Green County: Groundwater Quality

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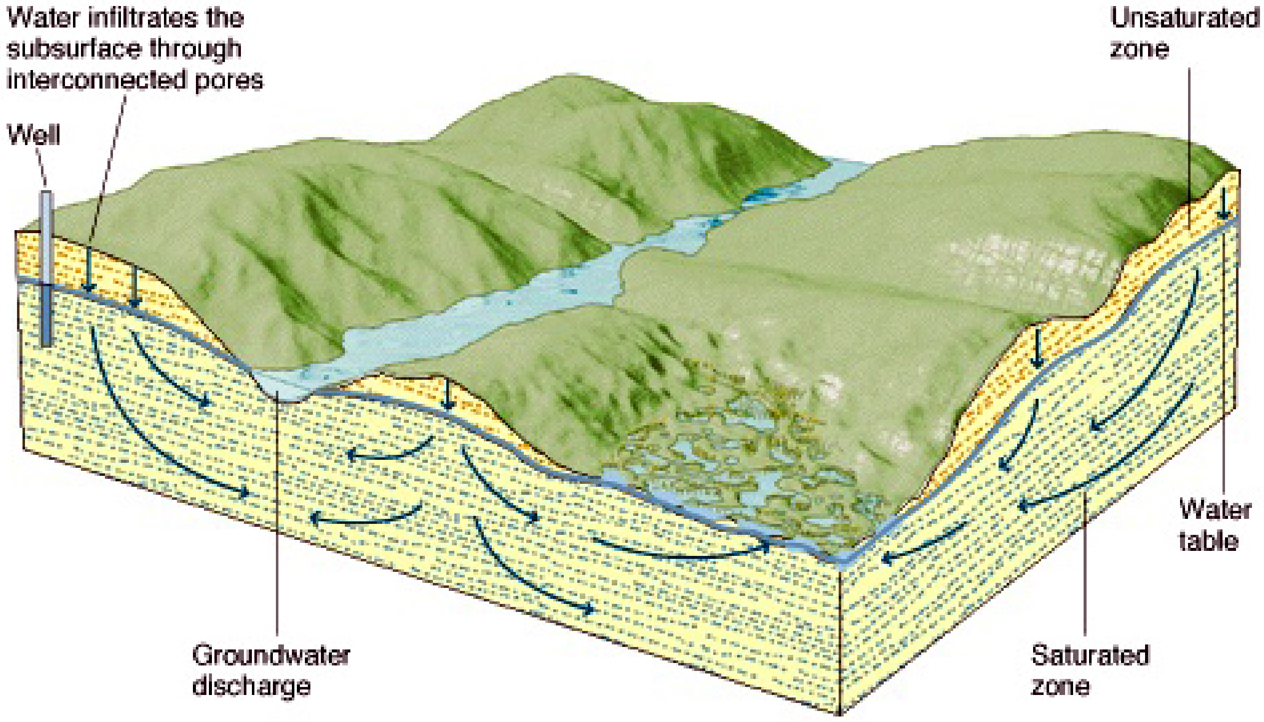
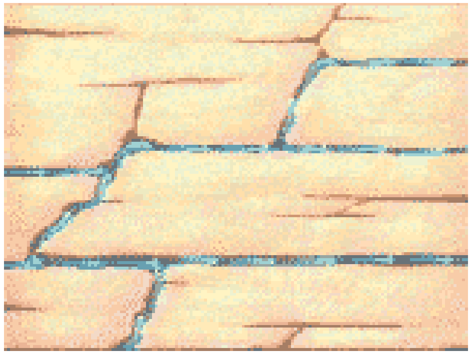
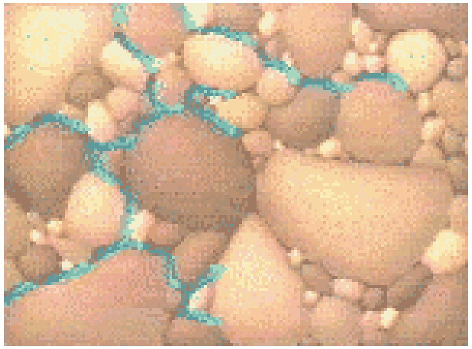
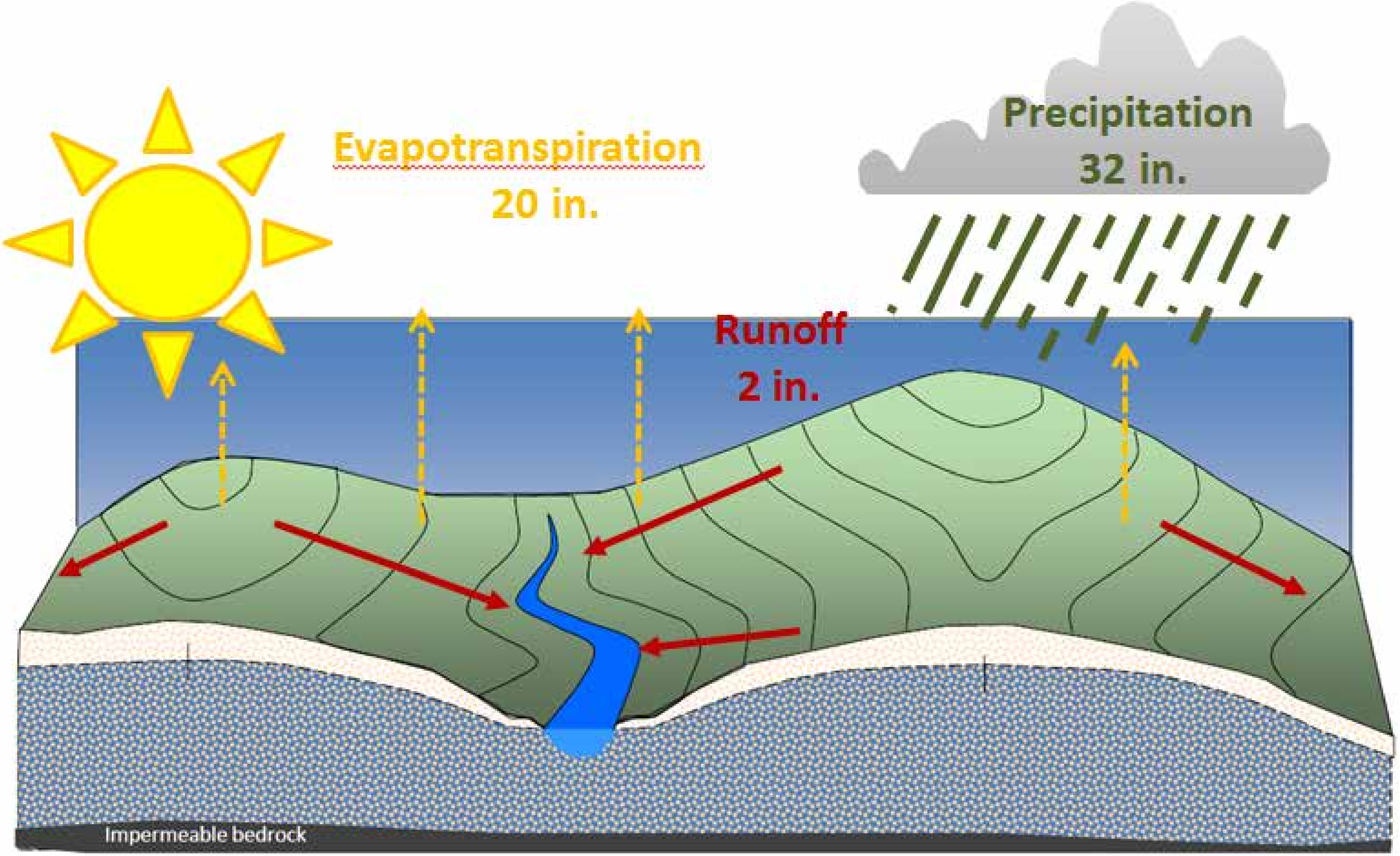
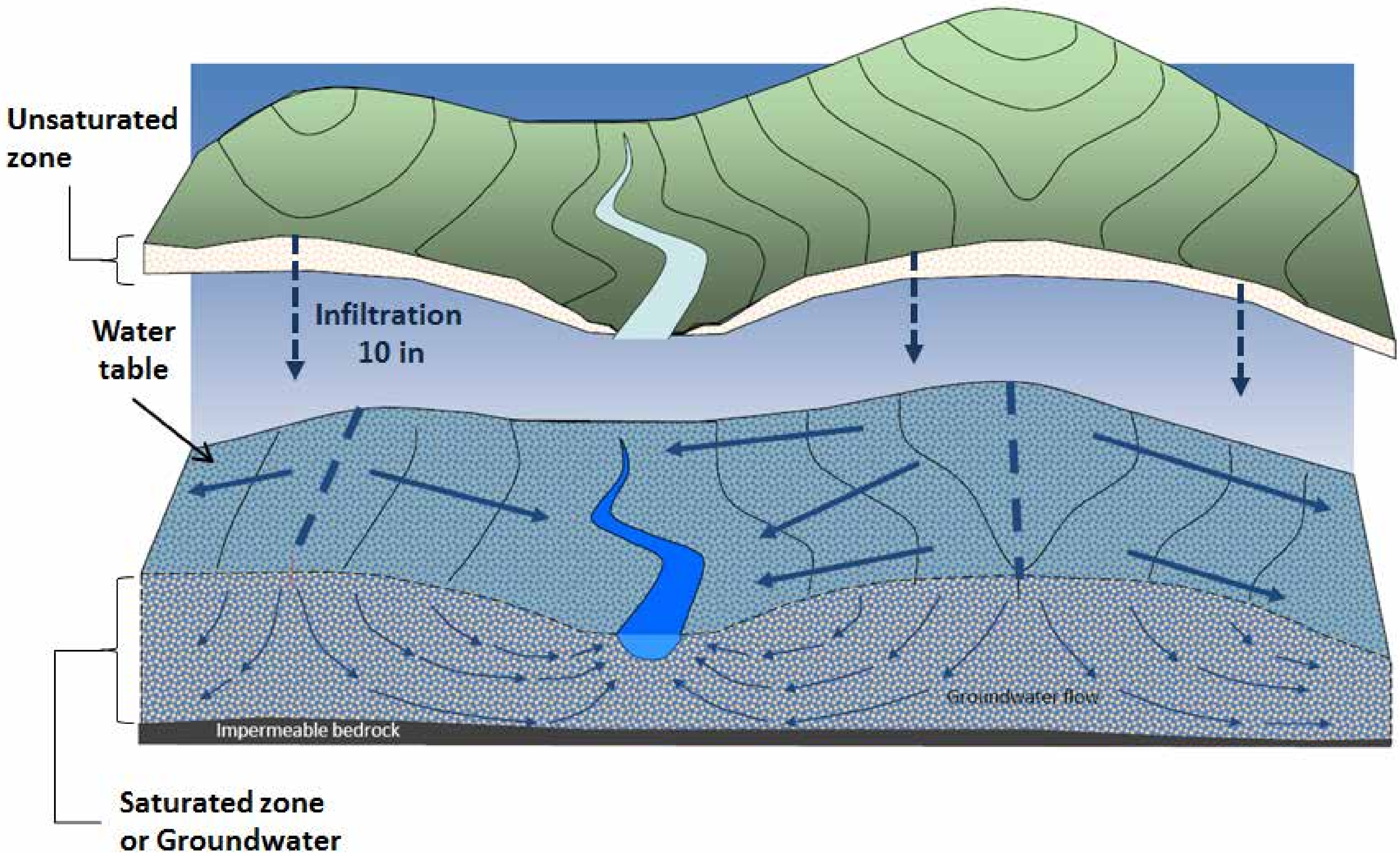
Groundwater Movement







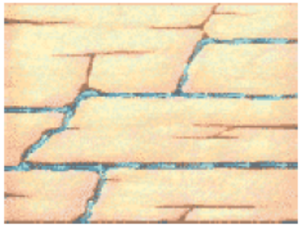

Evapotranspiration
20 in.
Precipitation
32 in.
Runoff
2 in.
Impermeable bedrock


Unsaturated zone
Water table
Infiltration 10 in
Groundwater flow
Impermeable bedrock
Saturated zone or Groundwater

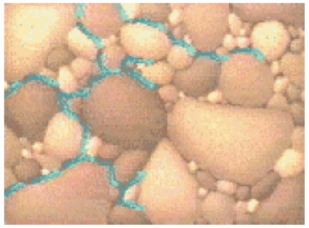
Aquifers: Our groundwater storage units

Aquifers are geologic formations that store and transmit groundwater.

The aquifer properties determine how quickly groundwater flows, how much water an aquifer can hold and how easily groundwater can become contaminated. Some aquifers may also contain naturally occurring elements that make water unsafe.



Water and contaminants can move quickly through cracks and fractures.



Water moving through tiny spaces in between sand particles or sandstone moves slower and allows for filtration of some contaminants.

Wisconsin's geology is like a layered cake. Underneath all of Wisconsin lies the Crystalline bedrock which does not hold much water. Think of this layer like the foundation of your house. All groundwater sits on top of this foundation. Groundwater is stored in the various **sandstone**, **dolomite** and **sand/gravel** aquifers above the **crystalline bedrock** layer. The layers are arranged in the order which they formed, oldest on the bottom and youngest on top.

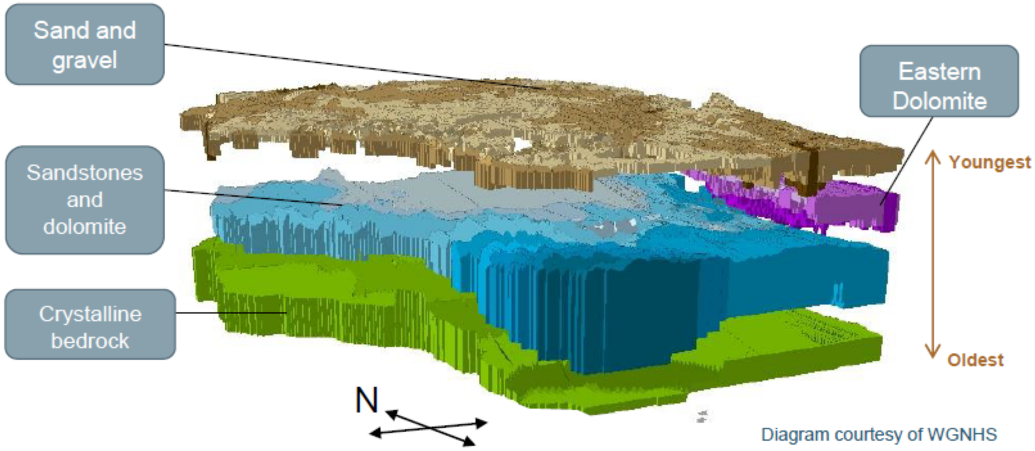


Diagram courtesy of WGNHS

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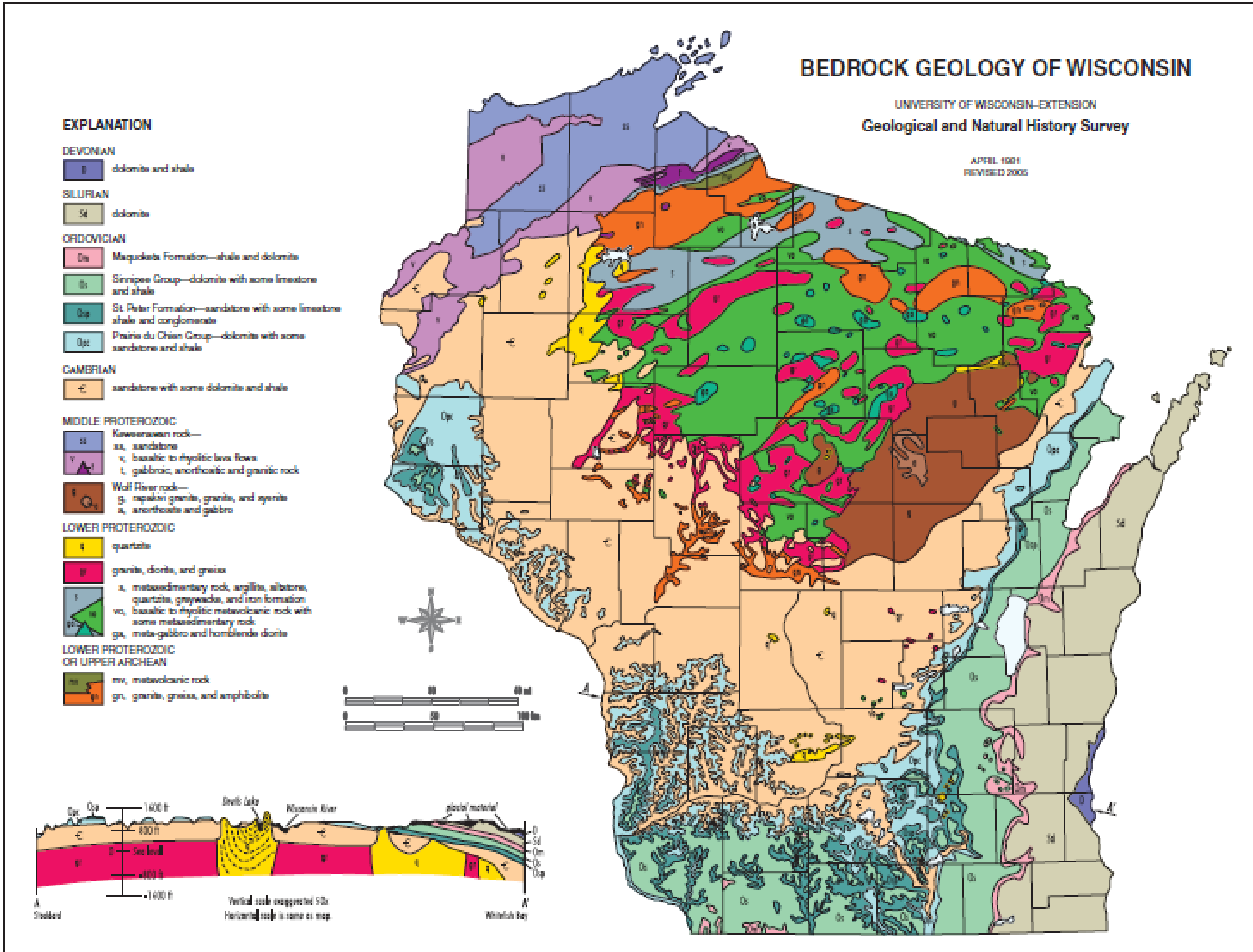
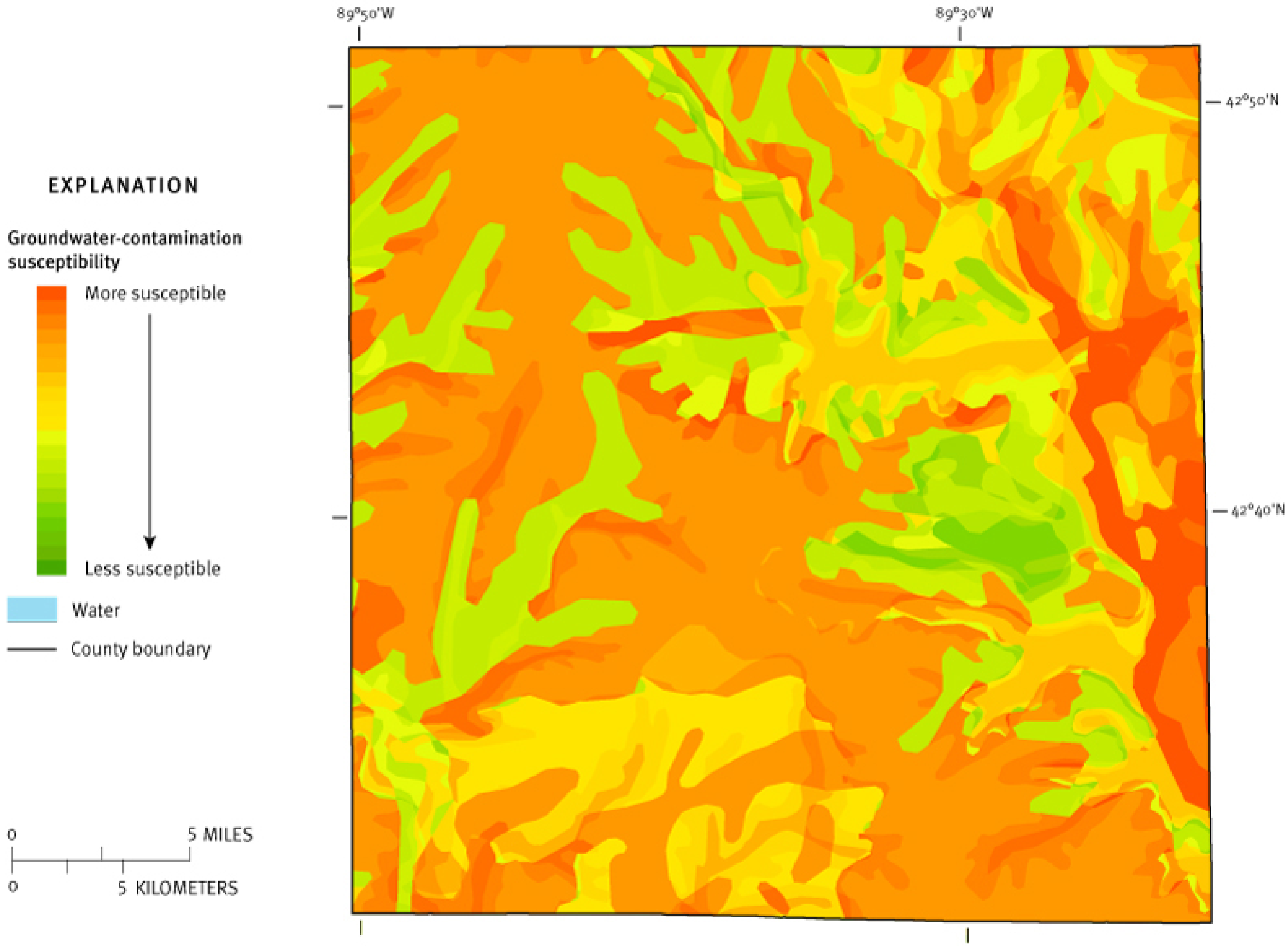

BEDROCK GEOLOGY OF WISCONSIN
UNIVERSITY OF WISCONSIN–EXTENSION
Geological and Natural History Survey
APRIL 1981
REVISED 2005
EXPLANATION
DEVONIAN
dolomite and shale
SILURIAN
dolomite
ORDOVICIAN
Maquoketa Formation—shale and dolomite
Sinnipee Group—dolomite with some limestone and shale
St. Peter Formation—sandstone with some limestone shale and conglomerate
Prairie du Chien Group—dolomite with some sandstone and shale
CAMBRIAN
sandstone with some dolomite and shale
MIDDLE PROTEROZOIC
Keweenawan rock—
ss, sandstone
v, basaltic to rhyolitic lava flows
t, gabbroic, anorthositic and granitic rock
Wolf River rock—
g, rapakivi granite, granite, and syenite
a, anorthosite and gabbro
LOWER PROTEROZOIC
quartzite
granite, diorite, and gneiss
s, metasedimentary rock, argillite, siltstone, quartzite, graywacke, and iron formation
vo, basaltic to rhyolitic metavolcanic rock with some metasedimentary rock
ga, meta-gabbro and hornblende diorite
LOWER PROTEROZOIC OR UPPER ARCHEAN
mv, metavolcanic rock
gn, granite, gneiss, and amphibolite
Devils Lake
Wisconsin River
glacial material
Sea level
1600 ft
800 ft
Vertical scale exaggerated 50x
Horizontal scale is same as map.
Whitefish Bay

Green County – Groundwater-Contamination Susceptibility Analysis

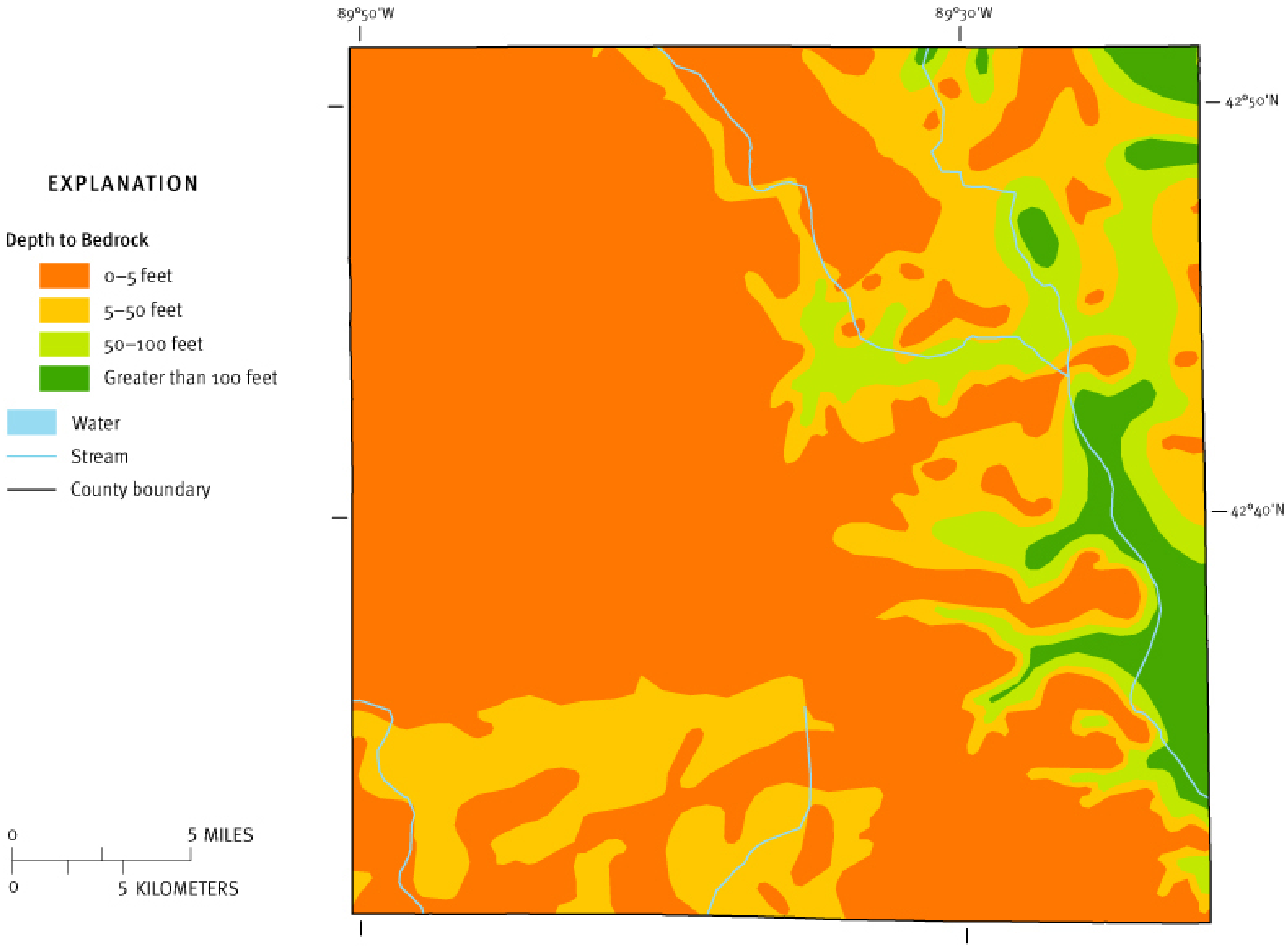


This groundwater-contamination susceptibility map is a composite of five resource characteristic maps, each of which was derived from generalized statewide information at small scales, and cannot be used for any site-specific purposes.

