Land Management and Water Quality

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Wisconsin Agribusiness Classic

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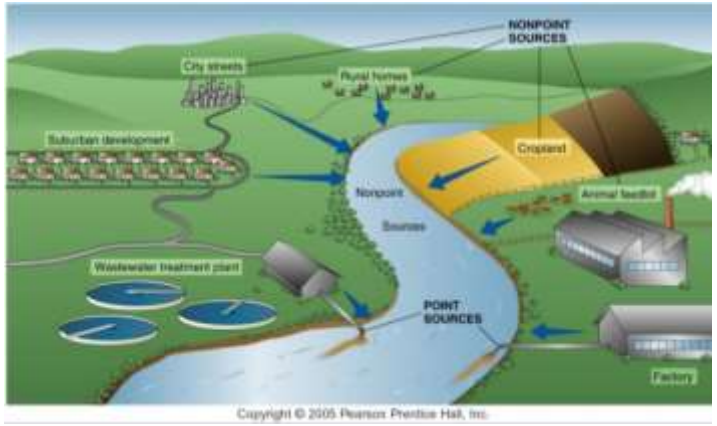
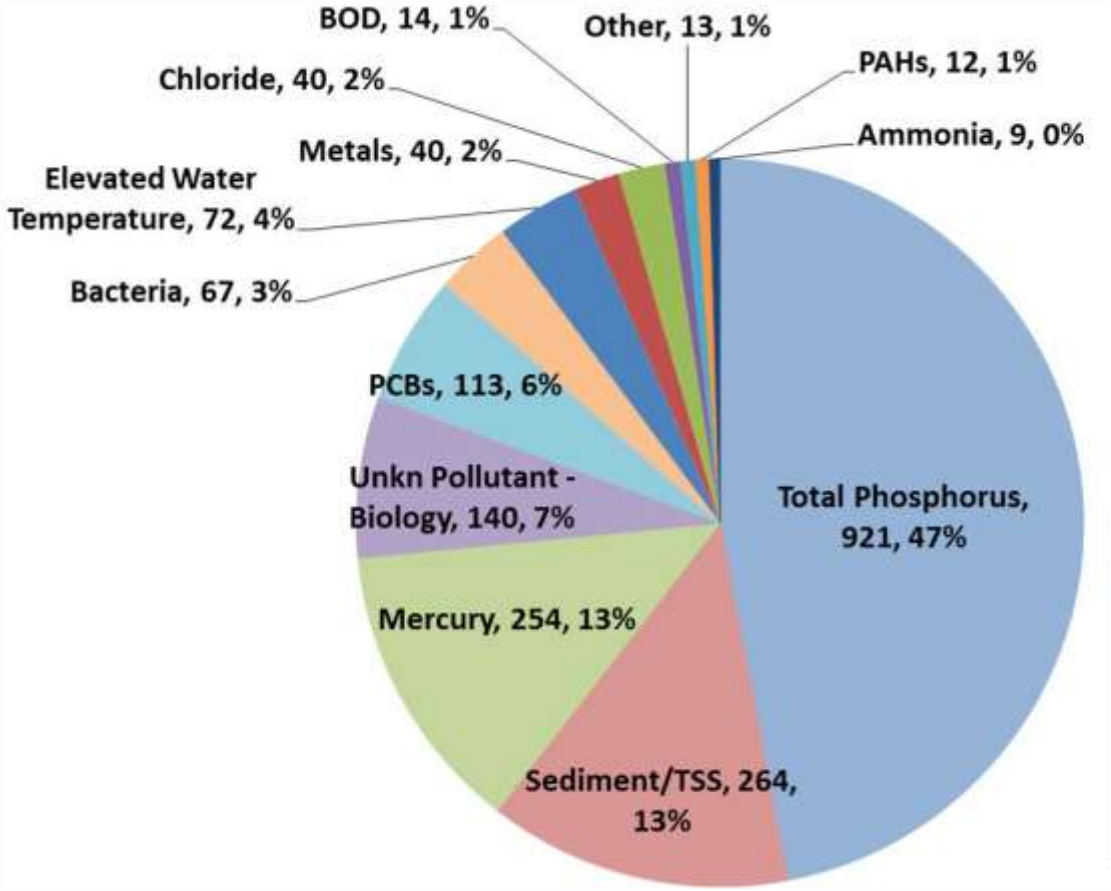
Biological Systems Engineering
UNIVERSITY OF WISCONSIN-MADISON

