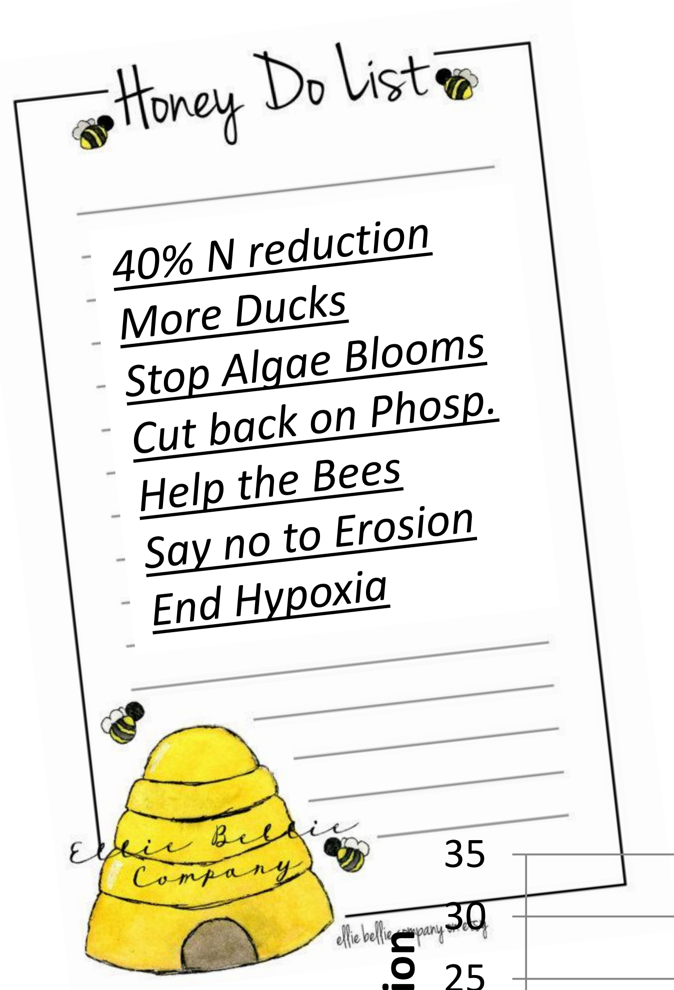
- ❤ I clean up water
- ❤ Don't take up much space
- ❤ Government supported
- ❤ Chicks dig me

Alfalfa

- ✓ Make good food
- ✓ 15 million calories/acre
- ✓ Can make Ethanol
- ✓ Fix Nitrogen
- ✓ Good at holding soil
- ✓ Smells good

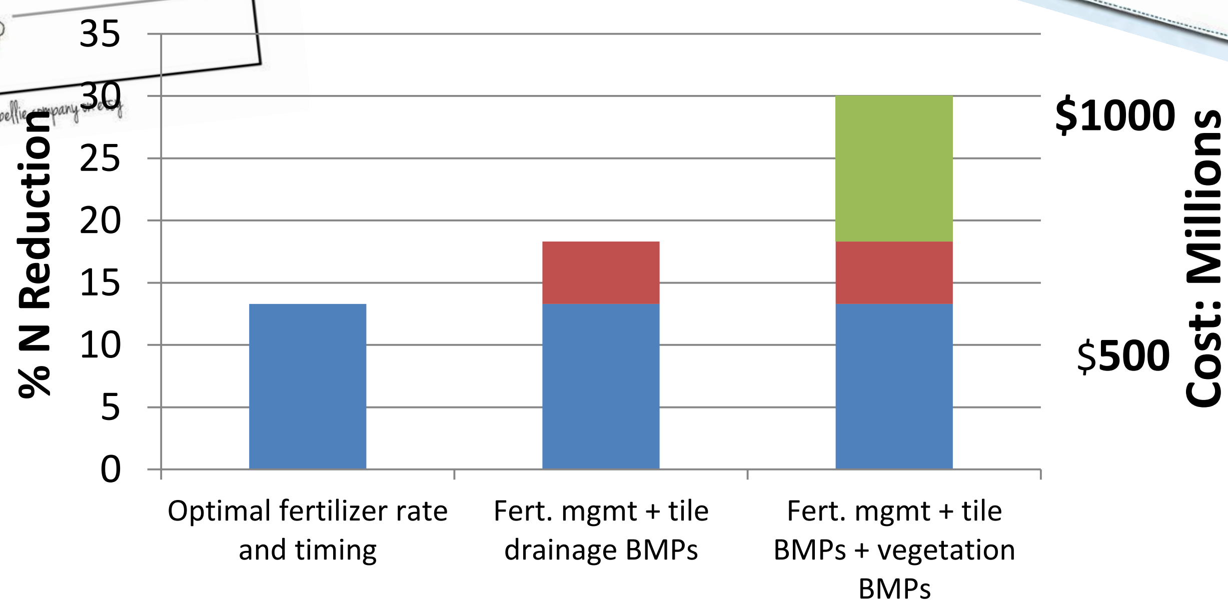
Corn

- ♡ Make good food
- ♡ 15 million calories/acre
- ♡ Can make Ethanol
- ♡ Well developed markets



$1 billion

per year

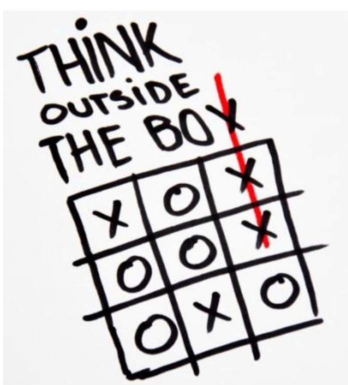


Water Quality and Habitat Improvement Strategies

So, how are we going to pay for it?