Map source: Schmidt, R.R., 1987, Groundwater contamination susceptibility map and evaluation: Wisconsin Department of Natural Resources, Wisconsin's Groundwater Management Plan Report 5, PUBL-WR-177-87, 27 p.

Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" web site, 2007, *http://wi.water.usgs.gov/gwcomp/*

Green County – Depth to Bedrock

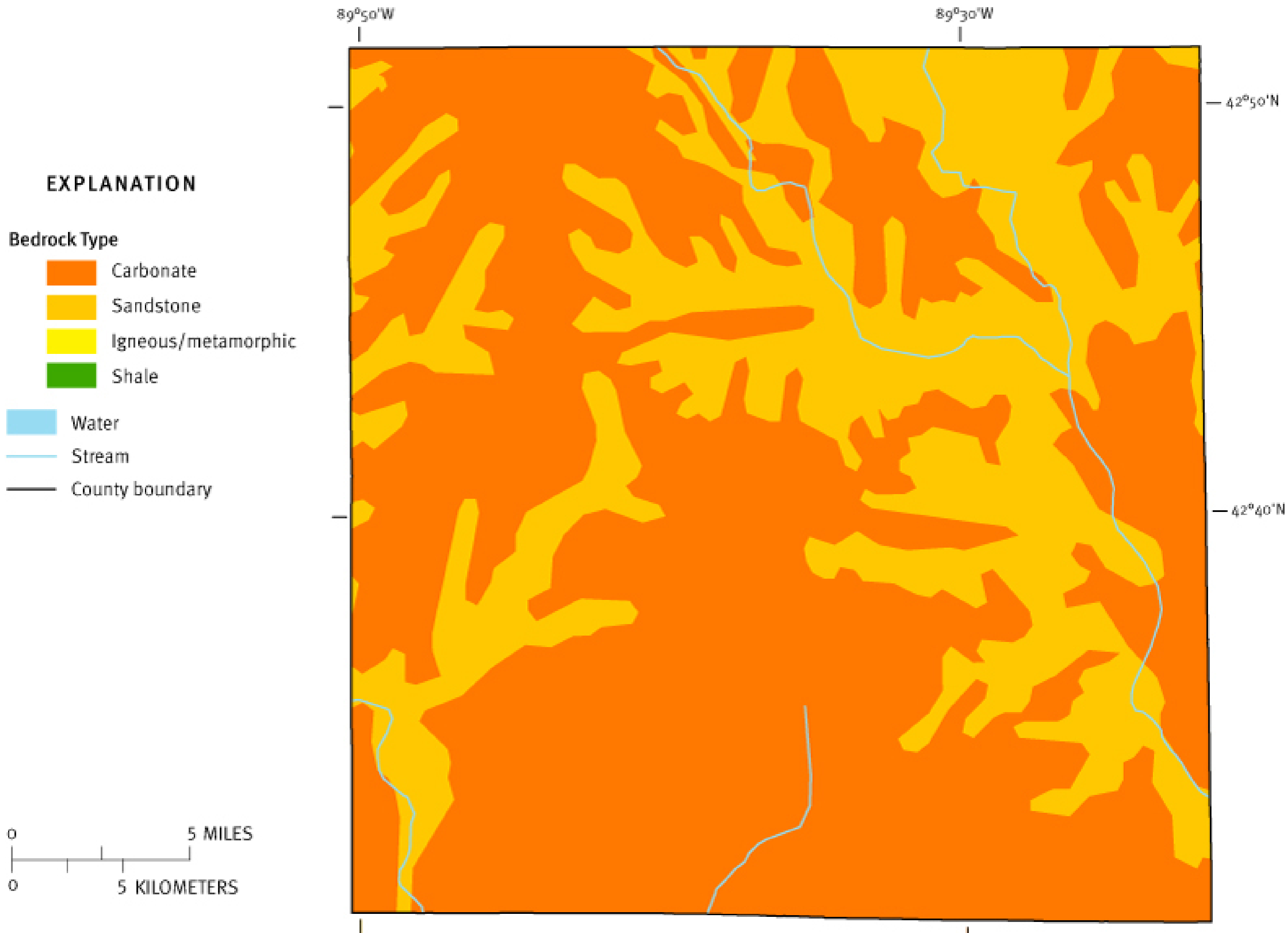


This resource characteristic map was derived from generalized statewide information at small scales, and cannot be used for any site-specific purposes.

Map source: Schmidt, R.R., 1987, Groundwater contamination susceptibility map and evaluation: Wisconsin Department of Natural Resources, Wisconsin's Groundwater Management Plan Report 5, PUBL-WR-177-87, 27 p.

Figure created for the "Protecting Wisconsin's Groundwater Through Comprehensive Planning" web site, 2007, *http://wi.water.usgs.gov/gwcomp/*

Green County – Bedrock Type



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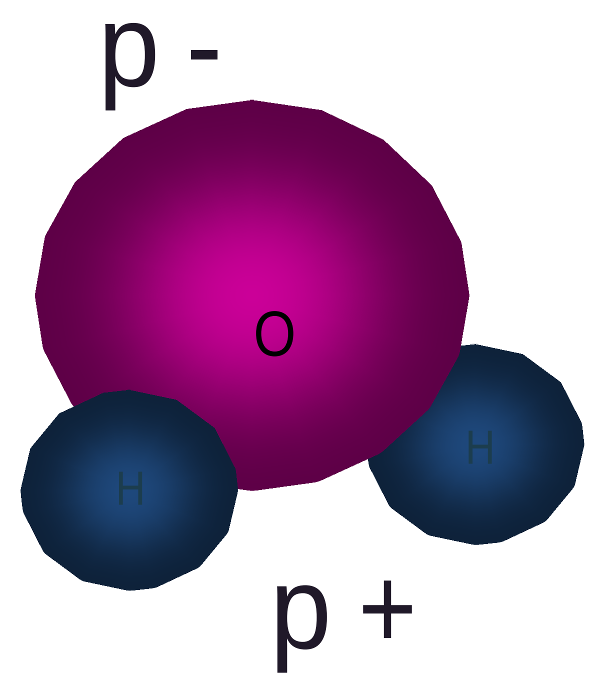
water quality basics

- "Universal Solvent"
- Naturally has "stuff" dissolved in it.
  - Impurities depend on rocks, minerals, land-use, plumbing, packaging, and other materials that water comes in contact with.
- Can also treat water to take "stuff" out



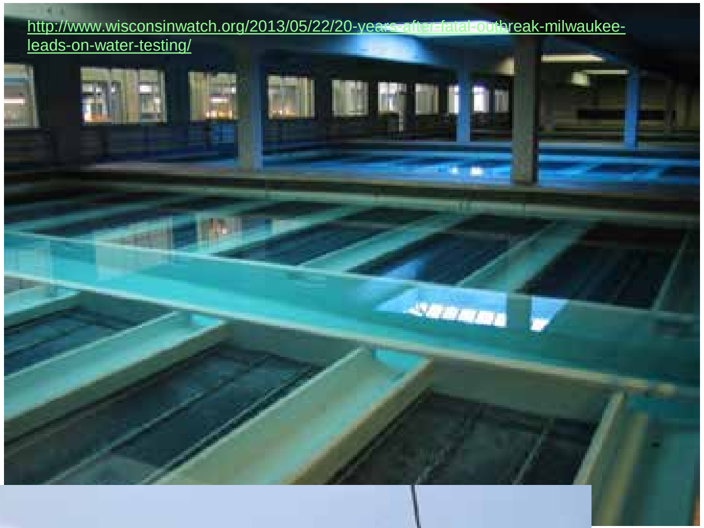
Public vs. Private Water Supplies

Public Water Supplies

- Regularly tested and regulated by drinking water standards.

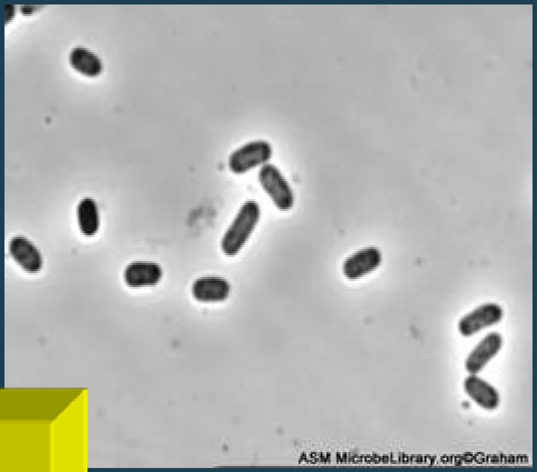
Private Wells

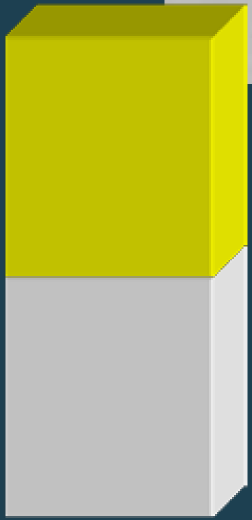
- Not required to be regularly tested.
- Not required to take corrective action
- Owners must take special precautions to ensure safe drinking water.



Coliform bacteria

- Generally do not cause illness, but indicate a pathway for potentially harmful microorganisms to enter your water supply.
  - Harmful bacteria and viruses can cause gastrointestinal disease, cholera, hepatitis
- Sanitary water supply should not contain any coliform bacteria
- Recommend using an alternative source of water until a test indicates your well is absent of coliform bacteria
- Sources:
  - Live in soils and on vegetation
  - Human and animal waste
  - Sampling error





Present =Unsafe

Absent = Safe

If coliform bacteria was detected, the sample is checked for E.coli

- Confirmation that bacteria originated from a human or animal fecal source.
- E. coli are often present with harmful bacteria, viruses and parasites that can cause serious gastrointestinal illnesses.
- Any detectable level of E.coli means your water is unsafe to drink.

Contaminants	Sources	Symptoms
BACTERIA		
Escherichia coliform (E. coli) *Salmonella* *Campylobacter* *E. coli 0157* (Requires a special water test for detection. Causes similar, but more serious illness than other E.coli strains. Requires medical treatment.)	• Infected human and animal feces • Manure • Septic systems • Sewage	• Gastrointestinal illness • Low-grade fever • Begins 12 hrs - 7 days after exposure
Leptosporidia	• Urine of livestock, dogs and wildlife • Manure	• High fever, severe headache and red eyes • Gastrointestinal illness • Begins 2-28 days after exposure
MICROSCOPIC PARASITES		
Cryptosporidia *Giardia*	• Infected human and animal feces • Manure • Septic systems • Sewage	• Gastrointestinal illness • Begins 2-14 days after exposure
VIRUSES		
Norovirus	• Infected human feces and vomit • Septic systems • Sewage	• Gastrointestinal illness • Low-grade fever & headache • Begins 12-48 hrs after exposure
CHEMICALS		
Nitrate	• Fertilizers • Manure • Bio-solids • Septic systems	Methemoglobinemia or "Blue Baby Syndrome" – No documented cases in Door County, but elevated nitrate levels in well water may indicate risk of contamination by additional pathogens.
Atrazine (trade-name herbicide for control of broadleaf and grassy weeds)	Estimated to be most heavily used herbicide in the U.S. in 1987/89, with its most extensive use for corn and soybeans in the Midwest, including WI. In 1993, it became a restricted-use herbicide nationally. U.S. EPA set a max. contaminant level (MCL) at 3 parts per billion for safe drinking water.	Short-term exposure above the MCL may cause: congestion of heart, lungs and kidneys; low blood pressure; muscle spasms; weight loss; damage to adrenal glands. Long-term exposure above MCL may cause: weight loss, cardio-vascular damage, retinal and some muscle degeneration; cancer.

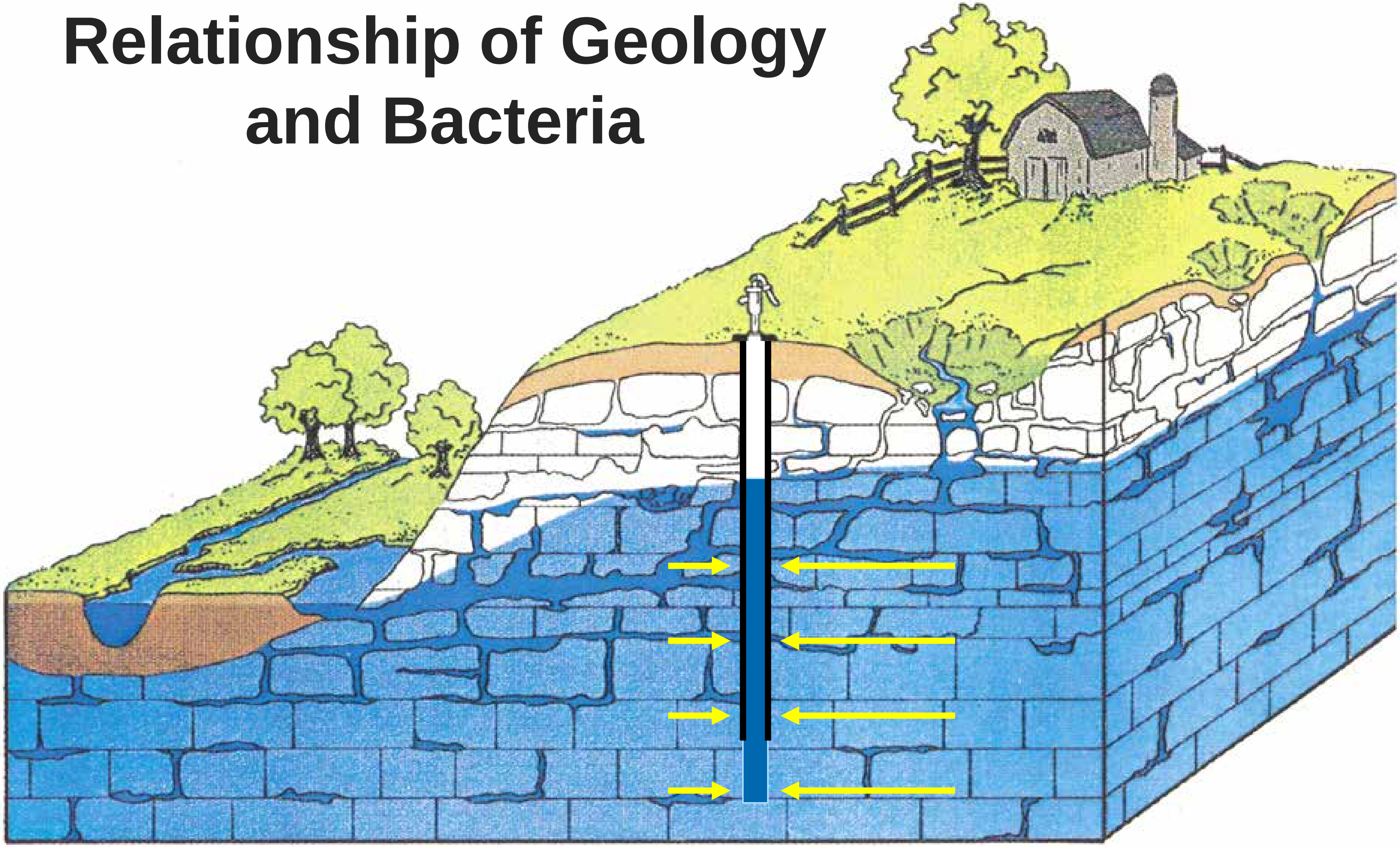
Information Sources: United States Department of Health and Human Services – Centers for Disease Control and Prevention (www.cdc.gov) and United States Environmental Protection Agency (www.epa.gov)

Well Construction

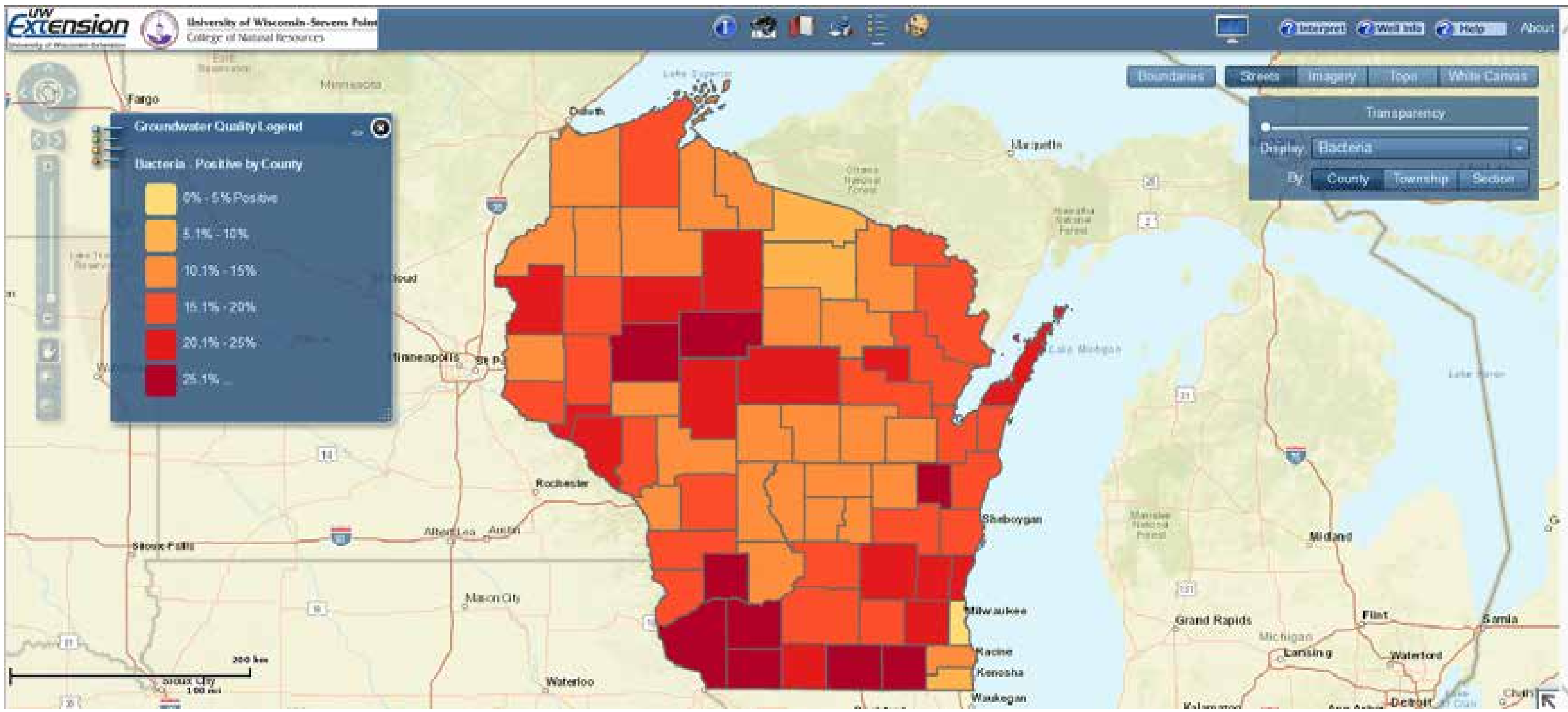
Photo: Sandy Heimke, WI DNR

Photos courtesy of: Matt Zoschke

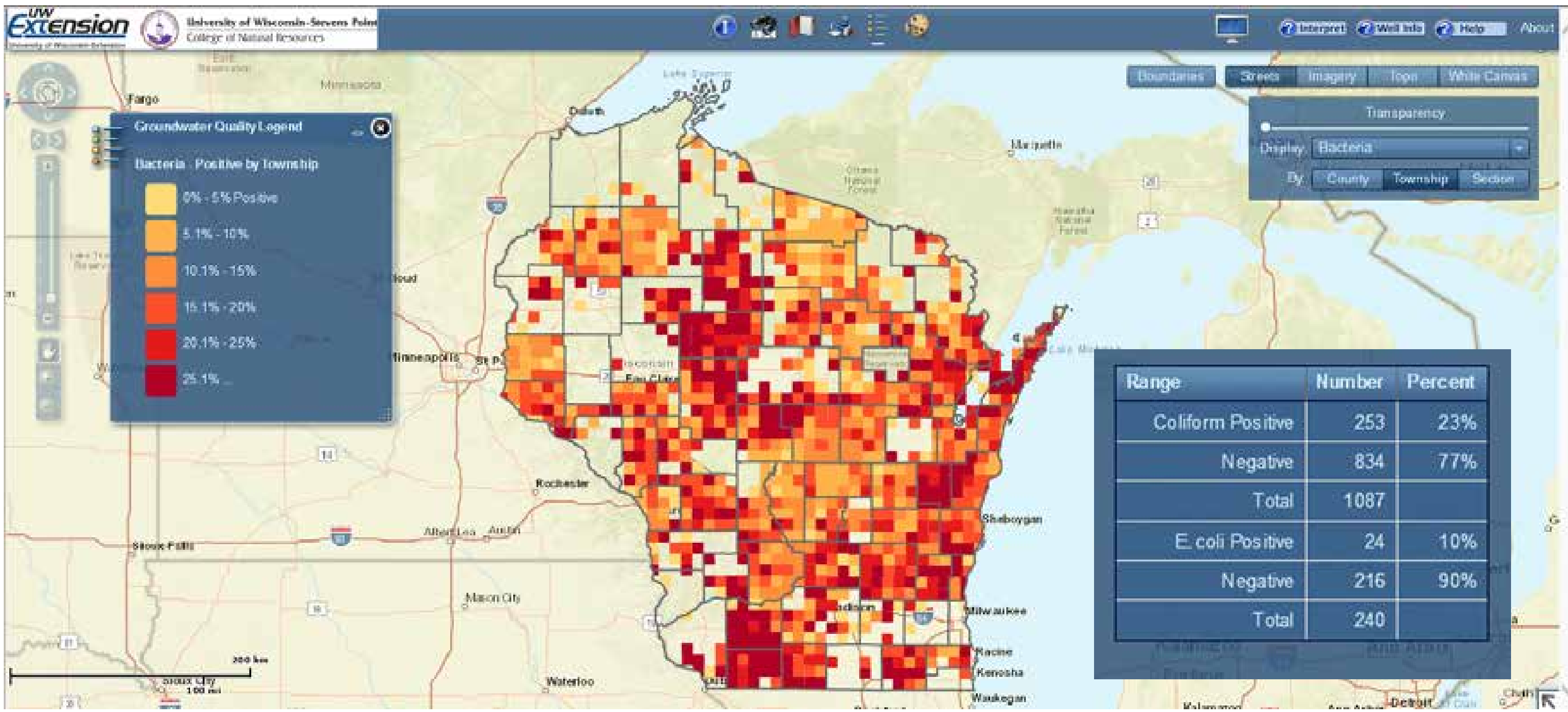
Relationship of Geology and Bacteria



Coliform Bacteria by County



Coliform Bacteria by County



Nitrate and Human Health

Infants and pregnant women
- Methemoglobinemia or “blue-baby syndrome”
- Possible correlation to central nervous system malformations

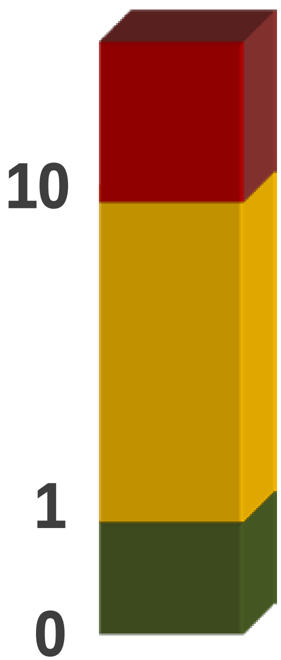
Adults
Possible correlations to:
- Non-Hodgkin’s lymphoma
- Various cancers (ex. gastric, bladder)
- Thyroid function
- Diabetes in children

*Many are statistical studies that provide correlation between nitrate and health problems
*Studies don’t always agree, but cannot say with certainty that nitrate poses no health risk.

Nitrate often indicator of other possible contaminants
(ex. other agricultural contaminants, septic effluent, etc.)

Wisconsin Groundwater Coordinating Council, 2015; Weyer, 1999

Nitrate in drinking water



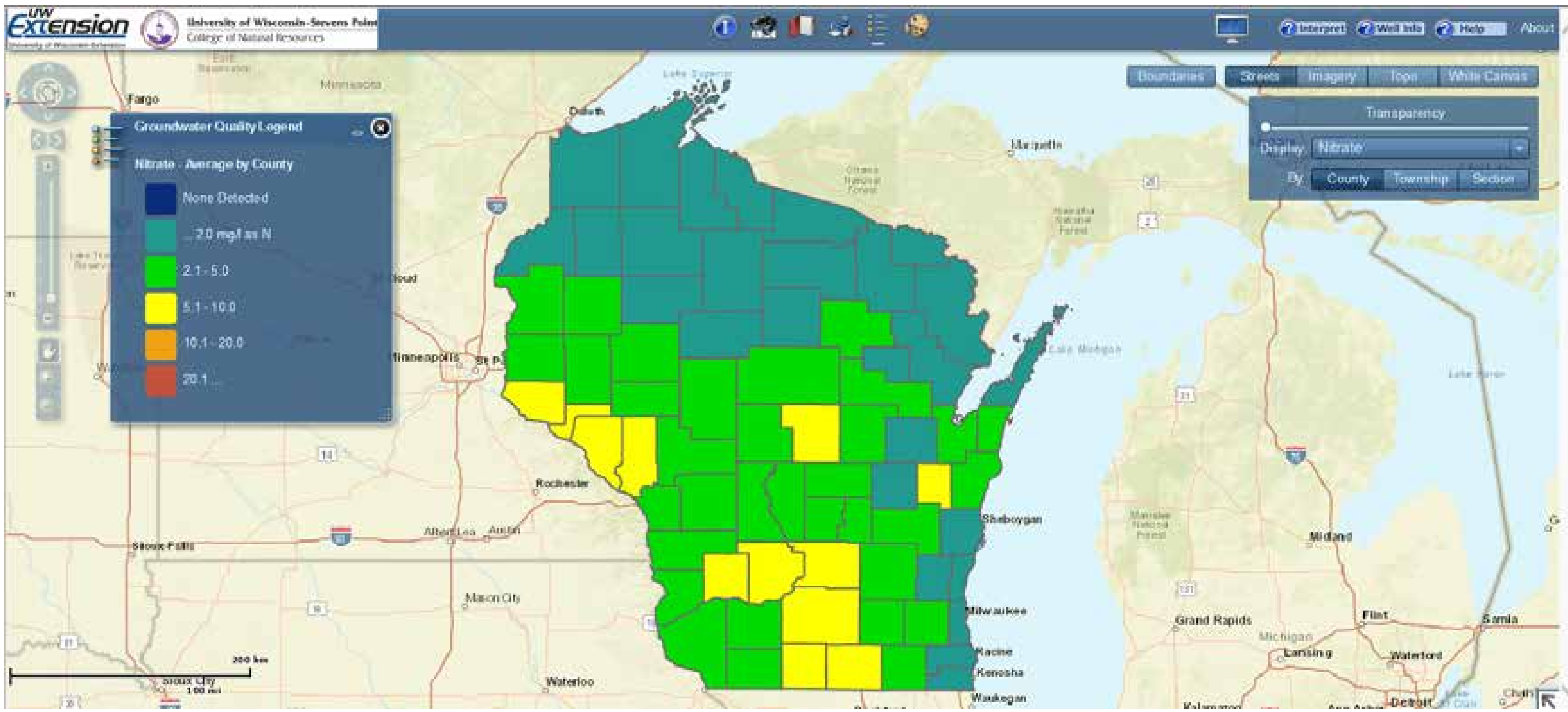
- **Greater than 10 mg/L**
  Impacted at a level that exceeds state and federal limits for drinking water

  - DO NOT give water to infants
  - DO NOT consume if you are a woman who is pregnant or trying to conceive
  - RECOMMEND everyone avoid long-term consumption

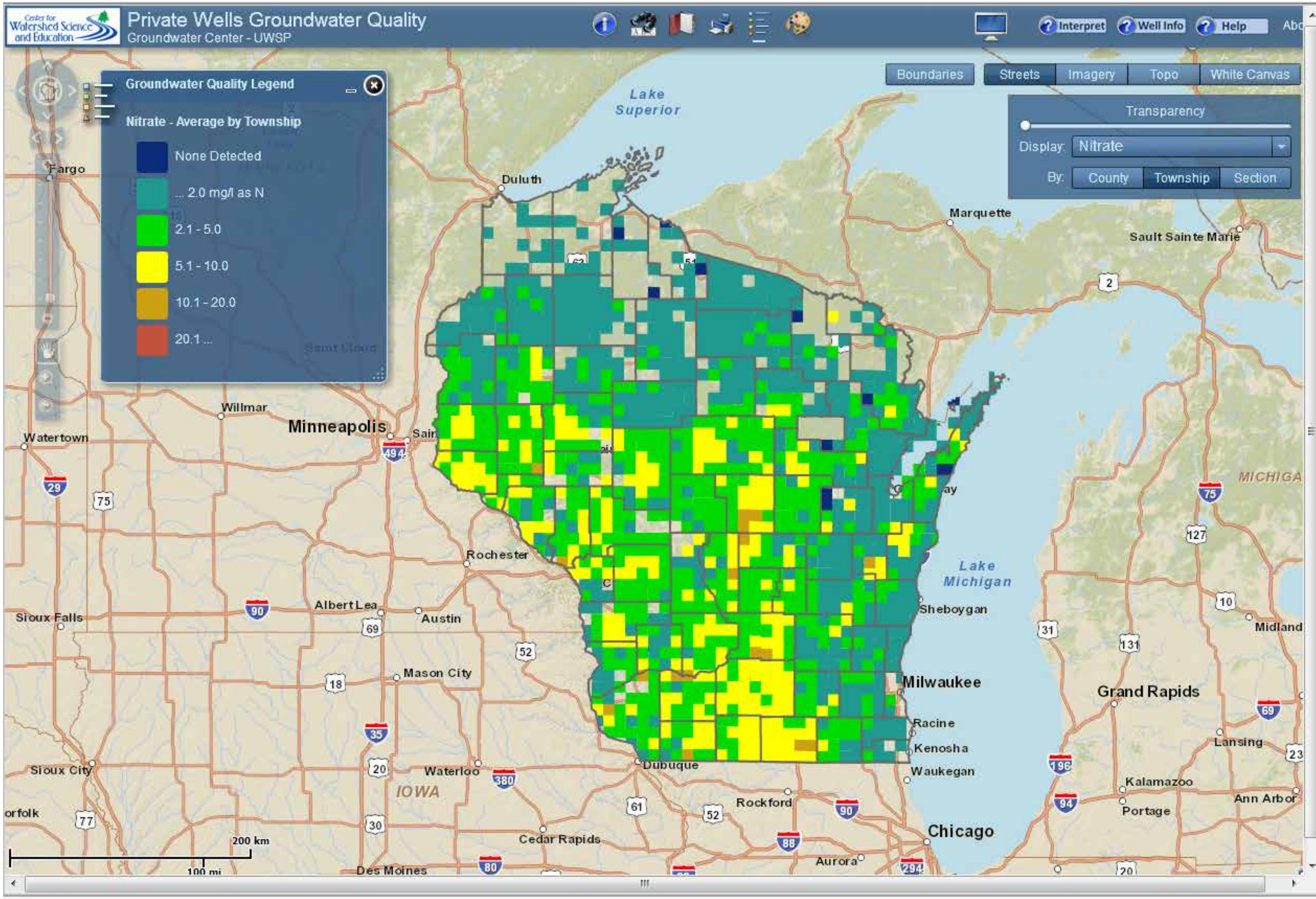
- **Between 1 and 10 mg/L**
  Evidence of land-use impacts
- **Less than 1 mg/L**
  Natural or background levels in WI groundwater

Considered suitable for drinking water

Nitrate-Nitrogen Average by County

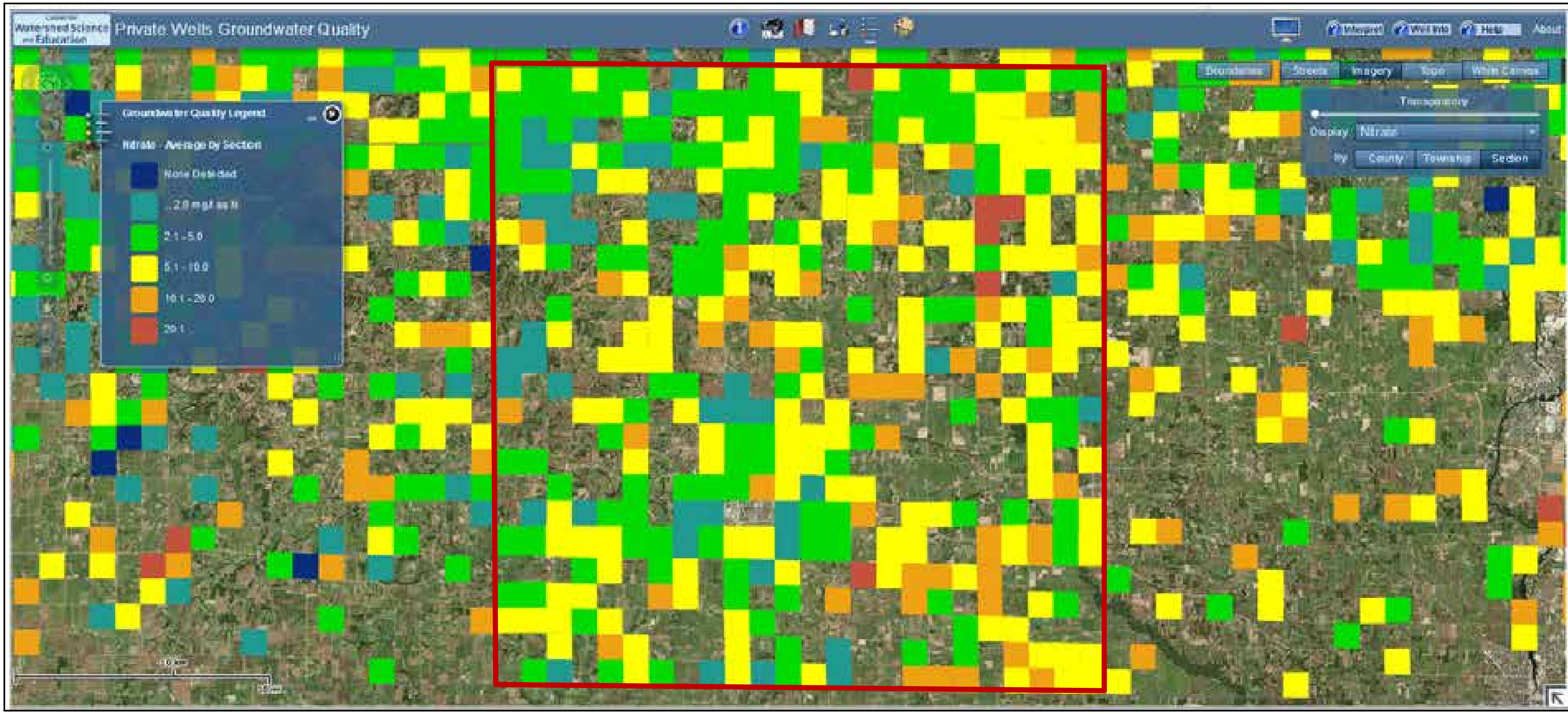


Nitrate-Nitrogen by Township-Range



http://www.uwsp.edu/cnr-ap/watershed/Pages/wellwaterviewer.aspx

Average Nitrate-N concentration by section.



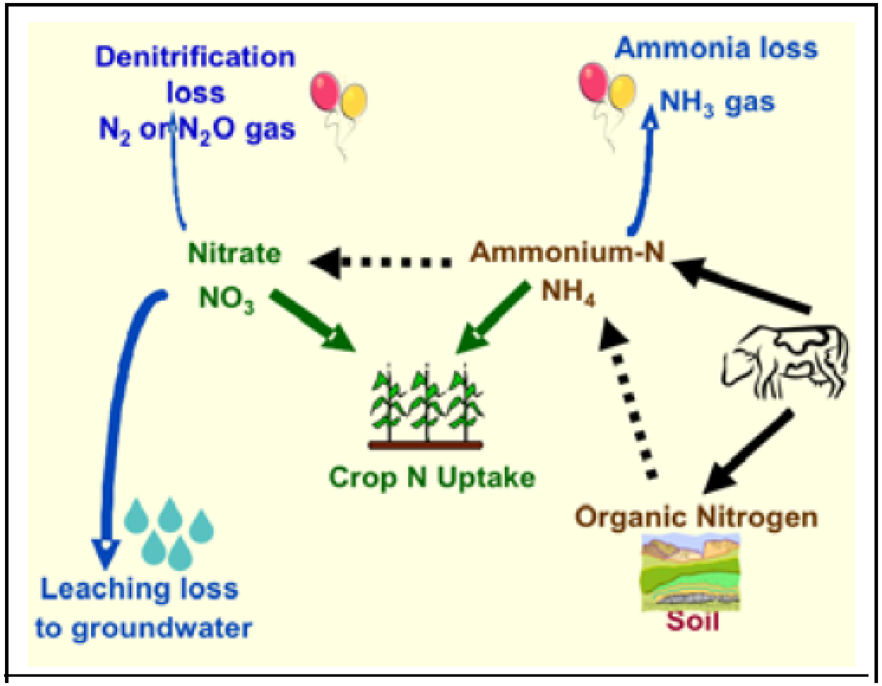
Range	Number	Percent	Summary
None Detected	194	7%	Minimum: No Detect
... 2.0	622	23%	
2.1 - 5.0	724	27%	Median: 4.1
5.1 - 10.0	694	26%	Average: 5.61288
10.1 - 20.0	364	14%	
20.1 ...	64	2%	Maximum: 69.9
Total	2662		
> 10mg/l N	428	16%	Exceeds Health Standard

http://www.uwsp.edu/cnr-ap/watershed/Pages/wellwaterviewer.aspx

Green County
Nitrate Summary

Nitrogen Cycle

"Nitrogen is neither created nor destroyed"



http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20528/em8954-e.pdf

The Environment and N Loss from Manures—Why Do We Care?

Plant-available N (PAN) losses from the soil represent lost fertilizer value. Nitrogen can be lost as ammonia, nitrate, or nitrous oxides (Figure 1, page 3). Besides losing a valuable resource, the lost PAN can contribute to off-site problems.

Ammonia lost to the atmosphere is an air pollution problem in some areas of the western U.S., particularly in winter when atmospheric inversions prevent air mixing. In the atmosphere, ammonia can react with dust and other compounds to reduce visibility and to acidify rain or fog. Ammonia emissions may contribute to:

- Human health problems (inhalation hazard)
- Changes in natural plant communities in forests and rangeland. (Nitrogen deposited in N-poor ecosystems can alter the balance between adapted species and N-loving invasive species.)
- Acid fog or rain damage to limestone buildings or cultural artifacts (for example, petroglyphs on limestone)
- Reduction in visibility (haze)

Nitrate moves with soil water. Nitrate lost from soil enriches groundwater or surface water and can contribute to:

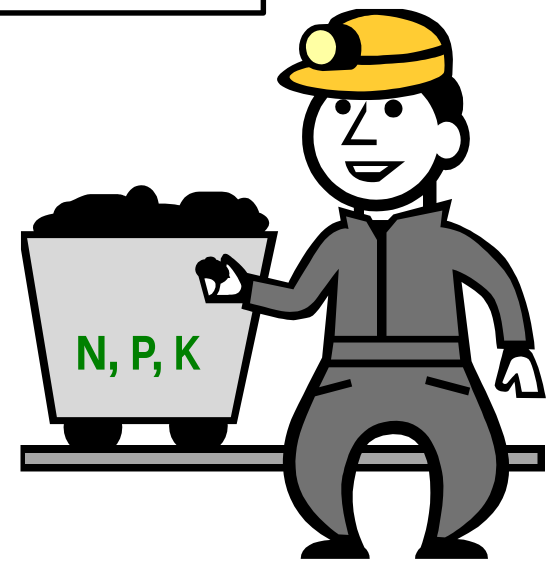
- Human health problems (blue baby syndrome, elevated cancer risk)
- Algae blooms in lakes or other slow-moving bodies of water
- Reduced survival and reproduction of some amphibians

Nitrous oxides lost to the atmosphere through denitrification can contribute to:

- Human health problems (inhalation hazard)
- Global warming (A molecule of nitrous oxide (N_2O) traps approximately 300 times more heat than a molecule of carbon dioxide.)
- Increased N deposits in sensitive ecosystems, resulting in soil acidification or change in plant communities
- Reduction in visibility (haze)

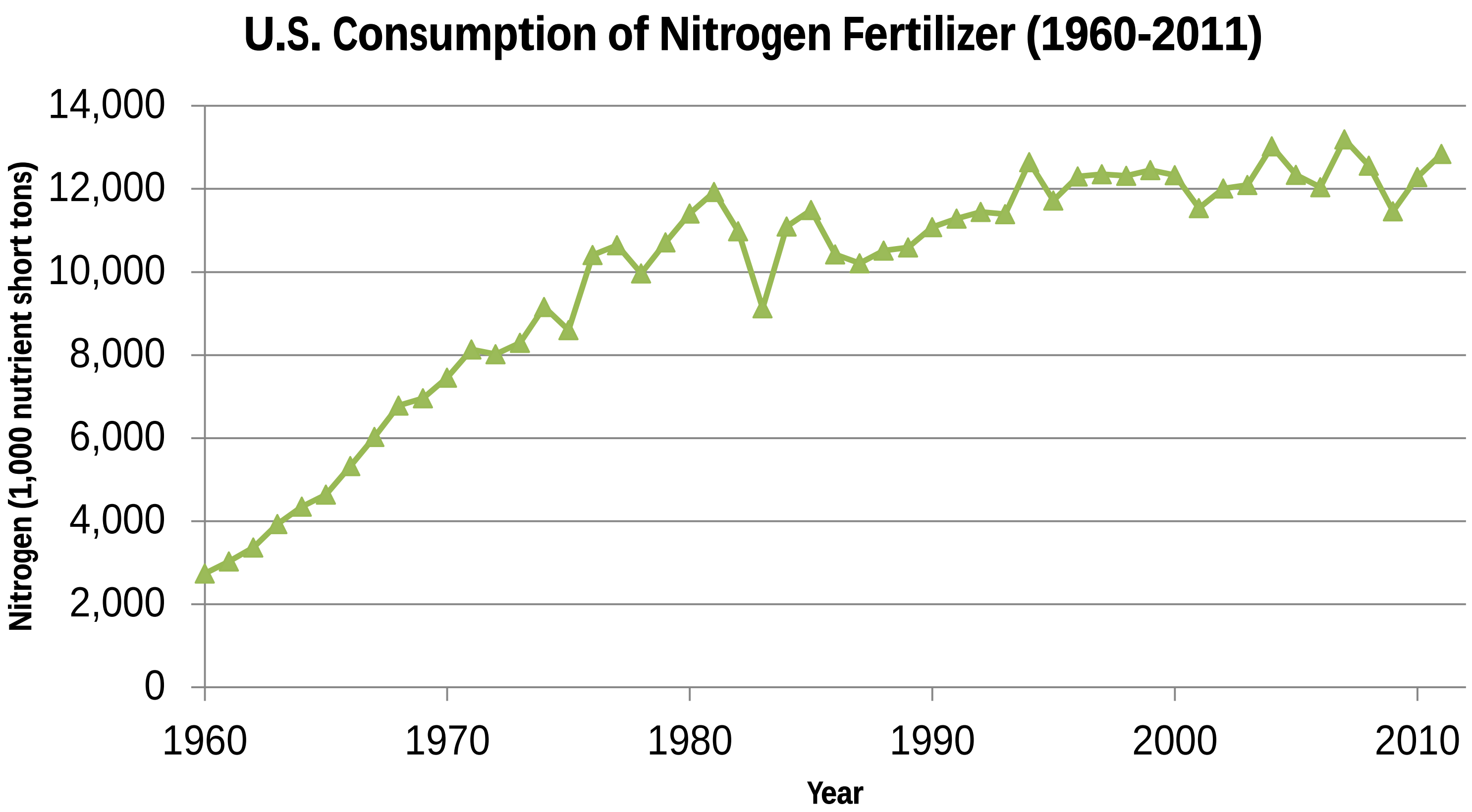
Nitrogen is vital to agriculture

7
N
14.01
Nitrogen



- Ancient civilizations farmed fertile flood plains
- Animal manures
- Crop rotations w/legumes
- Prairies and other organic rich soils
- Industrial fixation of N leads to commercial fertilizer and dramatic increase in N applications
- Manure management challenging