- The land is used for corn/soy because there are markets and mandates for corn/soy

  Corn/Soy Make Money---BMPs cost Money



- So, let’s create markets for perennial vegetation/crops
  (i.e. make perennials profitable)

Ethanol as a Market for Perennial Crops

a.k.a.
Ethanol as a Nutrient and Sediment Reduction Strategy
Ethanol as a Habitat Program

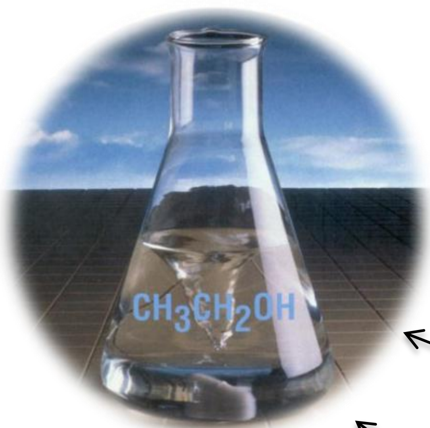
Energy Independence and Security Act of 2007 established the

Renewable Fuels Standard *(aka Ethanol Mandate)*

- Mandates that Americans consume 13-15 billion gallons of ethanol in our gasoline (~10% of auto fuel)

And

- Mandates increased use of cellulosic sources



Ethanol

Currently ~13 billion gallons from corn

By 2022:
Additional 16 billion gallons from cellulose

Corn stover (waste) is the "easy" source to meet the mandate..

~90 Million Acres of unused, **wasted** corn stalks, leaves and cobs

Stover:

- Organic Matter
- Prevents Erosion
- Store Nutrients
- Nourish Soil

Excessive Stover Harvest:
Negative Implications for Water Quality and Habitat

Mandate other sources to meet the Mandate

Perennials and alfalfa are a viable source of cellulosic ethanol

- Similar or more Net Energy
- Negligible soil loss
- Less water/nutrient runoff
- Build Organic Matter
- Store Carbon
- Provide Habitat

<u>If:</u>

- **Required ~50% of cellulosic ethanol from perennials**

<u>Then</u>

- **Put ~1/3 of corn acres in rotation with perennials (alfalfa)**
- **~2 million acres of perennials in Minnesota**
- **~30% reduction in Nitrate and Phosphorus**

Electricity as a Market for Perennials

i.e.
Electricity as a Water Quality/Habitat BMP

Switchgrass can be co-fired with coal for electricity

- **If replace 10% of BTUs from Coal with Grass**

= 410,000 acres of perennials in Minnesota

Could replace all Coal with 4 million acres of grass

200 ft wide grass buffer,
along 17,000 miles of waterways
= 10% of BTUs from coal

Crop Insurance as an Incentive for Perennials

Currently

- The public pays 63 % of a Farmer's Crop Insurance
- Crop Insurance rewards increased yield
- No Incentive for Conservation

What if we rewarded both yield and conservation

Crop Insurance as a BMP: Reward Farmers for Conservation

- **No conservation—farm as you want = Public pays 51% of premium**
- **Implement 4% perennial vegetation = Public pays 63%**
- **Implement more than 8% perennial vegetation = Public pays 75%**

- Voluntary
- Will get us to our water quality/habitat goals
- Doesn't cost taxpayers additional money!

A Market Driven, Water Quality/Habitat Improvement Strategy

Market Driven BMPs: How many acres of **perennials** from each

Practice	Acres in MN
• 50% Cellulosic Ethanol from Alfalfa/Grass	2 million
• 10% of Coal BTU's from Grass	410,000
• 100% of Coal BTU's from Grass	4 million
• Eating Premium Fed Beef	~350,000
• Crop Insurance Incentives	0.7 to 1.5 million

No additional cost to taxpayers,
"Simple": does not require infrastructure/consumer changes

Nutrient and Sediment Reduction Strategies:

—**Thinking** differently about choices that can change water quality

2015 Actions

Challenge in how to implement

Minnesota
Environmental
Partnership

Fall soybean with pennycress regrowth

Corn/PC/Soy bean Rotation

Pennycress seeded into corn

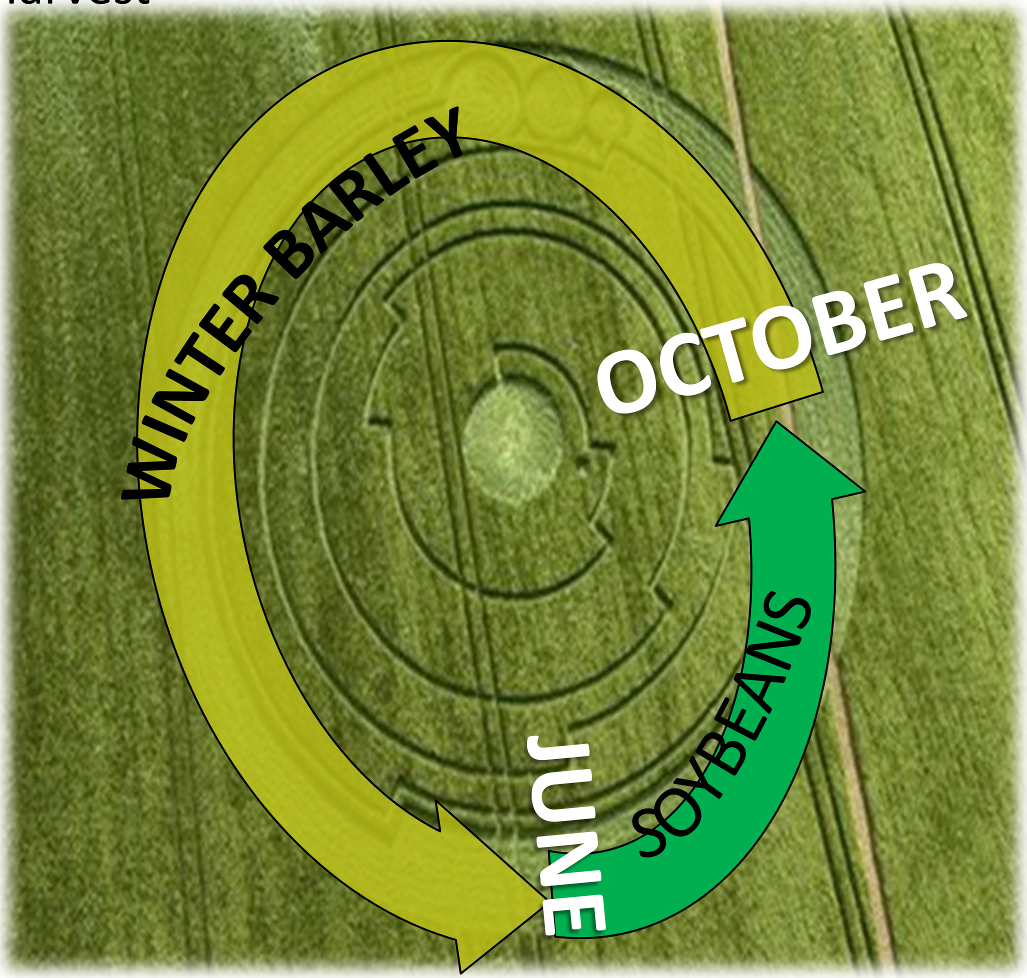
Soybean planted no till into pennycress stubble 1st

Pennycress mid- May

Pennycress late fall

Winter Barley

Crop Diversity, Spread Out Field Activities, **Double Cropping**, Earlier Harvest



Opportunities: Food Products--
PepisCo

Kura clover Continuous Living Cover

Forever Green

- 3rd year of funding for University research -- $1M/year
- Expect to secure subsequent years for sustained research program

Minnesota Environmental Partnership

Cellulosic Ethanol

- Demonstrate use of market forces to restore water quality in two Ag watersheds
- Proposal to incentivize cellulosic ethanol. 2 commercial scale plants built last year in IA.
- Federal mandate currently on hold
- Provide up to $6M/year for producer incentives

Minnesota Environmental Partnership

Cellulosic Ethanol

- Negotiated agreement:
  - 50% minimum perennial feedstock by year 5, higher state incentives for perennial-based ethanol
  - Incentivized establishment of perennial working lands
    - Target high impact areas within watersheds heavily impacted by ag pollution
    - Provide long-term contracts (10 yr min) to establish and maintain perennial crop lands
    - Can be used for cellulosic ethanol or livestock

Minnesota Environmental Partnership

Buffers on public waters and drainage ditches

- Governor Dayton surprise: 50 ft of vegetation on all waterways
- 50 foot buffers on all public water ways, 16.5 feet on public ditches
- Expect estimated 7,000 plus miles of new buffers over the next 3 years
- Provides tools, staff and penalties to enforce statewide

Minnesota Environmental Partnership

Green Lands, Blue Waters

Our Vision

- A long-term vision for agriculture in the U.S. Midwest. It's based on the concept of getting as much value as possible from farmlands by growing crops that keep the soil covered year-round: farming with Continuous Living Cover.
- The value comes in yields and profits; but also in reduced risk, improved soil health, more wildlife, and cleaner water

Minnesota Environmental Partnership

Green Lands, Blue Waters

- **2015 GLBW Conference**
  Bridges and Buffers, Farms and Cities: Continuous Living Cover Farming Systems
  Nov. 3 & 4
  Minneapolis, MN
  GreenlandsBlueWaters.net

Minnesota Environmental Partnership

Thank you.