Historical Nitrogen Use



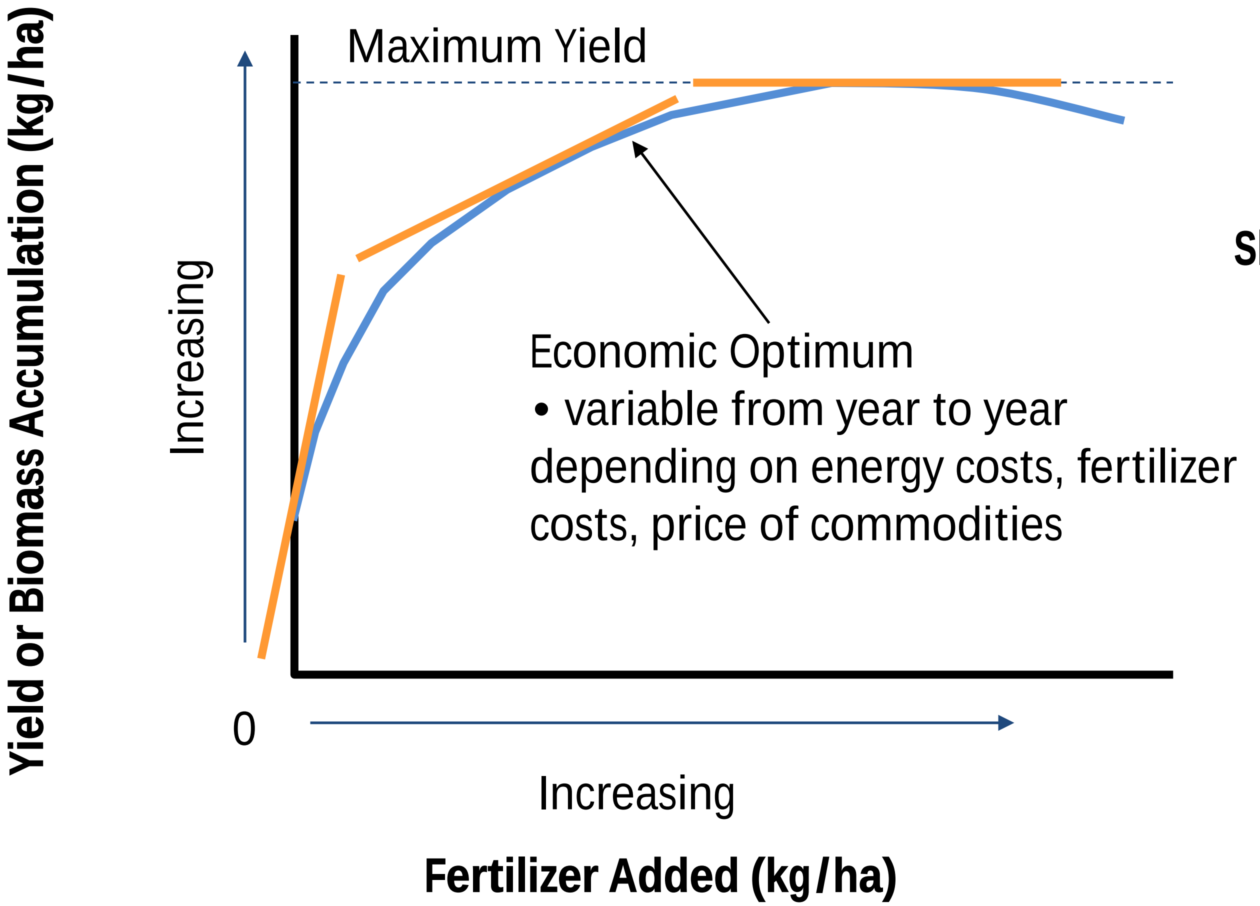
USDA Fertilizer Use and Price, 2013
http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx

Less

More

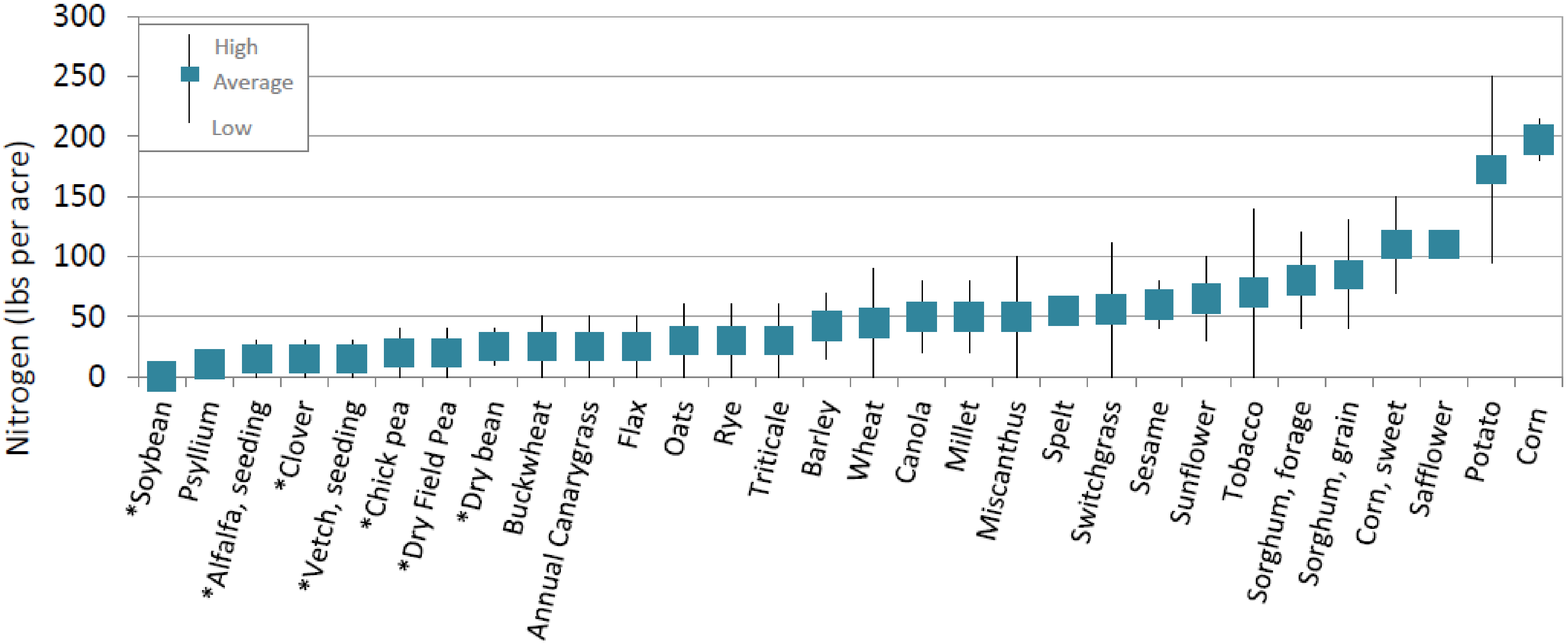
Nitrogen Fertilizer Added (lb/acre)

Yield response to nitrogen



Slope = $\frac{\textbf{Added Yield}}{\textbf{Fertilizer Unit}}$

Nitrogen fertilizer recommendations for common crops



* Legumes have symbiotic relationship with N fixing bacteria

Alternative Field Crops Manual, 1989. University of Minnesota and University of Wisconsin -Madison

Nutrient application guidelines for field, vegetable and fruit crops in Wisconsin. A2809. 2012. University of Wisconsin-Madison

Miscanthus and switchgrass recommendations: Anderson et al., 2013; McIsaac et al., 2010; Vogel et al., 2002; Arundale et al, 2014

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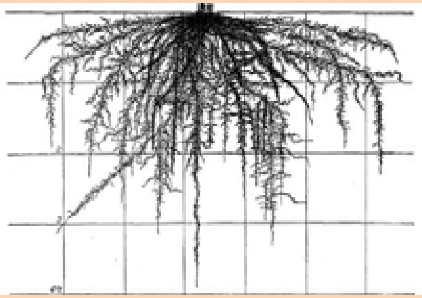
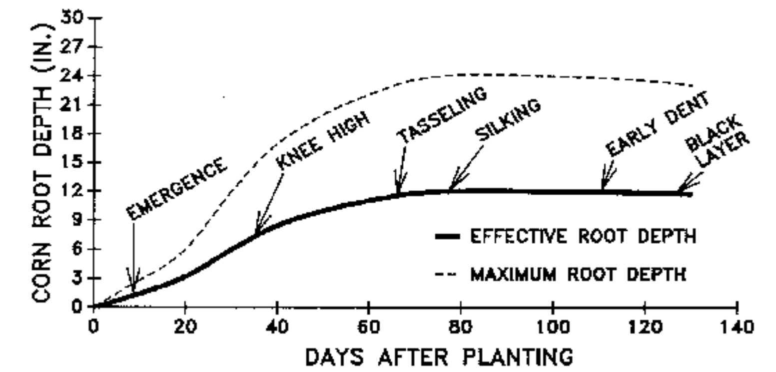
Comparing Corn to Perennial Ecosystems

Nitrogen fertilizer use efficiency for Midwestern corn systems
37%
(Cassman et. al. 2002)

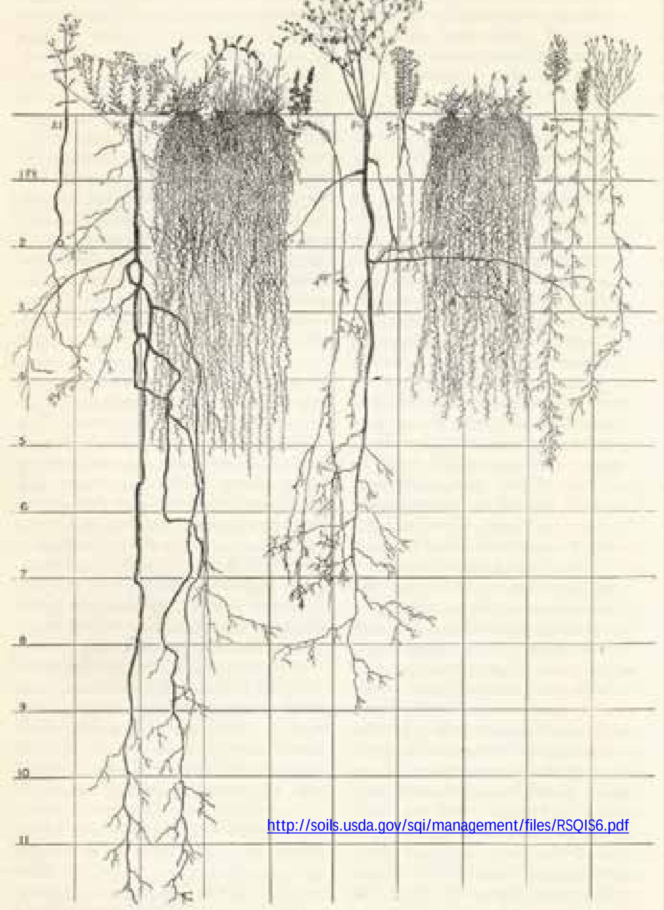


http://www.soilandhealth.org/01aglibrary/010137veg.roots/010137ch2.html



http://www.bae.ncsu.edu/programs/extension/evans/ag452-1.html

Mixed Native Perennial



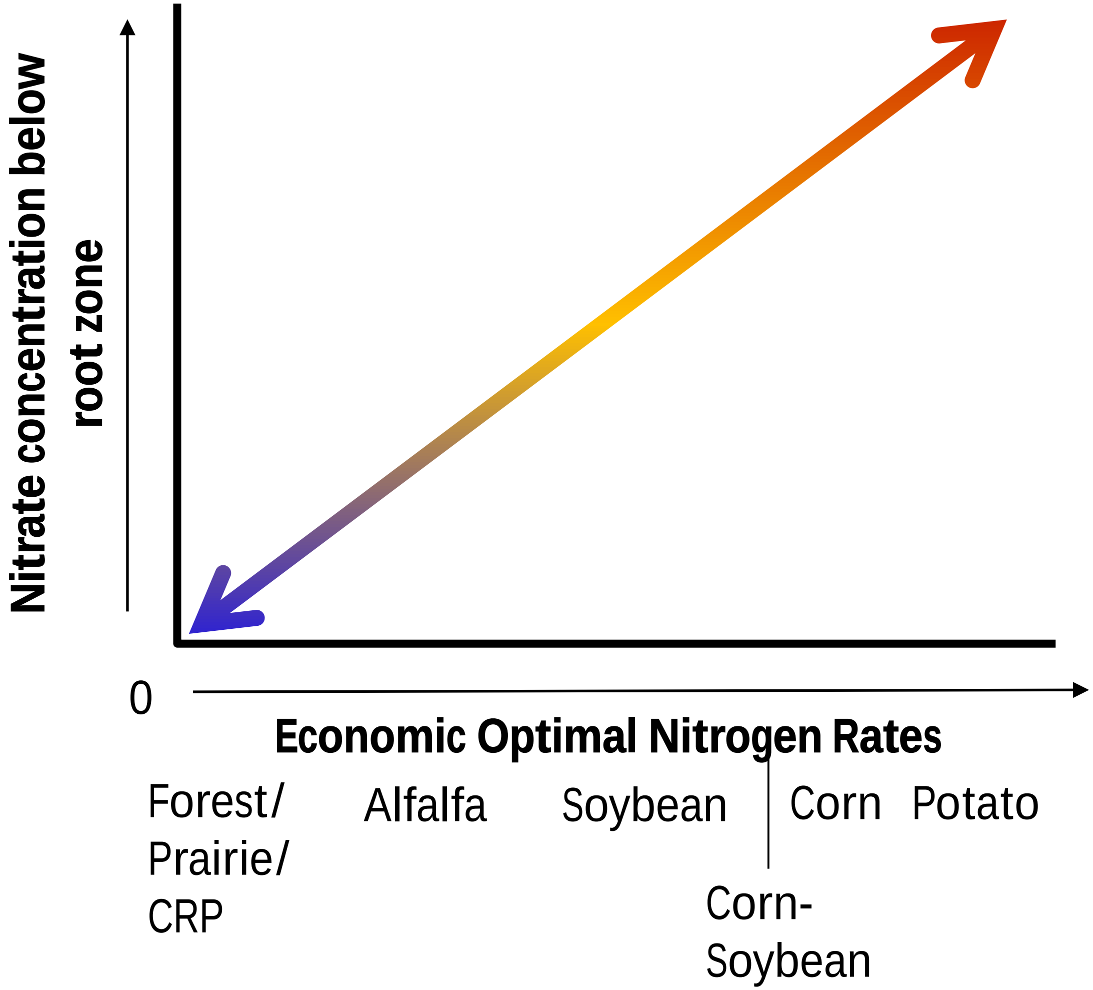
http://soils.usda.gov/sqi/management/files/RSQIS6.pdf

Effect of cropping systems on nitrate leaching loss in the Midwest

	Cropping systems	N Inputs	Nitrate-N Leaching	Water Drainage	Data Source
		kg N ha^{-1} yr^{-1}	kg N ha^{-1} yr^{-1}	mm yr^{-1}	
Annual	Corn-Corn	138	55	193	Randall et al., 1997 (1)
		180	37	399	Masarik et al., 2014 (2)
		151-221	17-32	63-187	Thomas et al., 2014 (3)
		202	63	590	Weed and Kanwar, 1996 (4)
		202	43	280	Randall and Iragavarapu, 1995 (5)
	Corn-Soybean	136-0	51	226	Randall et al., 1997 (1)
		168-0	34-46	ND	McIsaac et al., 2010 (6)
		168-0	34	470	Weed and Kanwar, 1996 (4)
		171-0	10-35	ND	Cambardella et al., 2015 (7)
Mixed	C-S-O/A-A	171-0-57-0	8-18	ND	Cambardella et al., 2015 (7)
Perennial	Alfalfa	0	2	104	Randall et al., 1997 (1)
	CRP	0	1	160	Randall et al., 1997 (1)
	Switchgrass	0	<1-4	ND	McIsaac et al., 2010 (6)
		112	2-11	52-156	Thomas et al., 2014 (3)
	Miscanthus	0	2-7	ND	McIsaac et al., 2010 (6)
		112	<1-1	52-147	Thomas et al., 2014 (3)
	Prairie	0	<1	122	Masarik, et al., 2014 (2)
	Pasture	0	1-10	ND	Cambardella et al., 2015 (7)

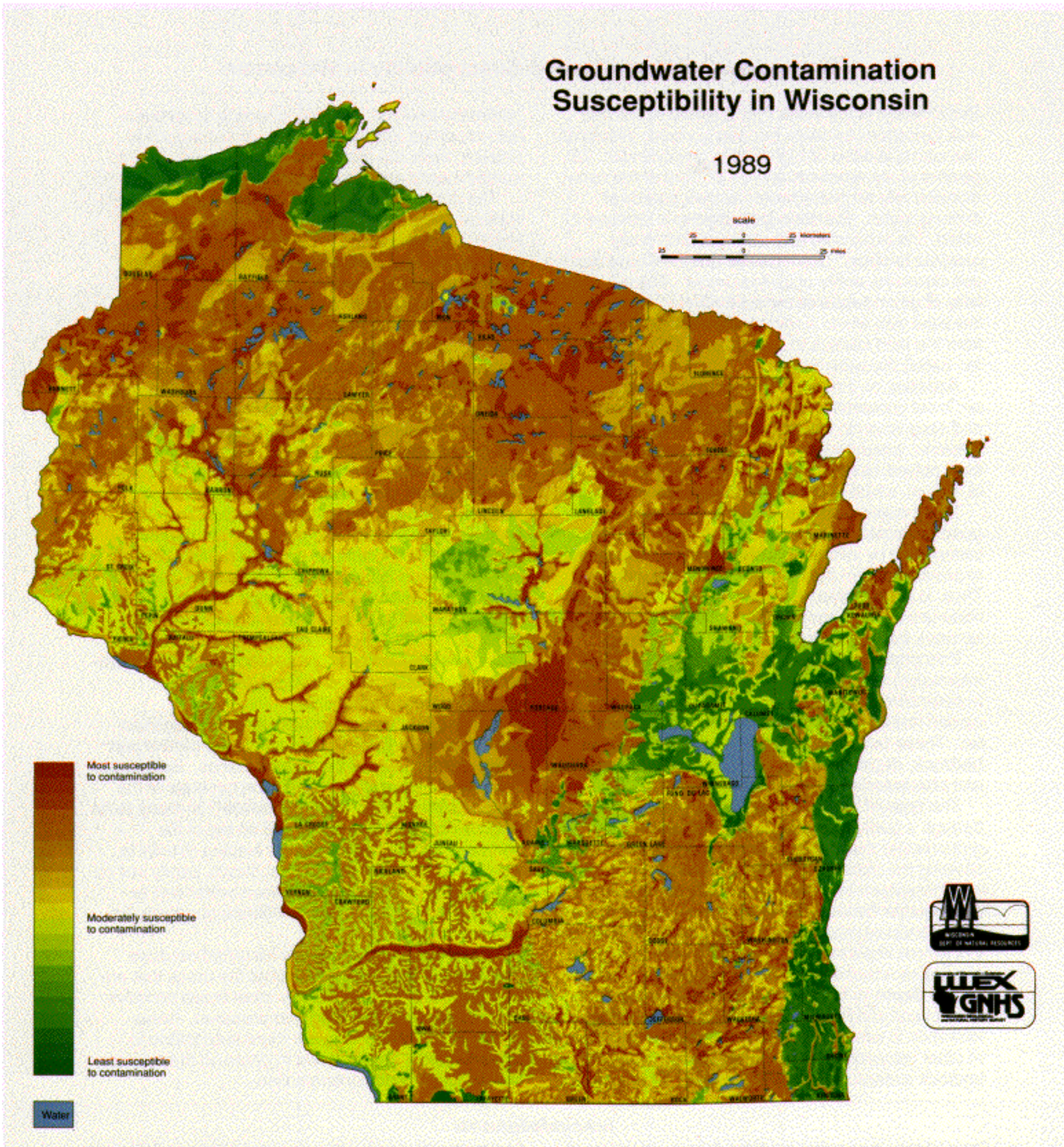
**16 -37X greater nitrate loss below continual corn cropping systems compared to perennial systems*

Nitrate Leaching Potential



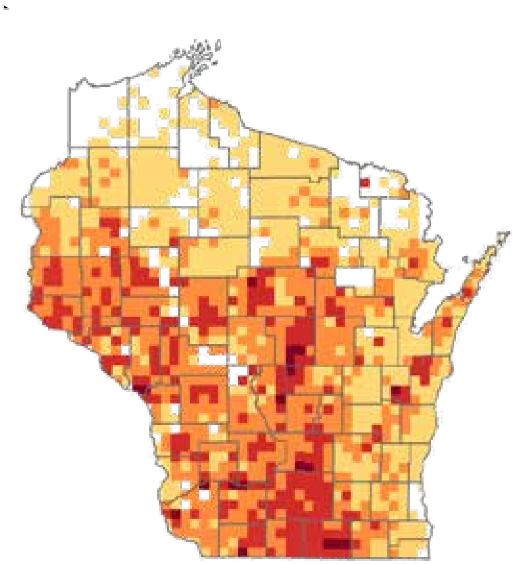
Masarik, UW-Extension

Groundwater Susceptibility



The GCSM was developed by the DNR, the US Geological Survey (USGS), the Wisconsin Geological & Natural History Survey (WGNHS), and the University of Wisconsin – Madison in the mid-1980s.

Coarse textured surficial deposits



Map created using: Groundwater Contamination Susceptibility Model (GCSM); Surficial Deposits ("sdppw95c")

The GCSM was developed by the DNR, the US Geological Survey (USGS), the Wisconsin Geological & Natural History Survey (WGNHS), and the University of Wisconsin – Madison in the mid-1980s.

Shallow carbonate rock aquifers

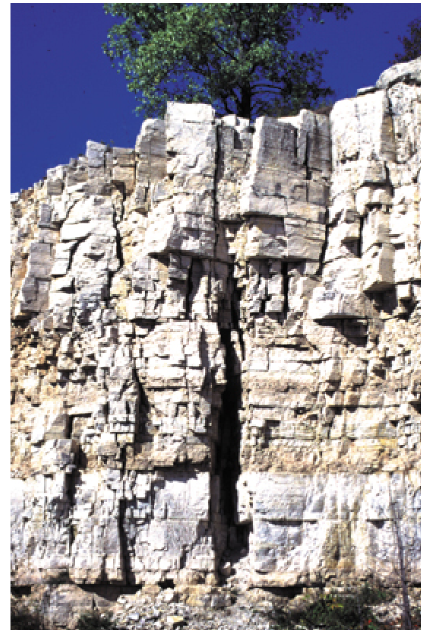
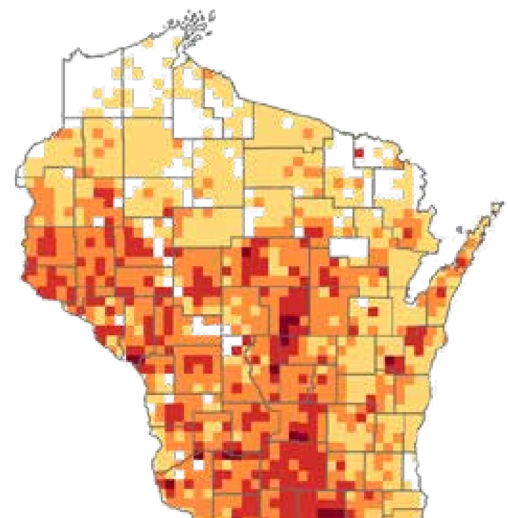
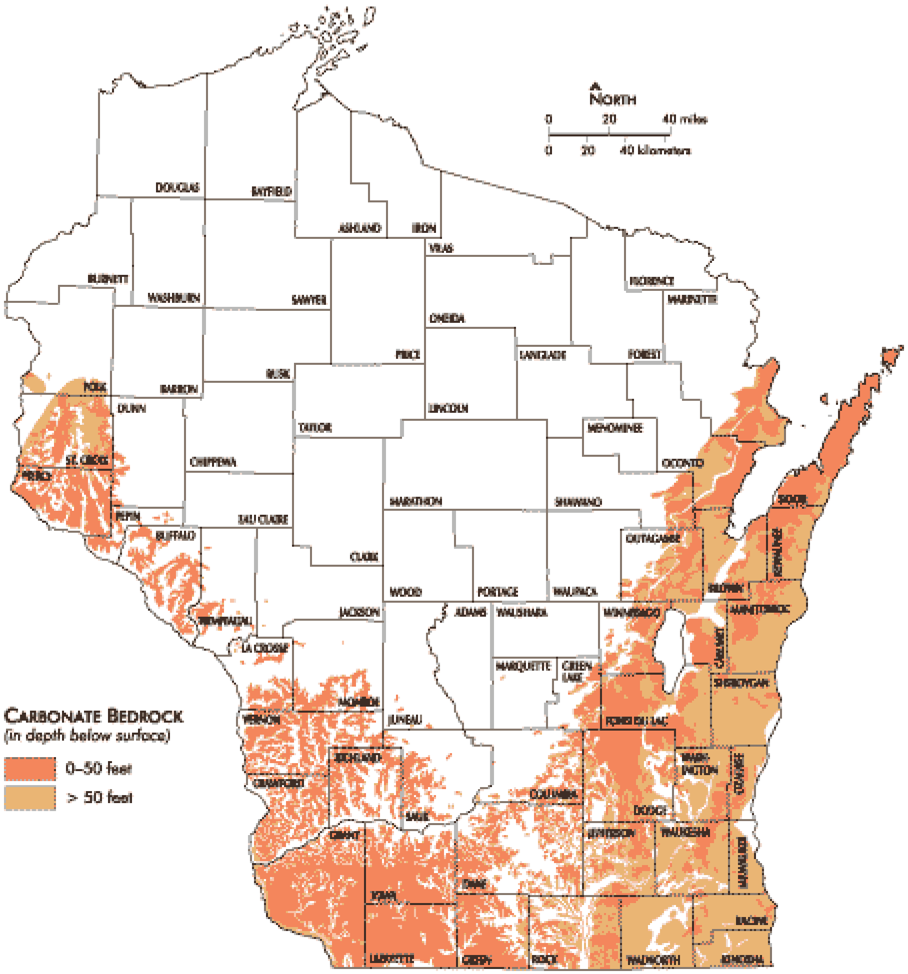
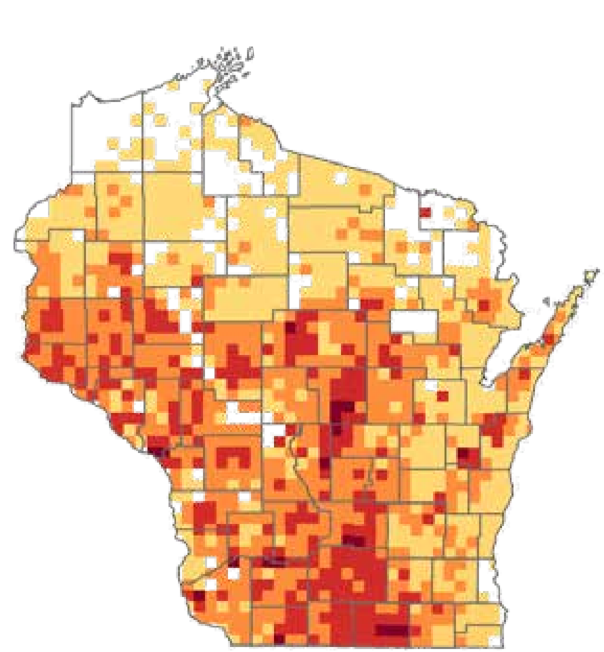


Photo credits: Ken Bradbury, WGNHS

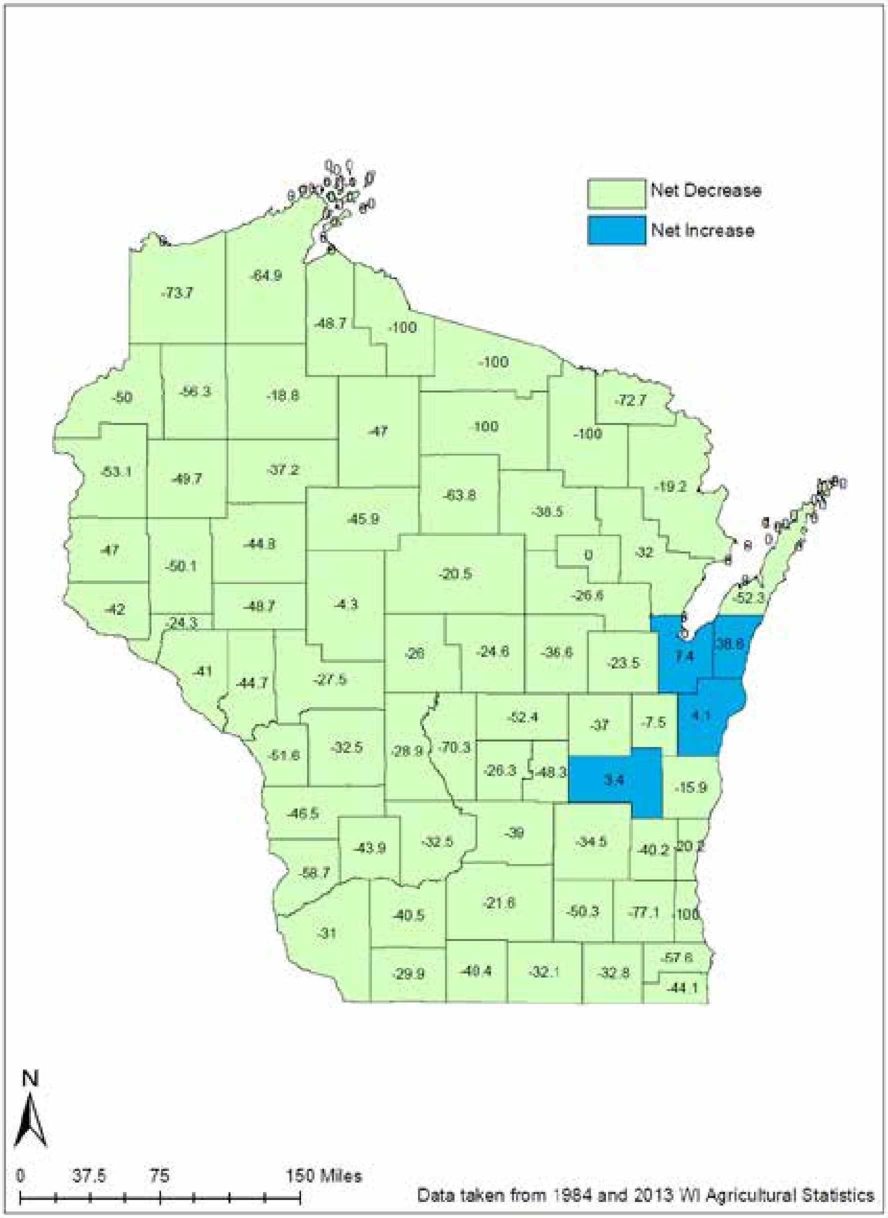


Karst Potential

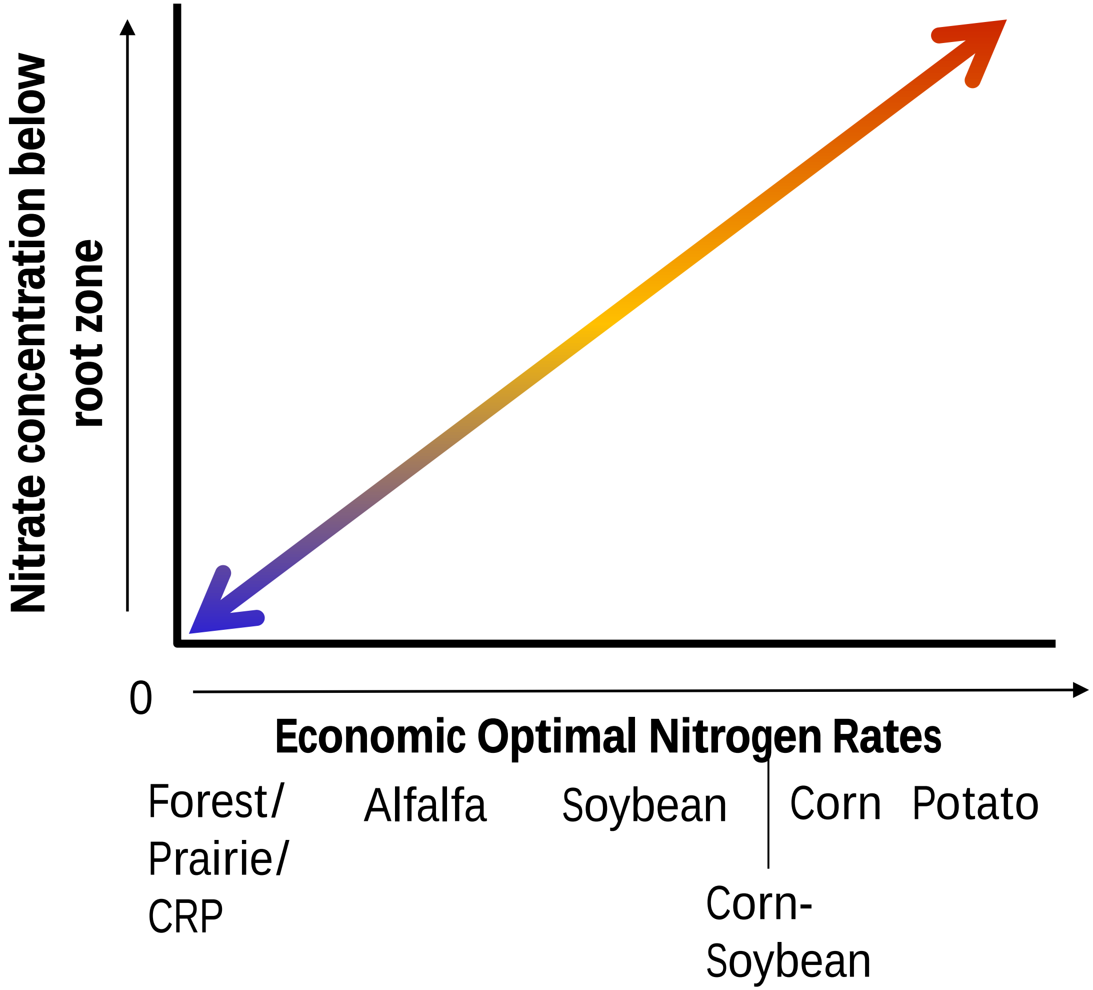




% Change in Dairy Cow Numbers from 1983-2012 by County

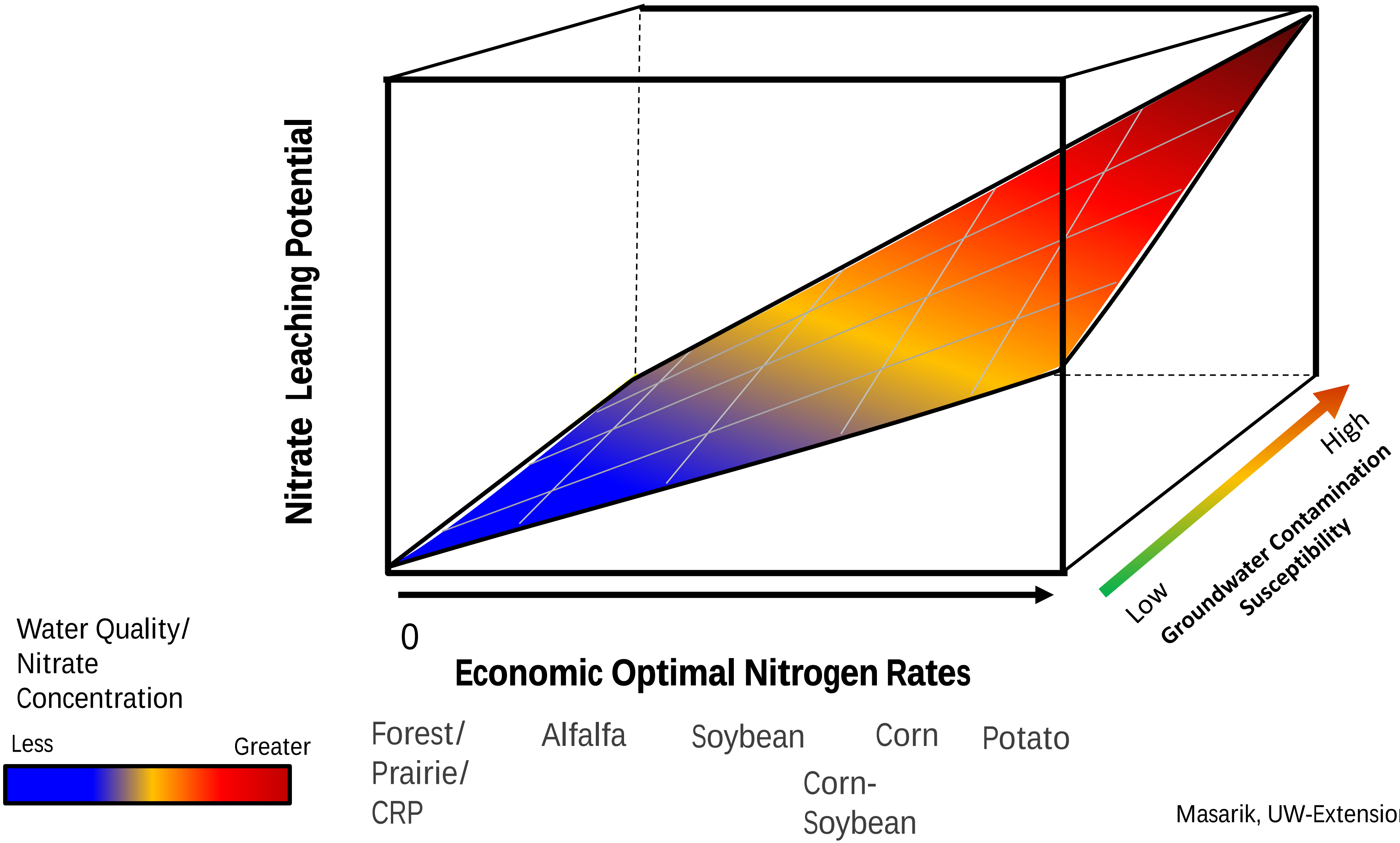


Nitrate Leaching Potential



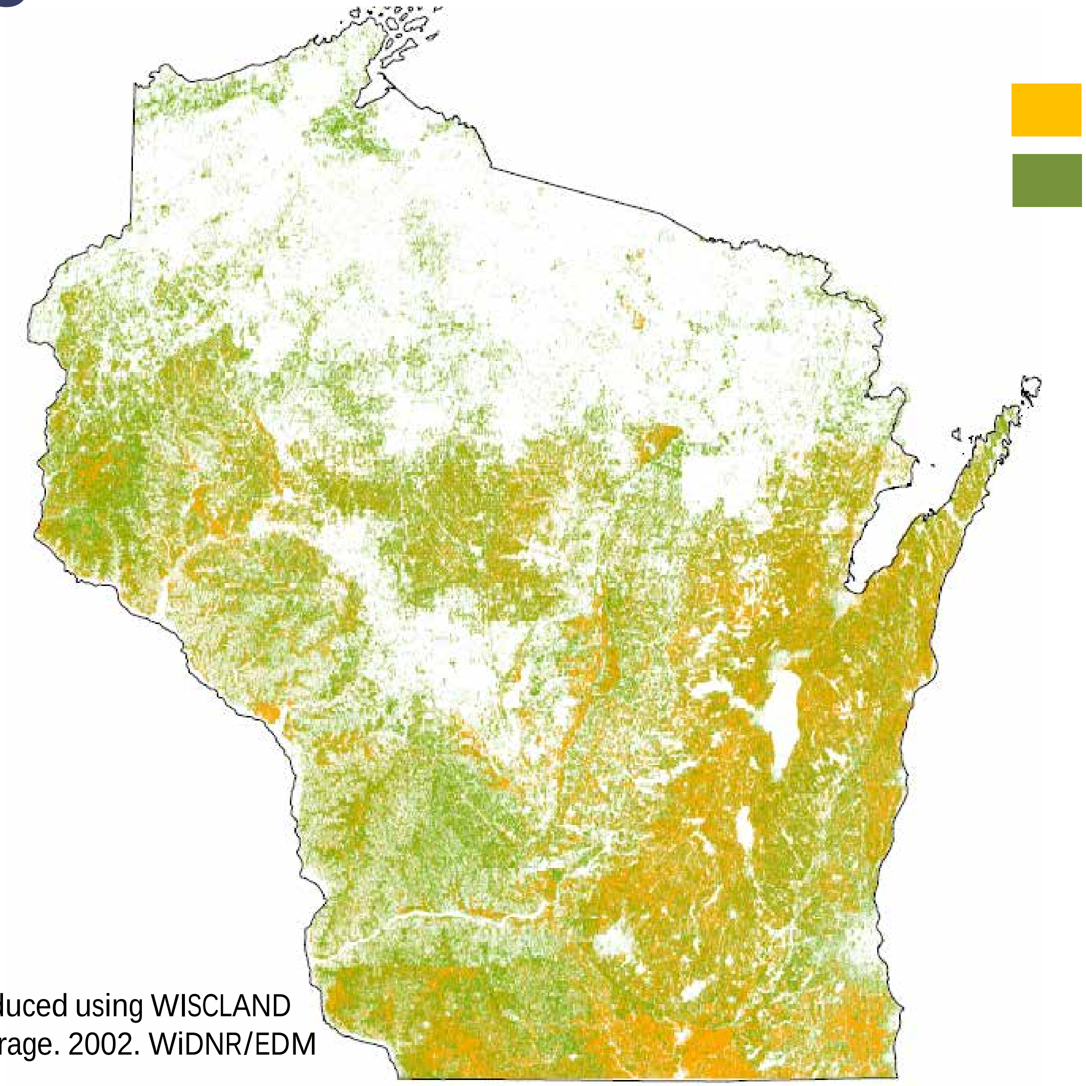
Masarik, UW-Extension

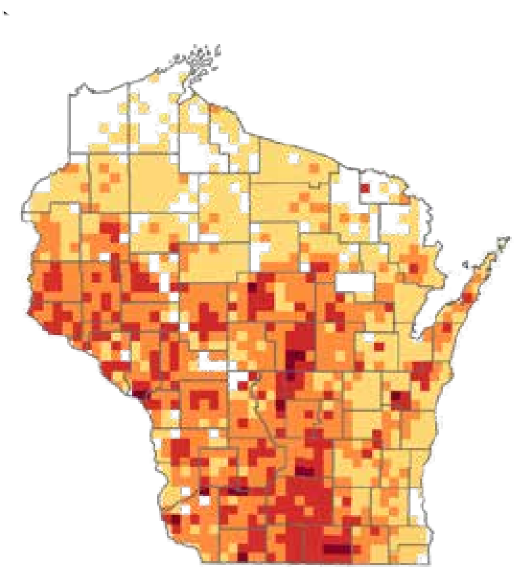
Nitrate Leaching Potential



Masarik, UW-Extension

Agricultural Lands of Wisconsin





Maps produced using WISCLAND
Data Coverage. 2002. WiDNR/EDM

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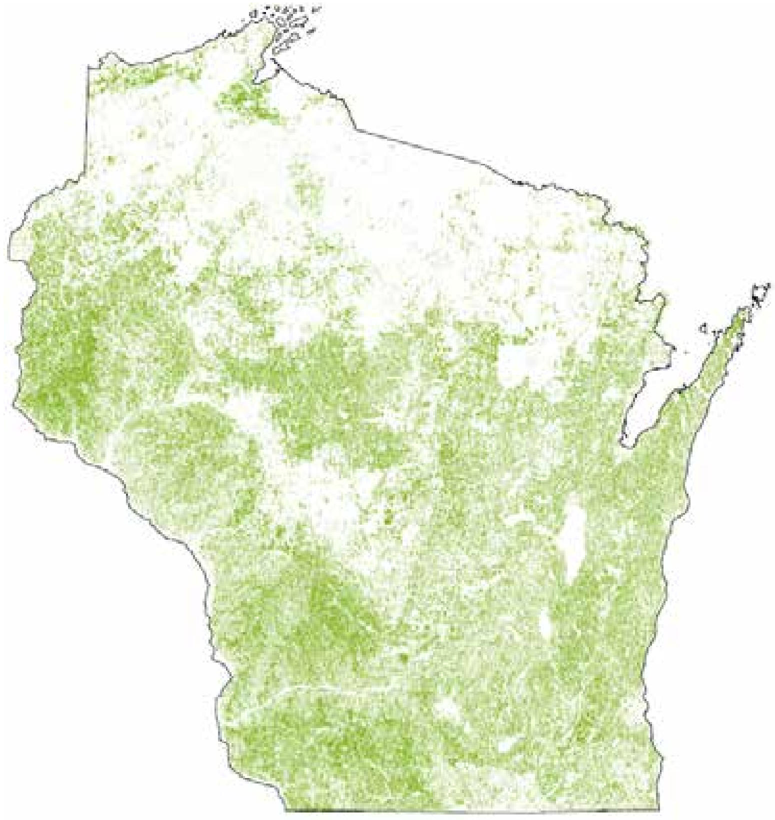
College of Natural Resources

Agricultural Lands of Wisconsin

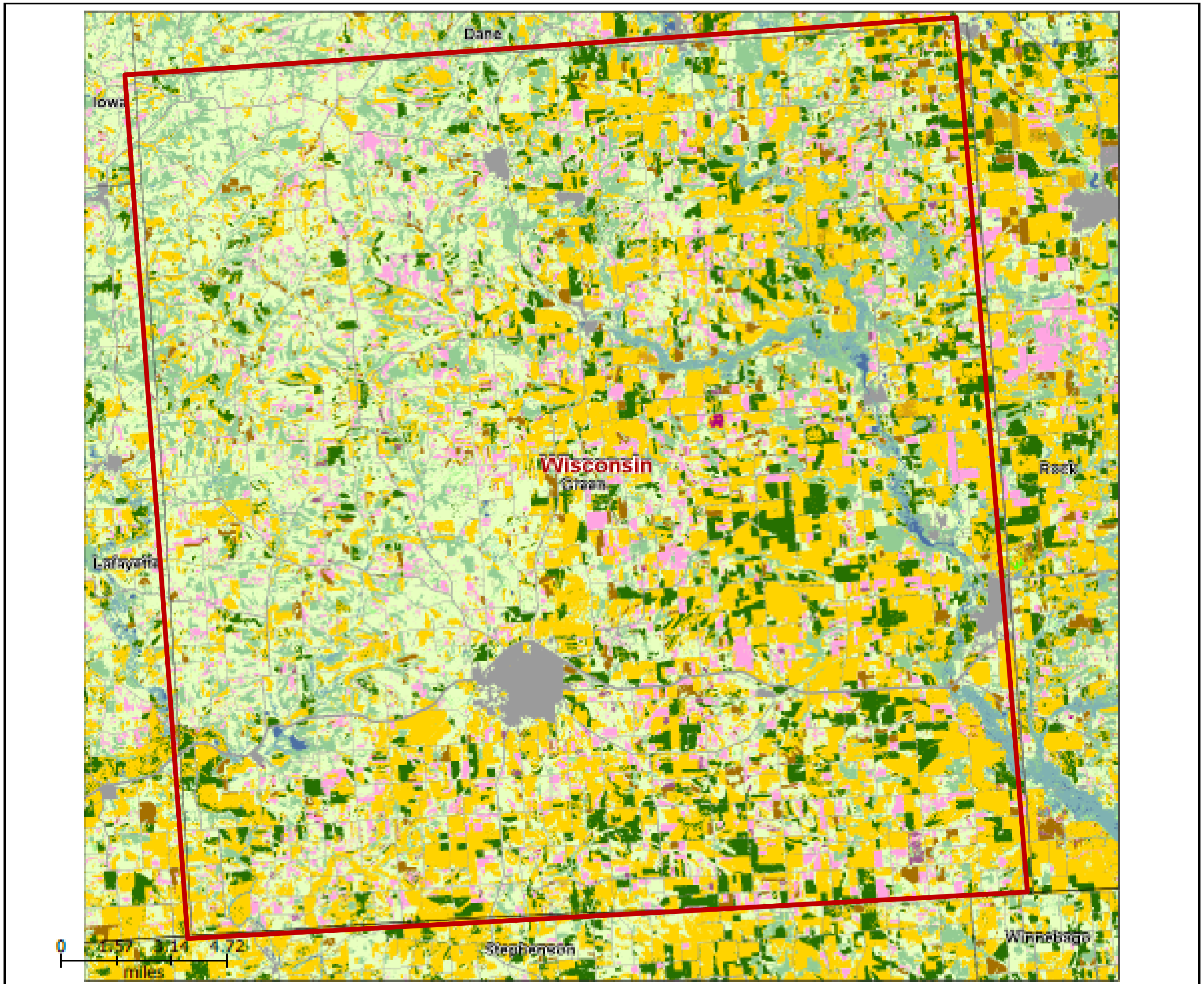
Row Cropping Systems



Forage Crops/Pasture/CRP

Maps produced using WISCLAND Data Coverage. 2002. WiDNR/EDM

2013 Area of Interest



Land Cover Categories

(by decreasing acreage)

AGRICULTURE*

- Grass/Pasture
- Corn
- Soybeans
- Alfalfa
- Winter Wheat
- Other Hay/Non Alfalfa
- Oats
- Sweet Corn
- Dbl Crop WinWht/Corn
- Rye
- Fallow/Idle Cropland
- Sorghum
- Peas
- Dbl Crop WinWht/Soybeans
- Sod/Grass Seed
- Dbl Crop Soybeans/Oats

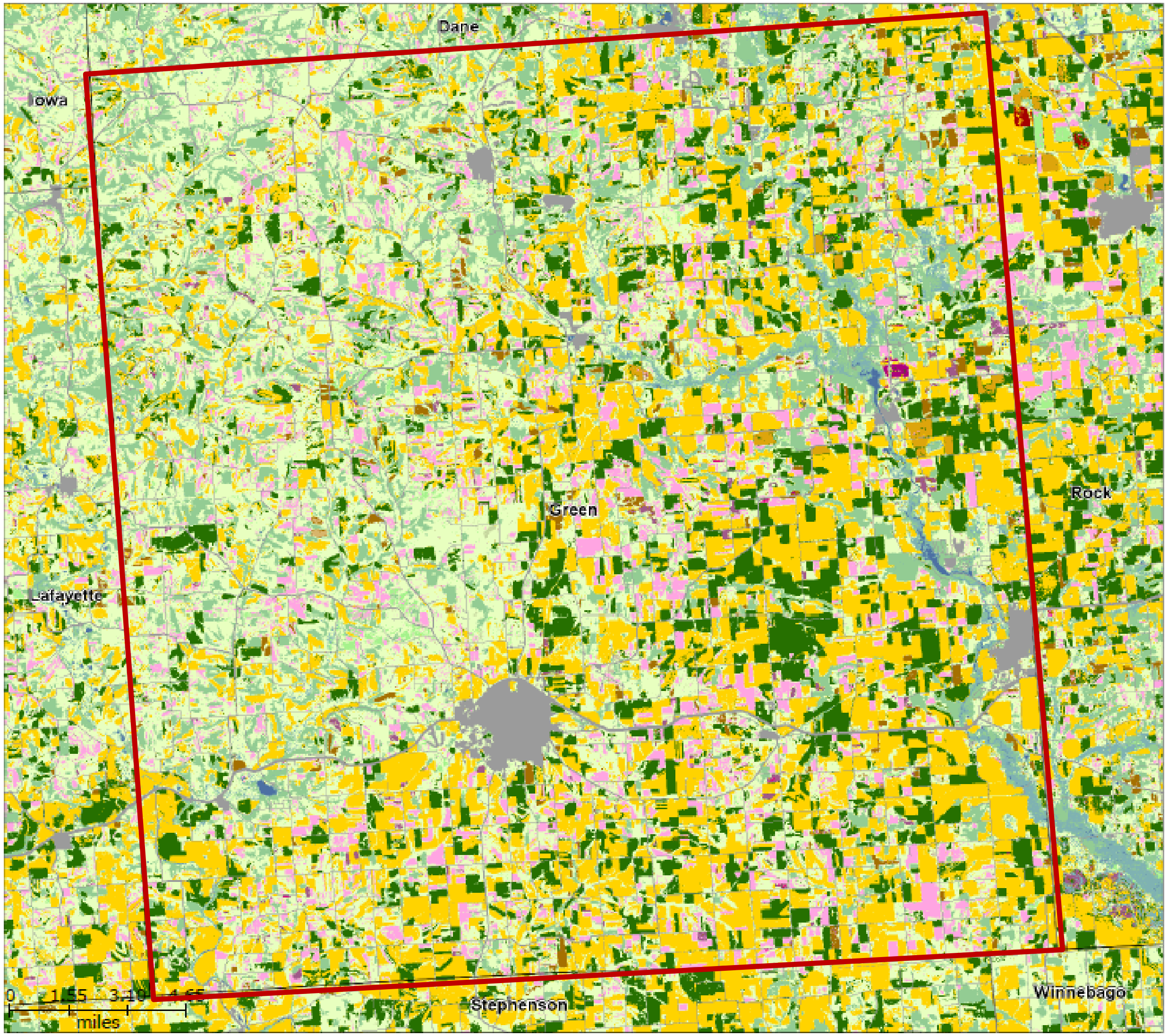
NON-AGRICULTURE**

- Deciduous Forest
- Developed/Open Space
- Developed/Low Intensity
- Herbaceous Wetlands
- Woody Wetlands
- Developed/Medium Intensity

Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

* Only top 16 agriculture categories are listed. ** Only top 6 non-agriculture categories are listed.

2014 Area of Interest



Land Cover Categories

(by decreasing acreage)

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- Oats
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- Dbl Crop WinWht/Corn
- Rye
- Dry Beans
- Fallow/Idle Cropland
- Spring Wheat
- Barley
- Dbl Crop WinWht/Soybeans
- Triticale

NON-AGRICULTURE**

- Deciduous Forest
- Developed/Open Space
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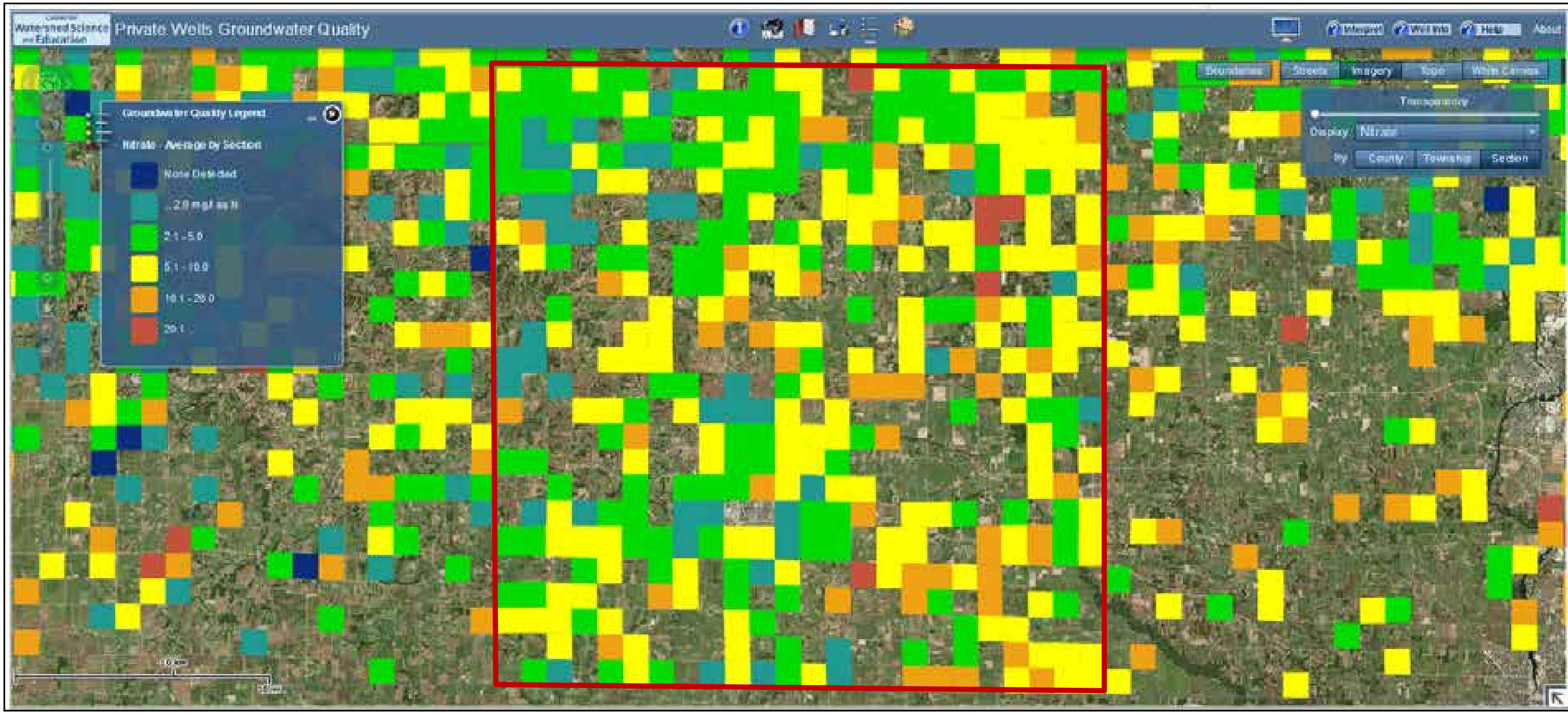
- Herbaceous Wetlands
- Woody Wetlands
- Developed/Medium Intensity

Produced by CropScape - http://nassgeodata.gmu.edu/CropScape

* Only top 16 agriculture categories are listed. ** Only top 6 non-agriculture categories are listed.

Average Nitrate-N concentration by section.



Range	Number	Percent	Summary
None Detected	194	7%	Minimum: No Detect
... 2.0	622	23%	
2.1 - 5.0	724	27%	Median: 4.1
5.1 - 10.0	694	26%	Average: 5.61288
10.1 - 20.0	364	14%	
20.1 ...	64	2%	Maximum: 69.9
Total	2662		
> 10mg/l N	428	16%	Exceeds Health Standard

http://www.uwsp.edu/cnr-ap/watershed/Pages/wellwaterviewer.aspx

Green County
Nitrate Summary

Factors affecting nitrogen loss to groundwater

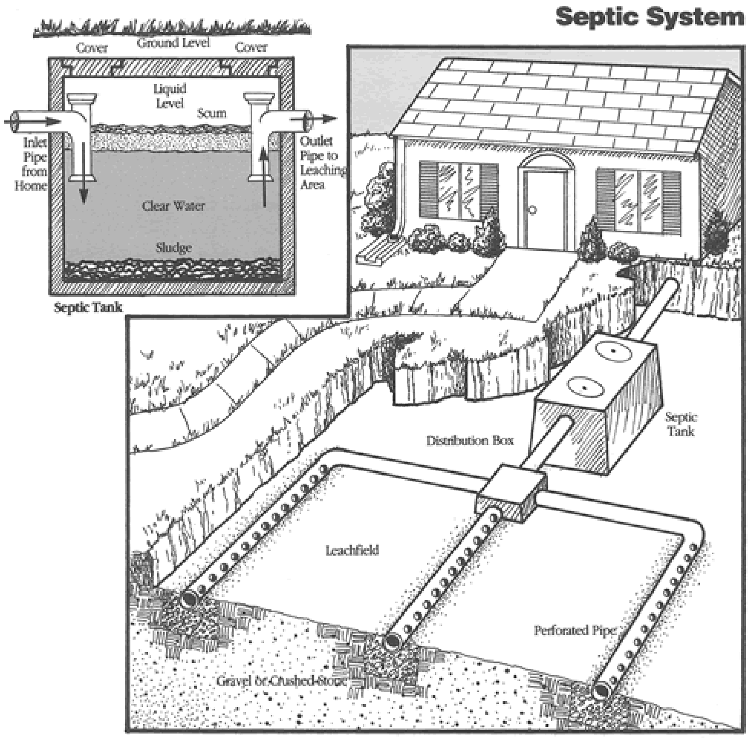
Within our control

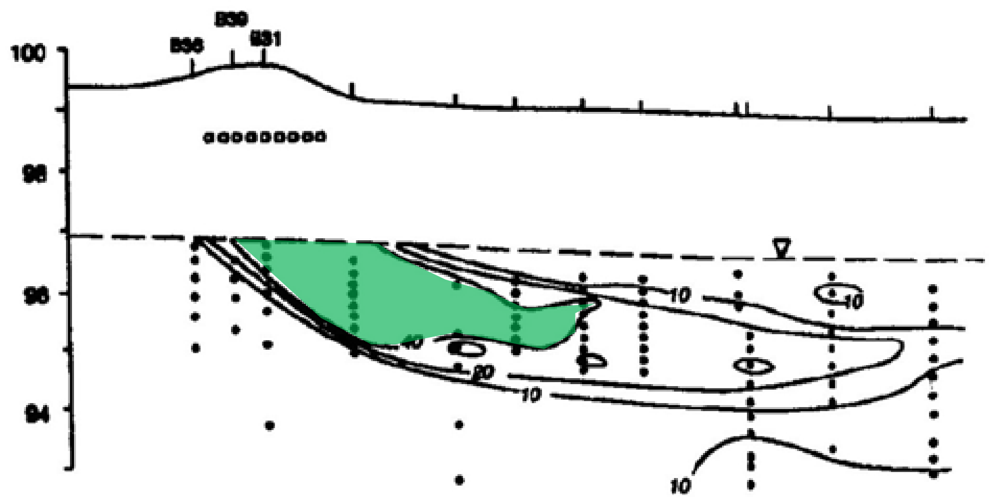
- Amount of nitrogen applied
  – As a function of cropping system
  – Nitrogen application rate relative to economic optimum – *right amount*
  – When, where, what form
- Percent of land base in production

Out of our control

- Geology
- Soil Type
- Precipitation / Climate

Septic systems and nitrate



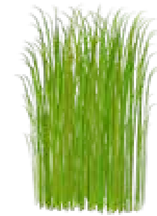


Robertson and Harman 1999

- Designed to dispose of human waste in a manner that prevents bacteriological contamination of groundwater supplies.

- **<u>Do not</u>** effectively remove all contaminants from wastewater: **Nitrate, chloride,** *viruses?, pharmaceuticals?, hormones?*

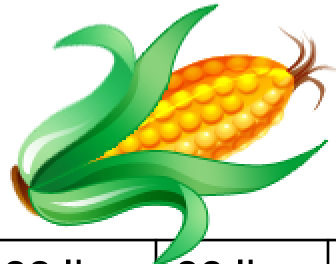
Comparing Land-use Impacts

	Corn[1] (per acre)	Prairie[1] (per acre)	Septic[2] System
Total Nitrogen Inputs (lb)	169	9	20-25
Nitrogen Leaching Loss (lb)	32	0.04	16-20
Amount N lost to leaching (%)	19	0.4	80-90

1 Data from Masarik, 2014
2 Data from Tri-State Water Quality Council, 2005 and EPA 625/R-00/008

Comparing Land-use Impacts



20 acres

32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs

32 lbs/ac x 20 acres = 640 lbs

14 mg/L

20 acres

20 lbs

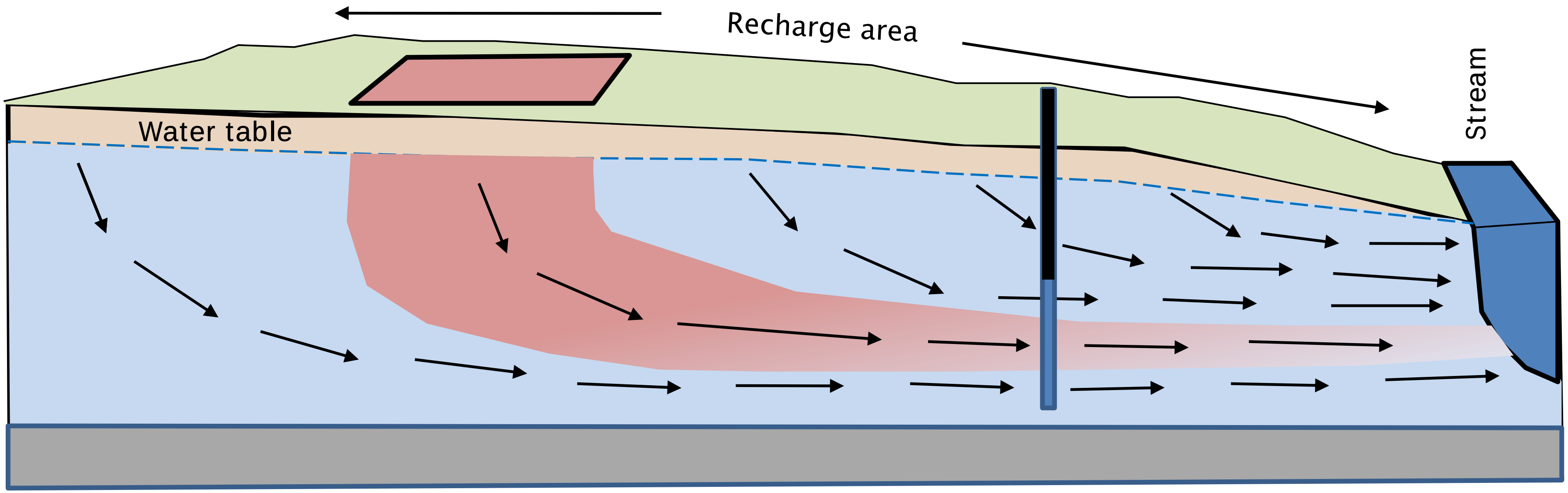
20 lbs/septic system x 1 septic systems = 20 lbs

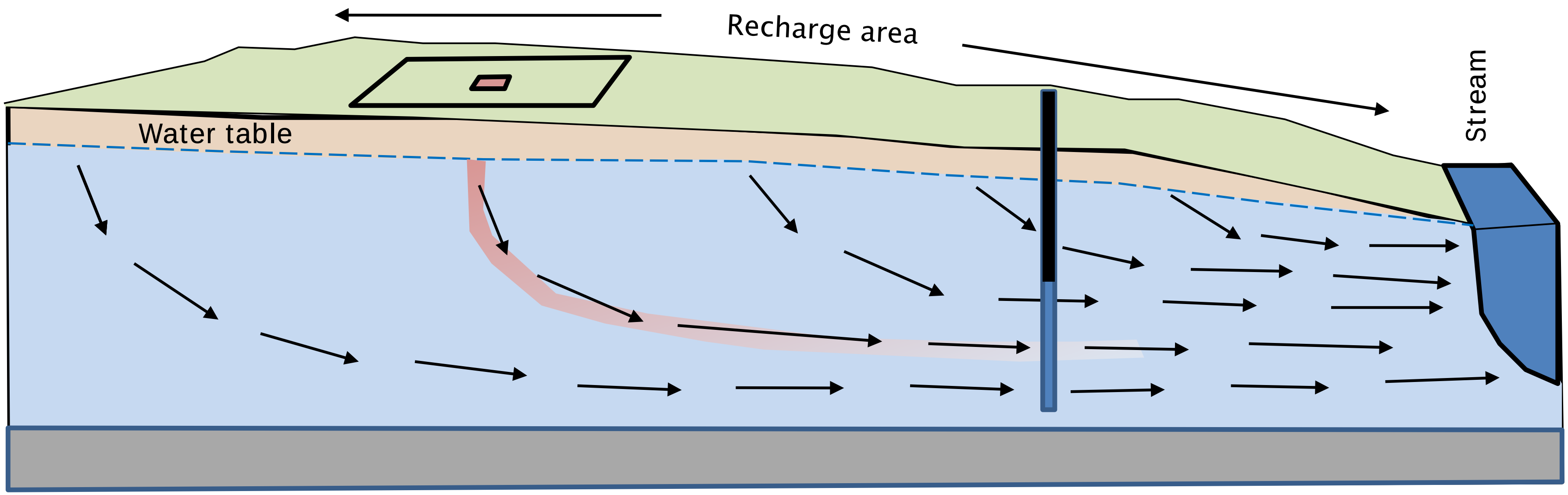
1/32nd the impact on water quality

0.44 mg/L

Assuming 10 inches of recharge

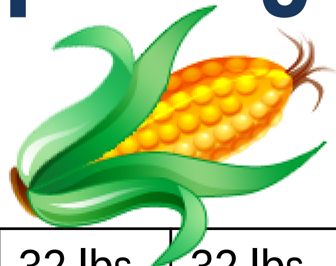
32 lbs/ac x 20 acres = 640 lbs





20 lbs/septic system

Comparing Land-use Impacts



20 acres

32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs
32 lbs	32 lbs	32 lbs	32 lbs

32 lbs/ac x 20 acres = 640 lbs

20 acres

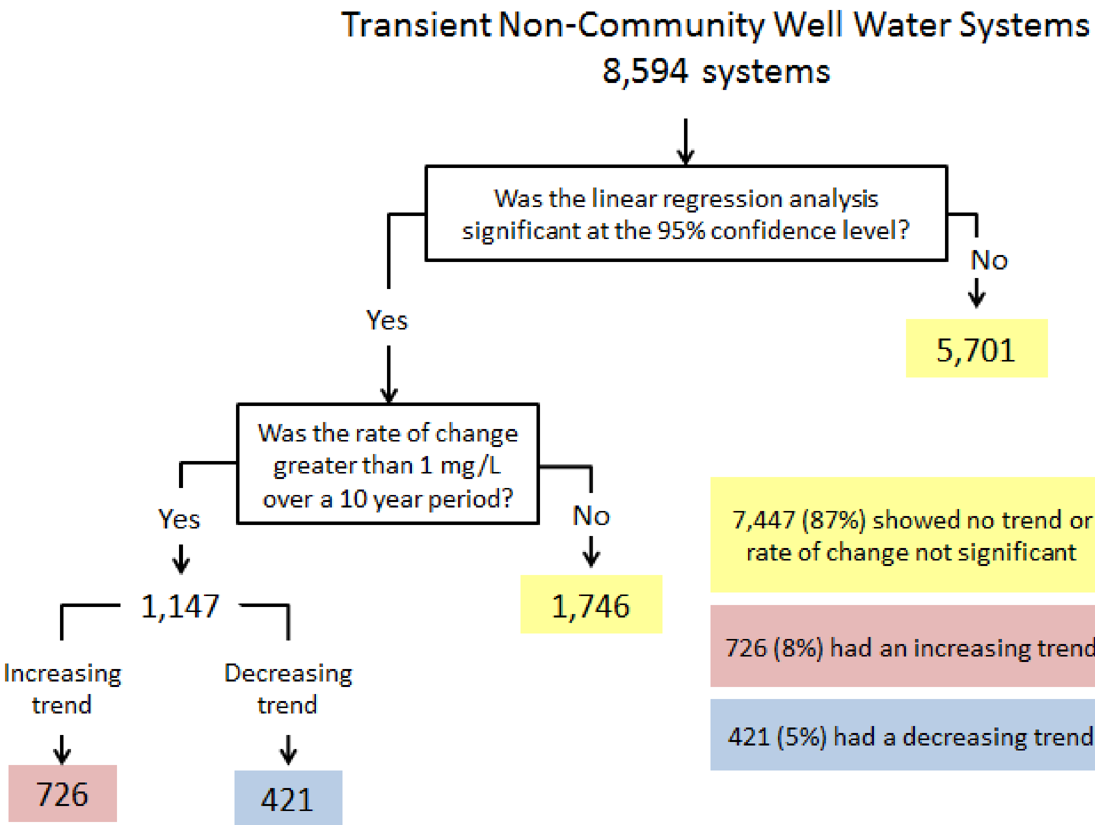
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs
20 lbs	20 lbs	20 lbs	20 lbs

20 lbs/septic system x 32 septic systems = 640 lbs

Using these numbers: 32 septic systems on 20 acres (0.6 acre lots) needed to achieve same impact to water quality as 20 acres of corn


© 2015 Google

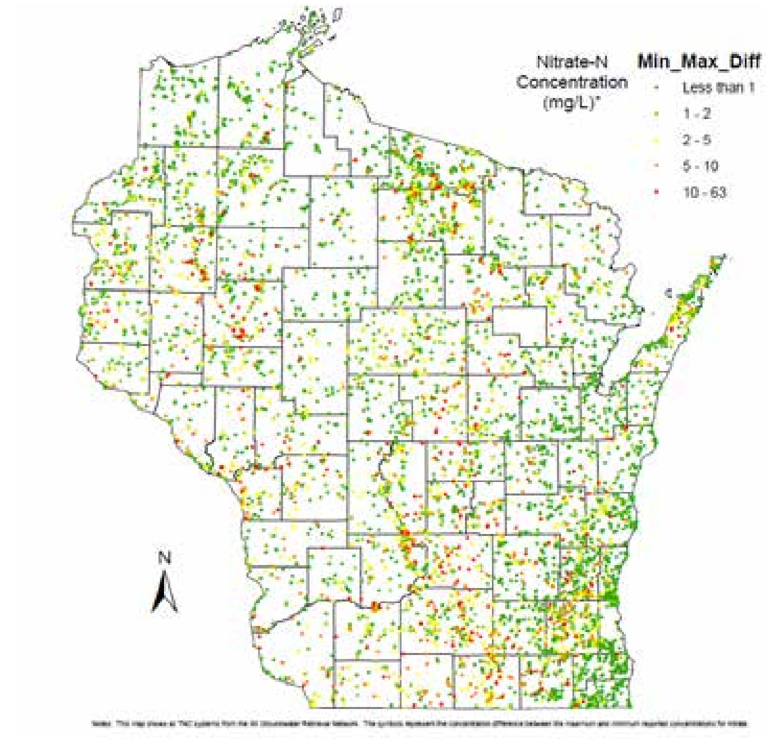
Nitrate Trends



7,447 (87%) showed no trend or rate of change not significant

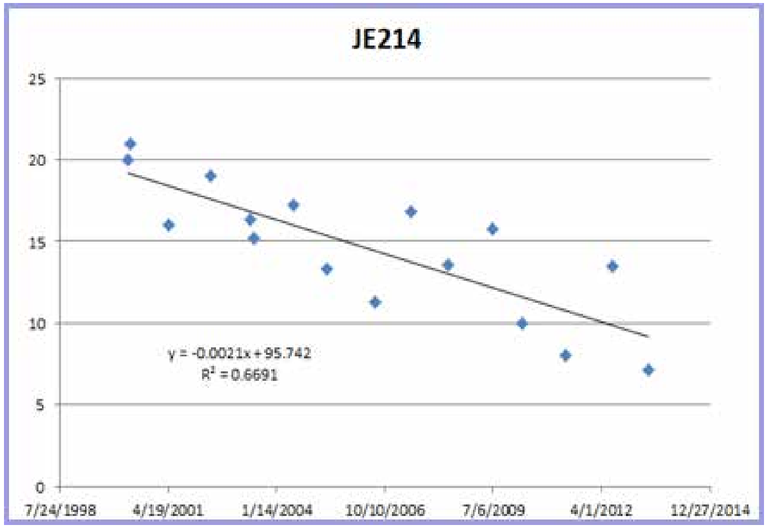
726 (8%) had an increasing trend

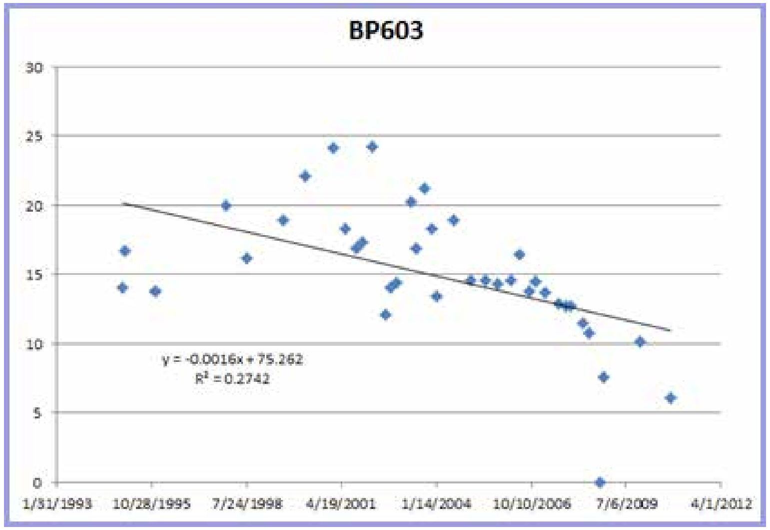
421 (5%) had a decreasing trend

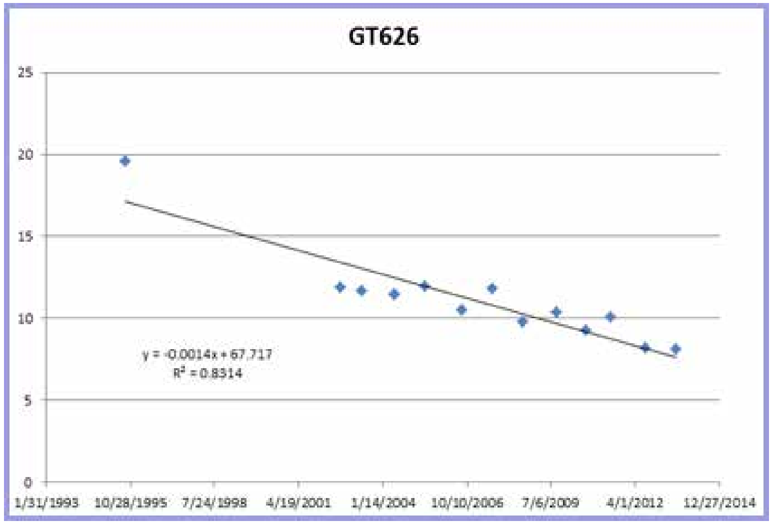


Masarik et al., 2014

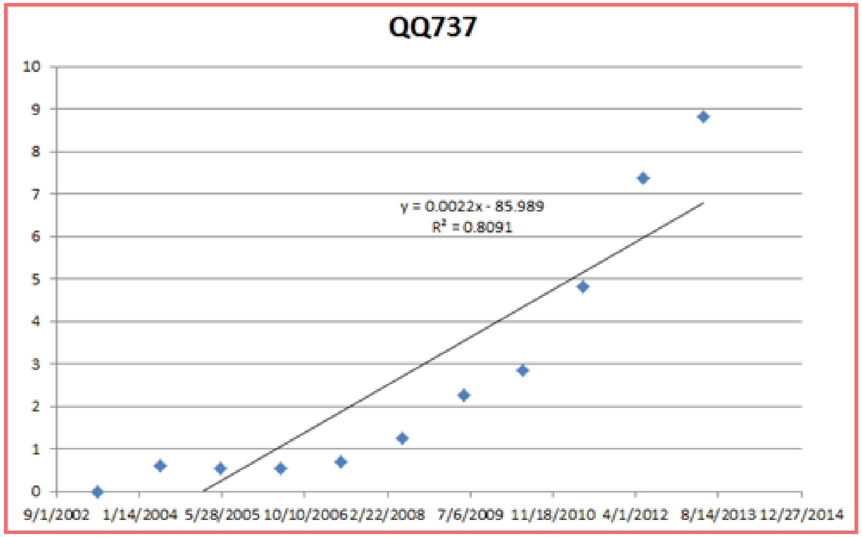
Examples of TNC wells with decreasing trend

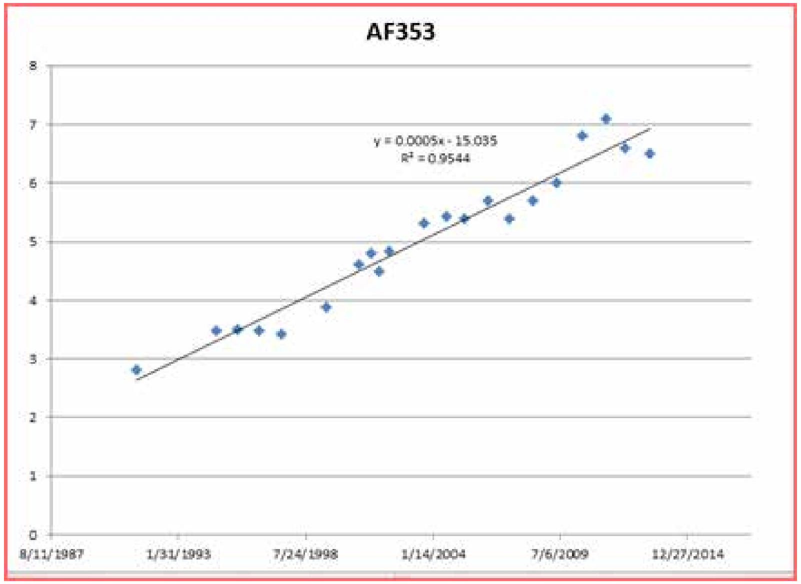


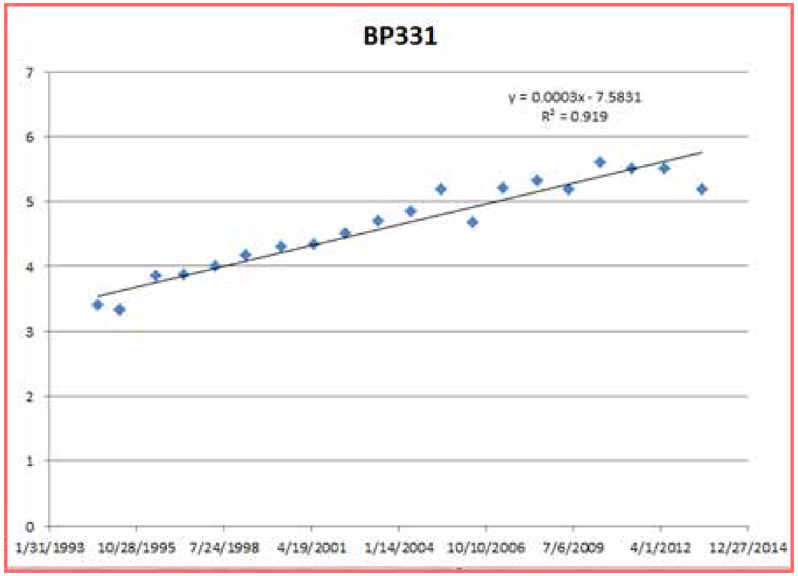




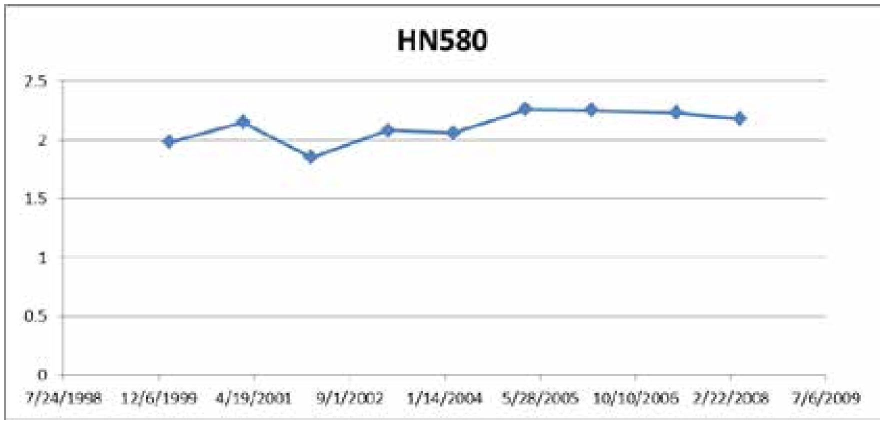
Examples of TNC wells with an increasing trend

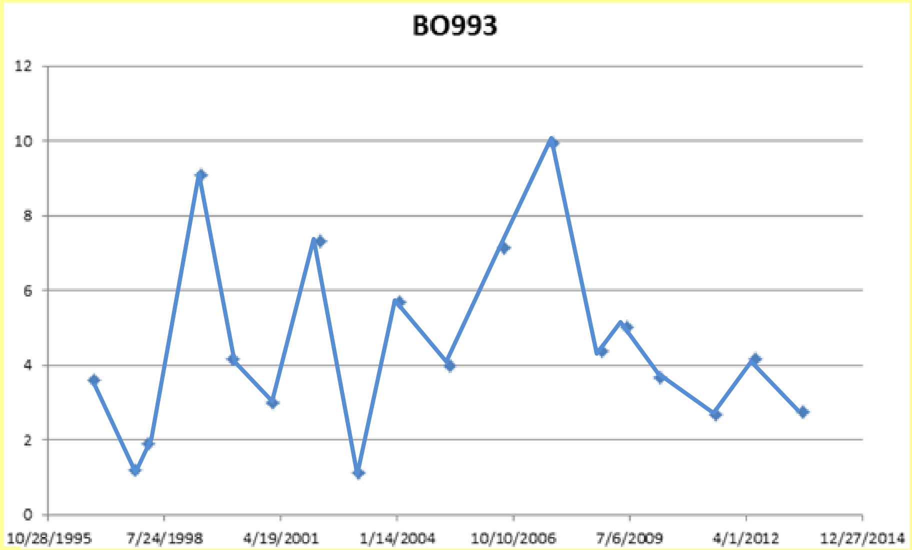


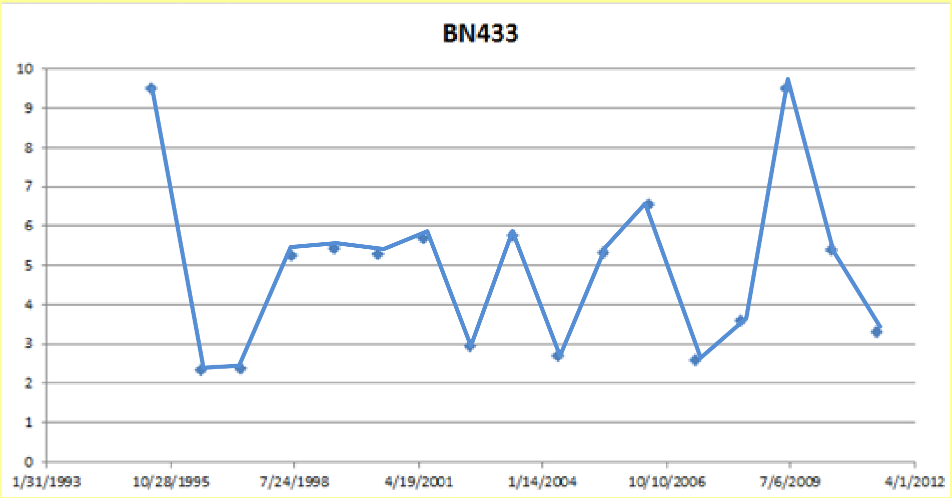


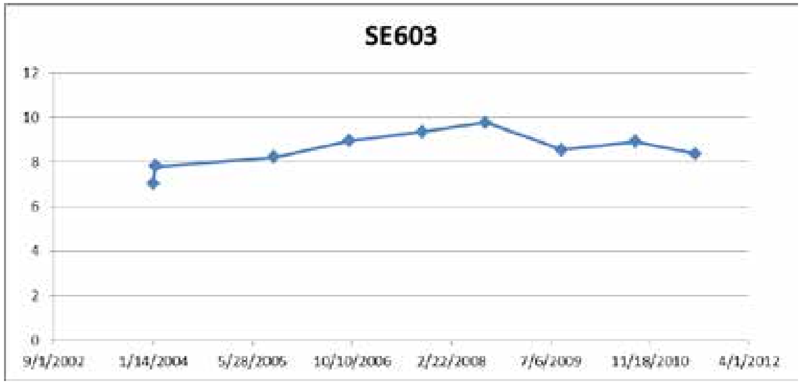


Examples of TNC wells w/no trend









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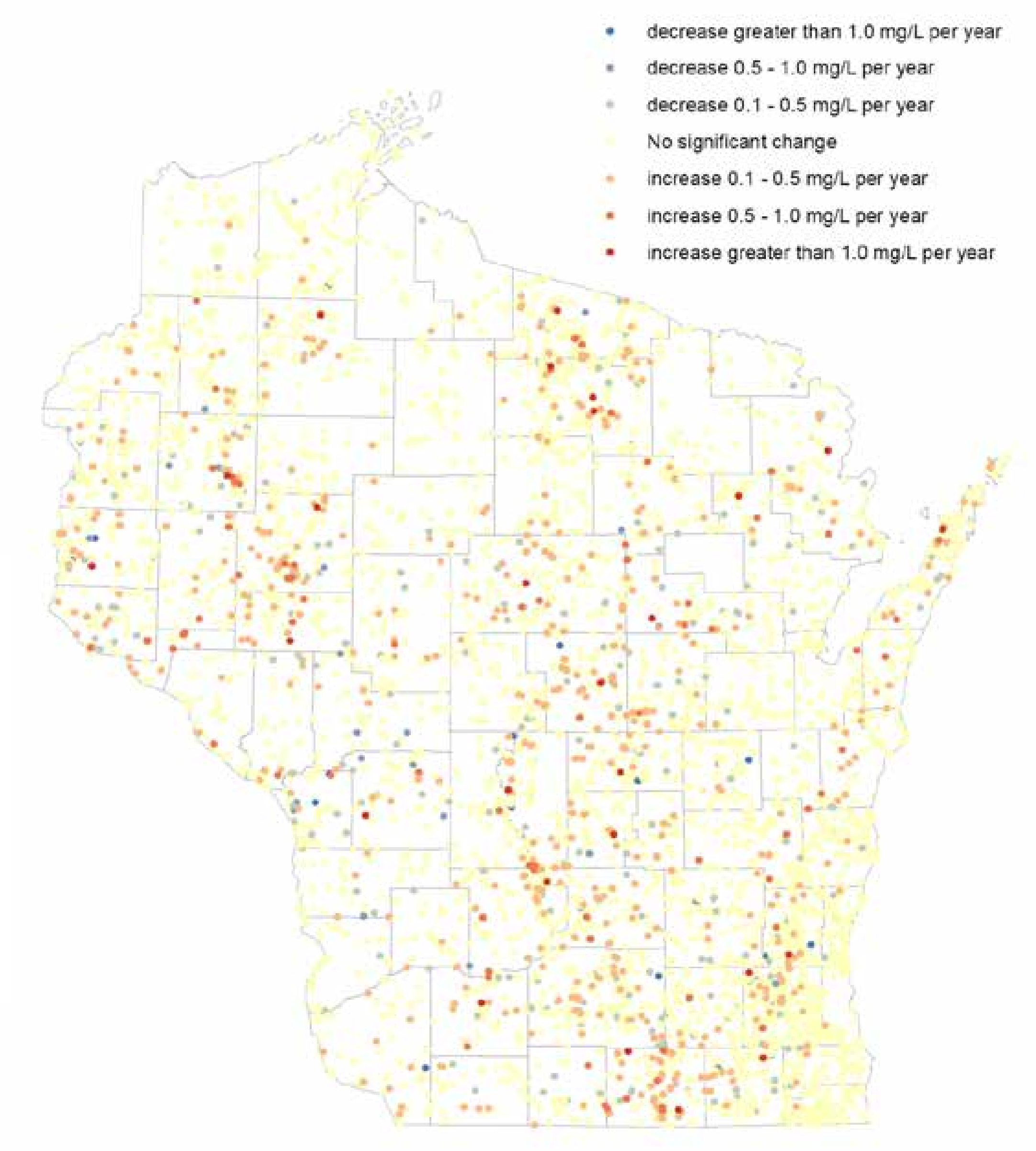
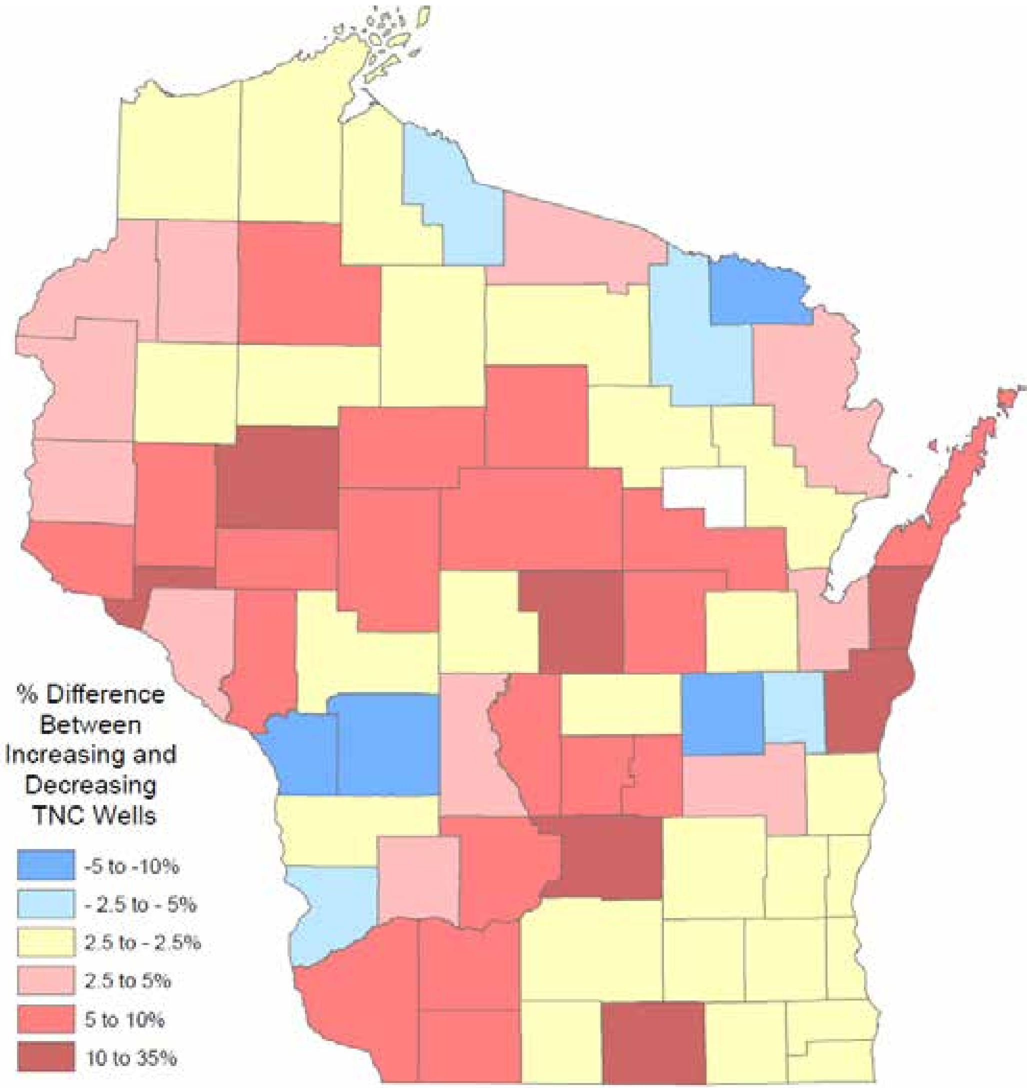
Location and result for TNC wells

- decrease greater than 1.0 mg/L per year
- decrease 0.5 - 1.0 mg/L per year
- decrease 0.1 - 0.5 mg/L per year
- No significant change
- increase 0.1 - 0.5 mg/L per year
- increase 0.5 - 1.0 mg/L per year
- increase greater than 1.0 mg/L per year

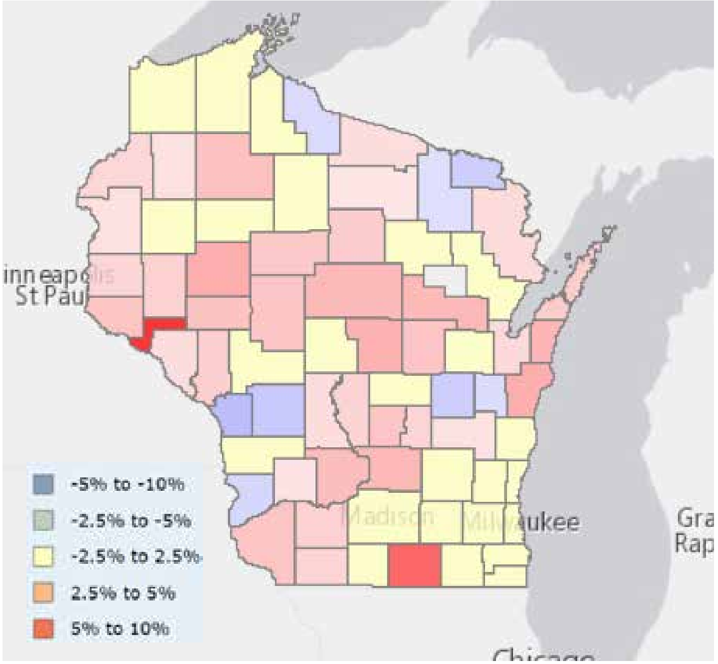


Counties that have seen more TNC wells increase (red) or decrease (blue)

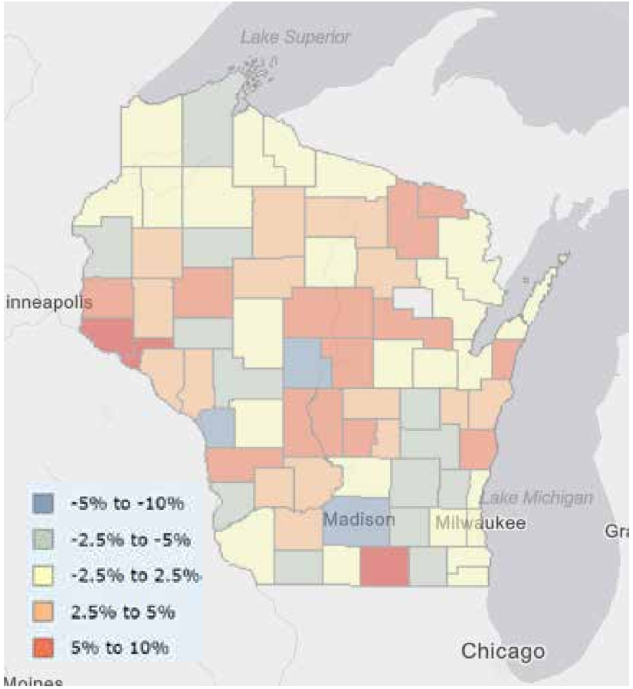


Masarik et al., 2014

Nitrate Trends by County



All TNC data, going back ~20 years



All TNC and NTNC systems limited to previous 10 years of data.

http://dnr.wi.gov/topic/groundwater/GCC/gwquality.html

Long-term nitrogen reduction strategies

Practice	Details	% Nitrate-N Reduction (SD)
Timing	Fall to Spring Pre-plant	6 (25)
	Spring pre-plant/sidedress 40-60 split compared to fall applied	5 (28)
	Sidedress – Soil test based compared to pre-plant	7 (37)
Nitrification Inhibitor	Nitrapyrin – Fall – Compared to applied w/out nitrapyrin	9 (19)
Cover Crops	Rye	31 (29)
	Oat	28 (2)
Perennial	Biofuel Crops (ex. switchgrass, miscanthus)	72 (23)
	Conservation Reserve Program	85 (9)
Extended Rotations	At least 2 years of alfalfa or other perennial crops in a 4 or 5 year rotation	42 (12)

Iowa Nutrient Reduction Strategy, 2014

How Manure Composition Affects N Mineralization

The rate of mineralization in soil depends upon the "digestibility" of manure organic matter and its carbon:nitrogen (C:N) ratio. Separation of whole manure into liquids and solids segregates coarse and fine manure particles that have different organic composition and different mineralization rates. Fine particles in manure contain organic compounds with low C:N ratios (high protein) and are rapidly decomposed in soil. Coarse particles have higher C:N ratios (lower protein) and are more slowly decomposed in soil.

Because thin slurry and lagoon water contain the finest organic particles, these materials have the most rapid N mineralization rate. Thick slurry and solid manures contain a mixture of fine and coarse particles, so they have a lower N mineralization rate.

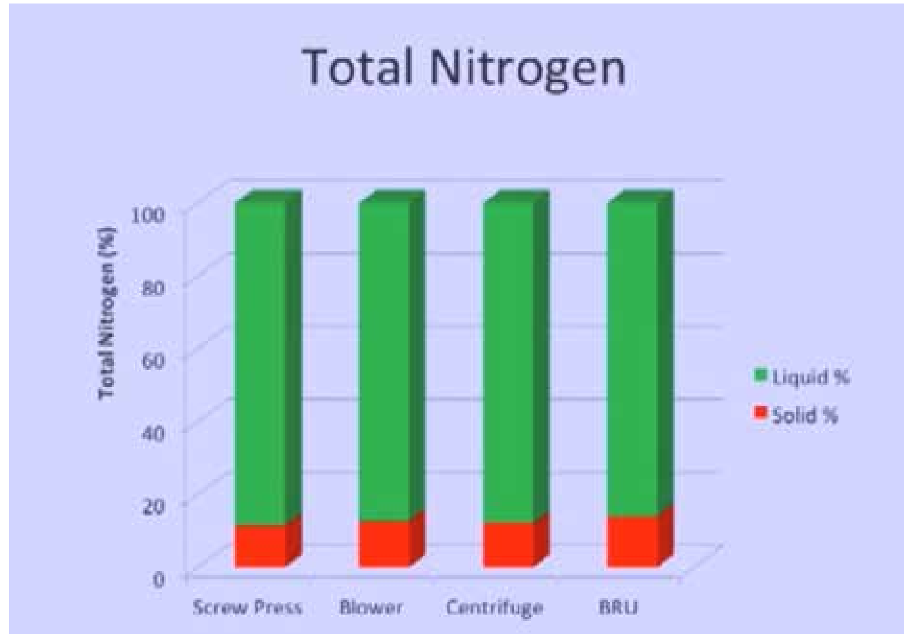
Solids separated from liquid manure by a mechanical separator (separated dairy solids) contain mostly coarse particles (bedding plus undigested feed). These solids have a unique pattern of mineralization over time in soil. Separated solids typically have negative N mineralization rates (PAN in soil decreases) for 4 to 8 weeks after application. After that, PAN is mineralized very slowly. Cumulative PAN from separated solids is much lower than for other fresh manures. The timing and amount of PAN release from horse manure is similar to that from separated dairy solids.

Separation of solids from liquid manure by gravity separation (settling basin or evaporation basin) does not change PAN, because the fine organic particles in the manure are recovered from the basin.

Composting manure reduces manure volume by 50 percent or more. During composting, some of the manure N is lost as ammonia gas, and some is transformed to more stable organic compounds. Compost organic matter decomposes very slowly in soil. Cumulative PAN for compost organic matter is similar to that of separated dairy solids.

Fresh poultry manure or broiler litter contains some organic N in the form of uric acid (similar to urea). In soil, uric acid is converted to PAN in 1 to 2 weeks. Most broiler litter sold as "compost" in western Oregon contains uric acid and behaves more like fresh litter than compost in terms of N availability. If you can smell ammonia in broiler litter, it probably is not thoroughly composted. Dry-stacking of broiler litter does not provide adequate moisture for composting.

Because thin slurry and lagoon water contain the finest organic particles, these materials have the most rapid N mineralization rate. Thick slurry and solid manures contain a mixture of fine and coarse particles, so they have a lower N mineralization rate.



Slide from presentation by Becky Larson, Manure Irrigation Workshop

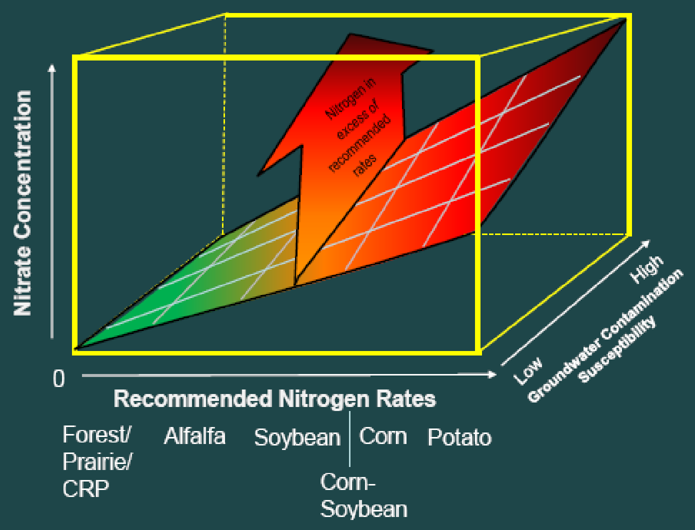
Liquid contains greater percentage of plant available N (i.e. ammonia/ammonium), ammonium readily converted into nitrate in aerobic conditions and susceptible to leaching.

http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/20528/em8954-e.pdf

Conclusions

- Nutrient management is a first step that creates a baseline concentration of nitrate in groundwater that reflects crop rotation and geology/soils.
- Significant nitrate leaching can occur even when nitrogen recommendations are followed – no environmental optimum rate
- Nutrient management and crediting of N will help reduce extreme nitrate concentrations in groundwater and reduce risk of brown water incidents in groundwater
- May take years or decades for groundwater quality to reflect changes in land-use practices

Nitrate = f(Crop + Excess N + soils/geology)



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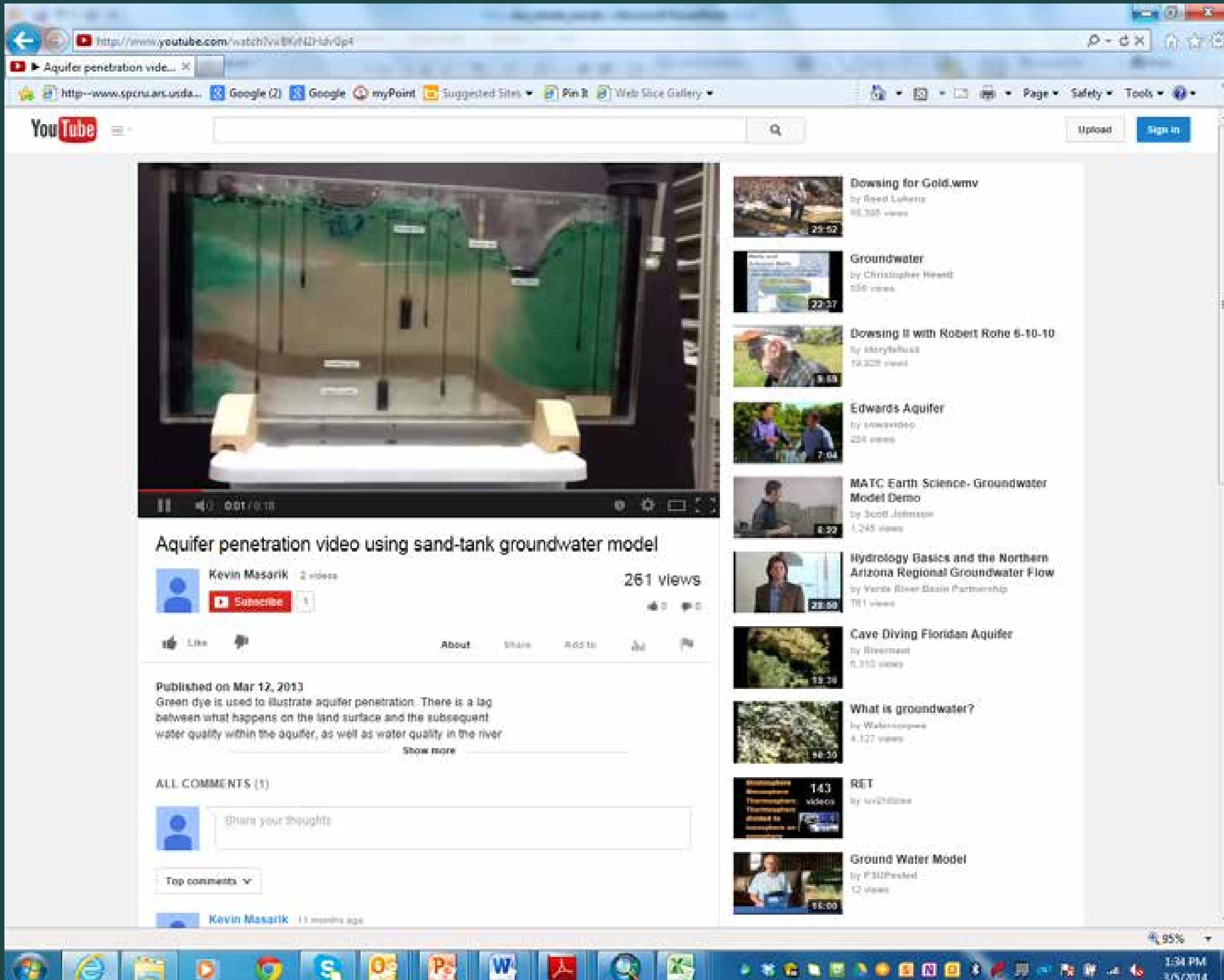
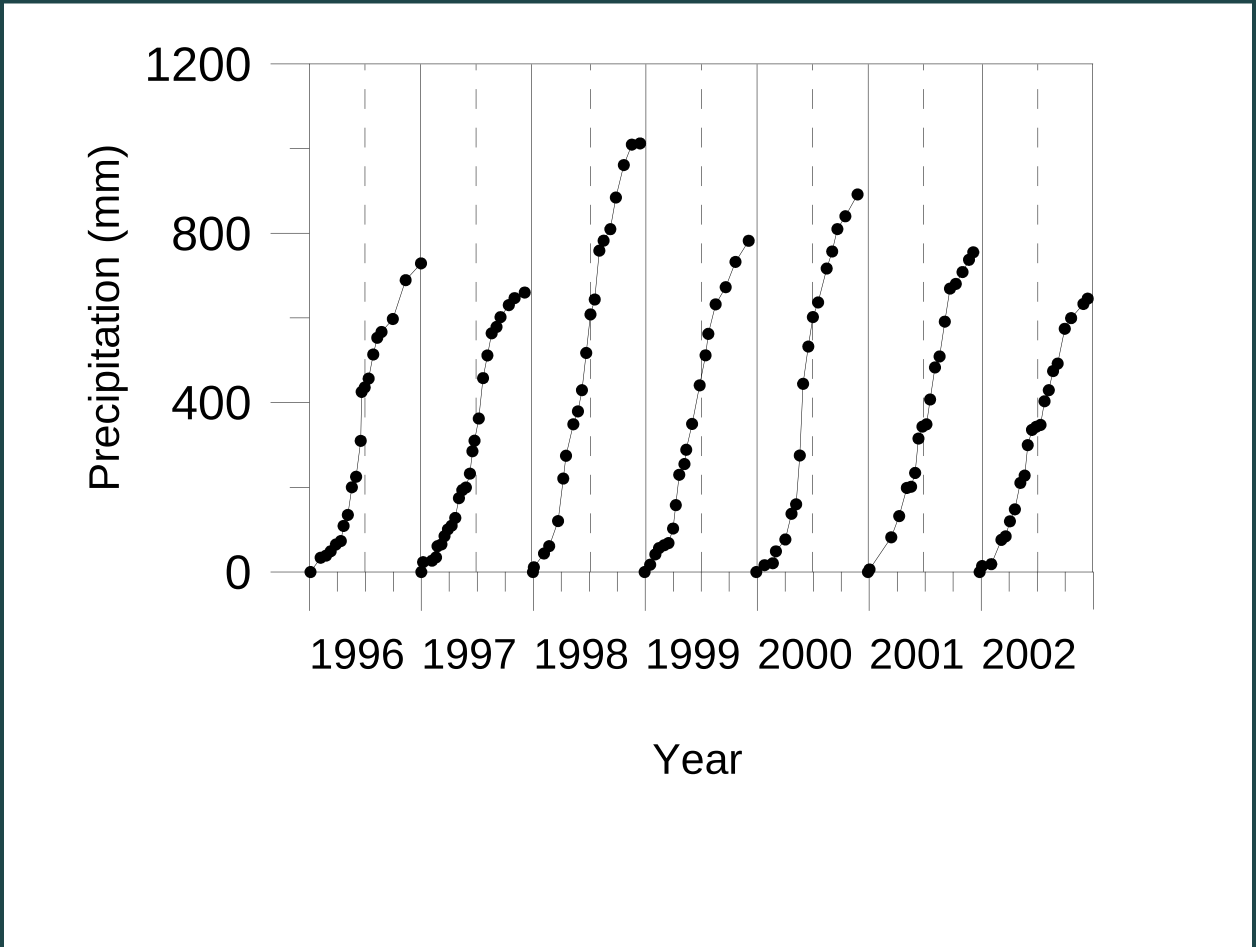
What can be done to reduce nitrate levels?

- **Short term**
  - Municipal Wells (GCC, 2015)
    - 47 systems have spent >$32 million as of 2012
      - Water Treatment
      - New wells
      - Blending
  - Private Wells (Lewandowski et. al. 2008)
    - New well (not guaranteed, deeper adds to expense) - $7,200
    - Bottled water - $190/person/year
    - Water treatment devices $800 + 100/yr
      - Reverse osmosis
      - Distillation
      - Anion exchange



http://www.youtube.com/watch?v=BKrN2HdvGp4

Annual Cumulative Precipitation

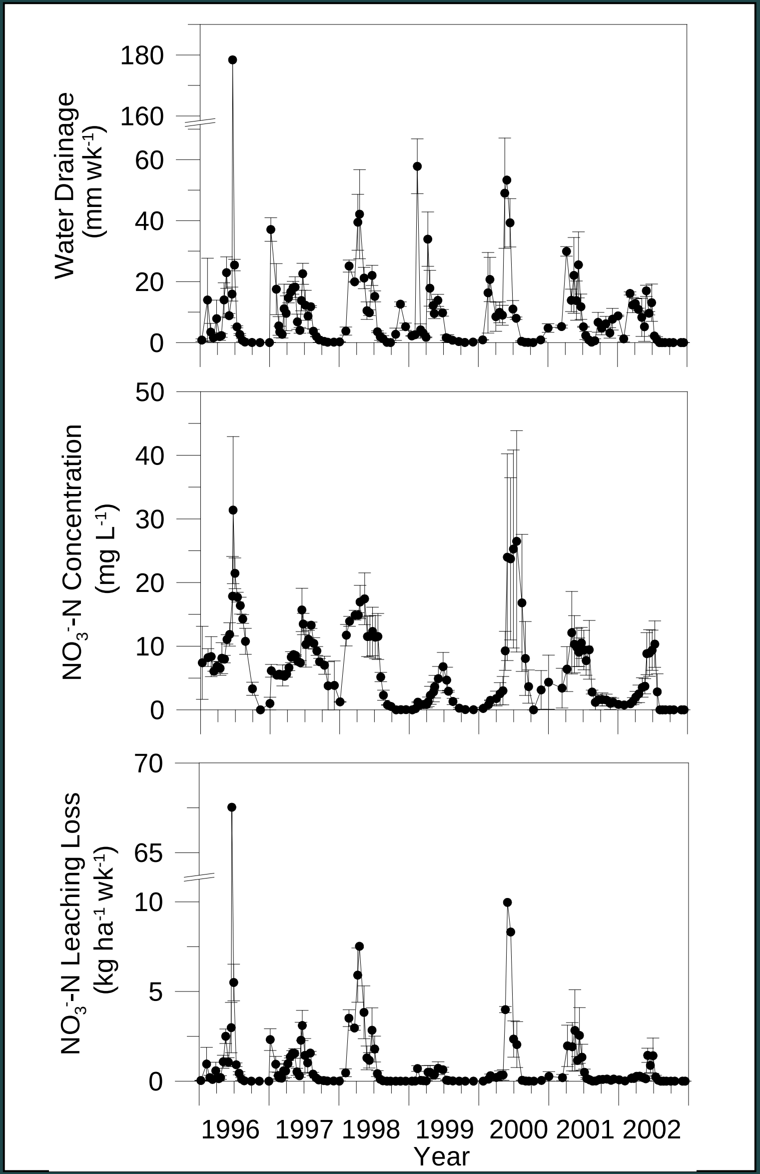


Long-term Nitrate Leaching Study

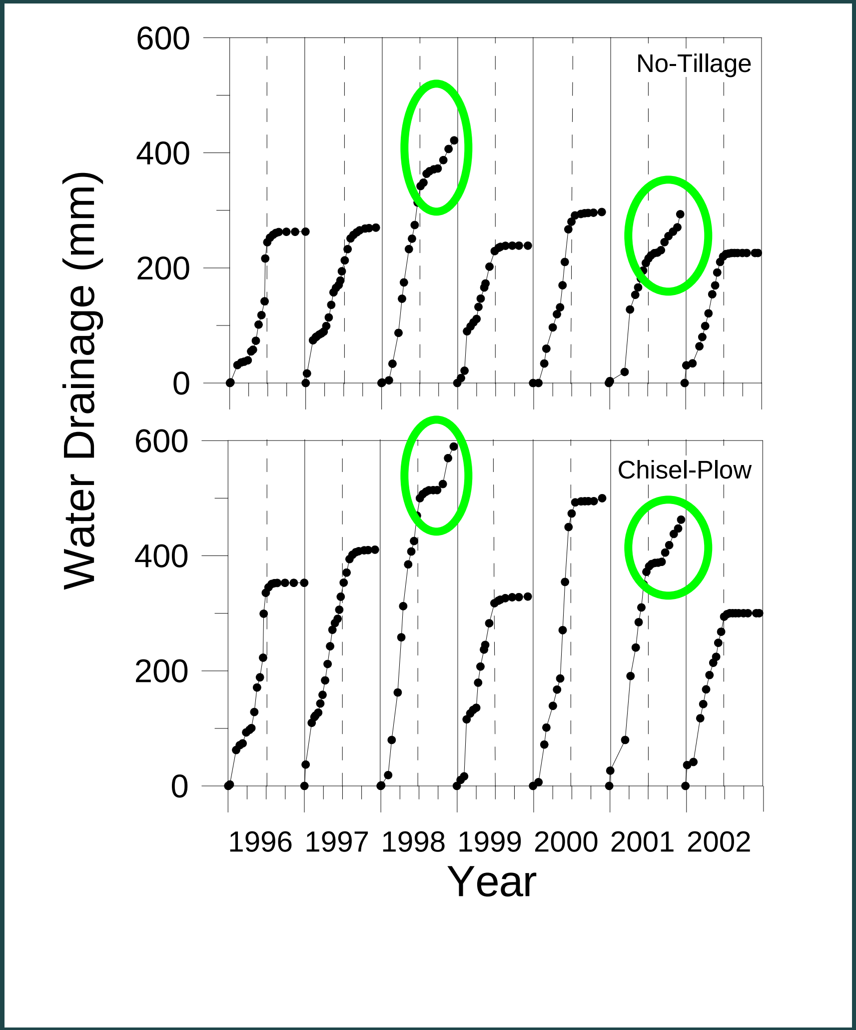
Water drainage
(mm)

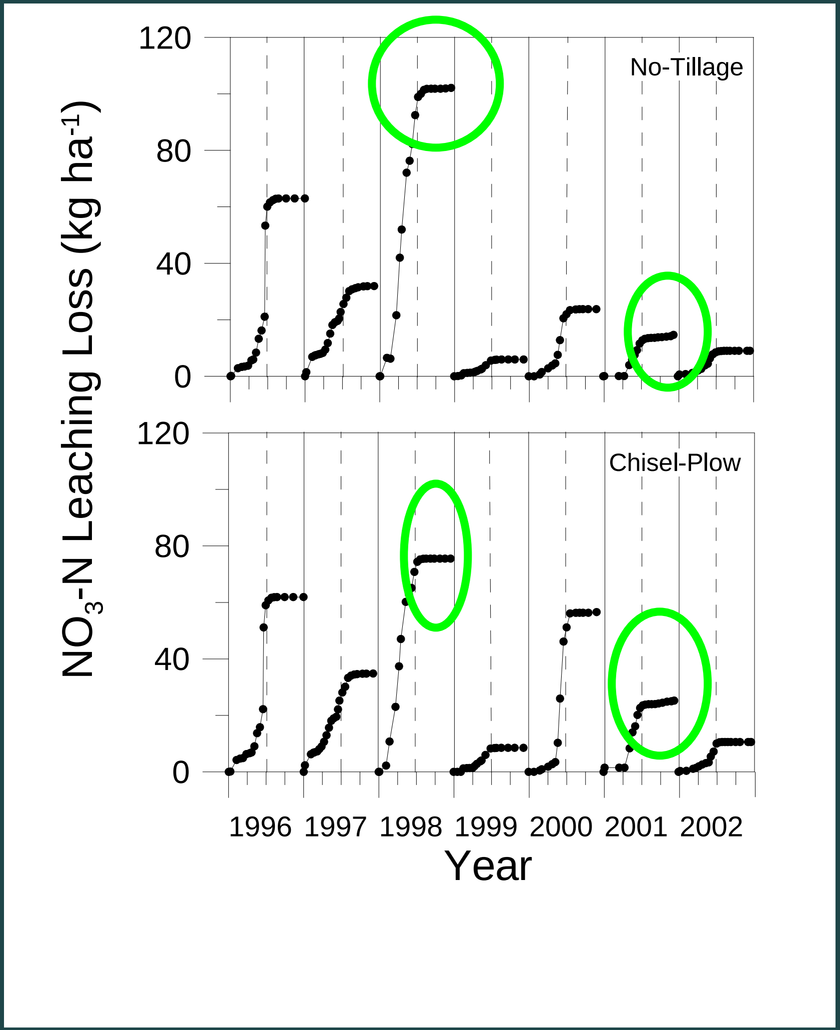
NO_3-N concentration
(mg L^{-1})

NO_3-N leaching loss
(kg ha^{-1})



Annual Cumulative Water Drainage & Nitrate Leaching





Nitrate-impacted Municipal Wells

As of 2005 total of $24 million

- Amherst
- Cambria
- Chippewa Falls
- Crivitz Utilities
- Embarrass
- Fitchburg
- Fontana
- Janesville Water Utility
- Mattoon
- Morrisonville
- Oconomowoc
- Orfordville
- Plover
- Rome
- Sauk City
- Strum Waterworks
- Valders
- Village of Arlington
- Village of Clinton
- Village of Dalton
- Village of Footville
- Village of Friesland
- Waunakee
- Waupaca
- Whiting

Data obtained from Laura Chern of WDNR

What can I do to reduce my nitrate levels?

- Possible Long-term Solution:
  - Reduce or eliminate nitrogen inputs

- Short term (Lewandowski et. al. 2008)
  - Change well depth or relocate well (not guaranteed) - $7,200
  - Bottled water - $190/person/year
  - Water treatment devices - $800 + 100/yr
    - Reverse osmosis
    - Distillation
    - Anion exchange