Take Home Points

- Land management and conservation practices important for improving water quality
- Achieving water quality goals requires identifying various sources within watershed
- Cold climates introduce additional variability in effectiveness of practices



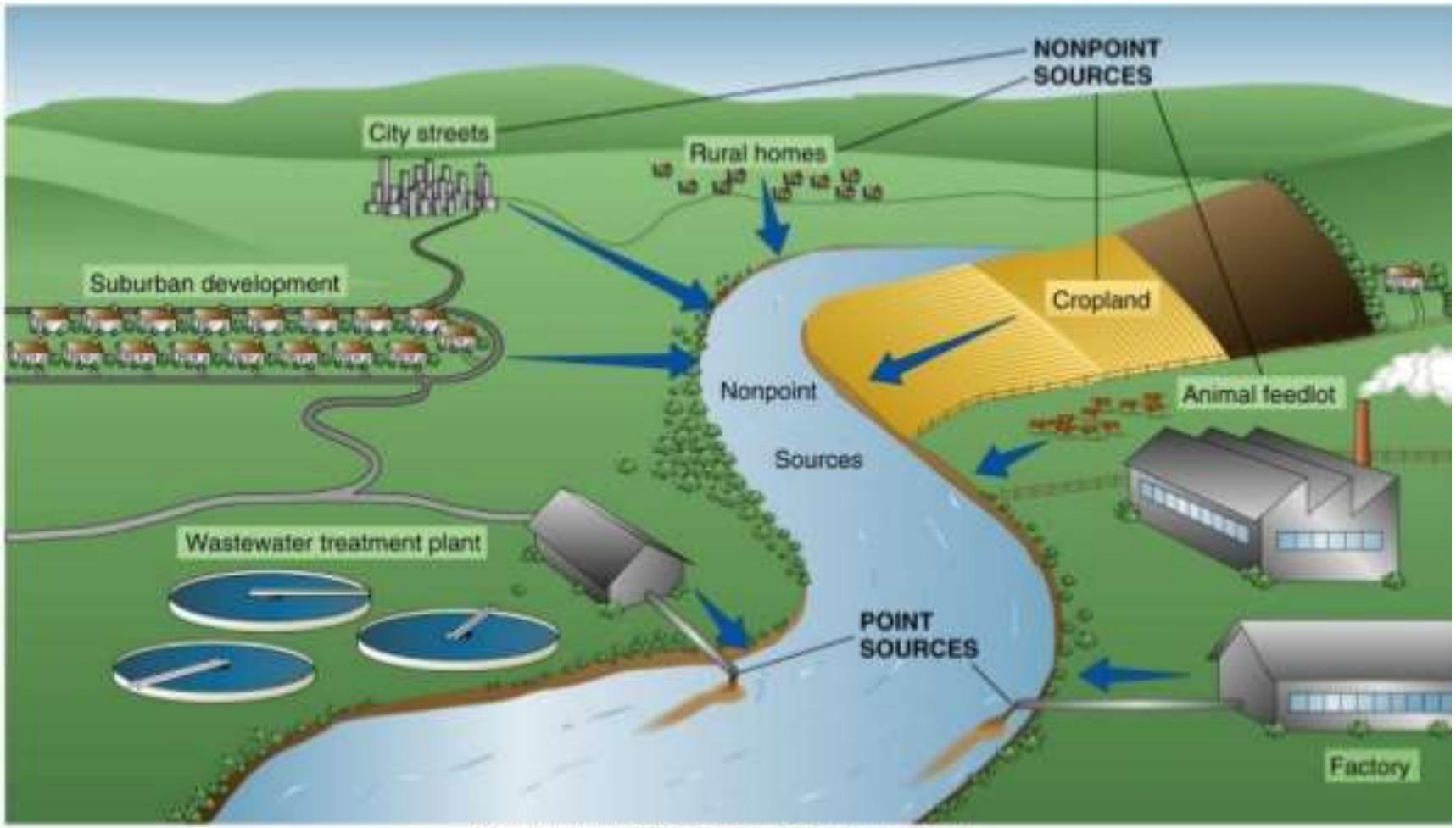
Wisconsin's 2018 CWA Section 303d List
Causes of impairment



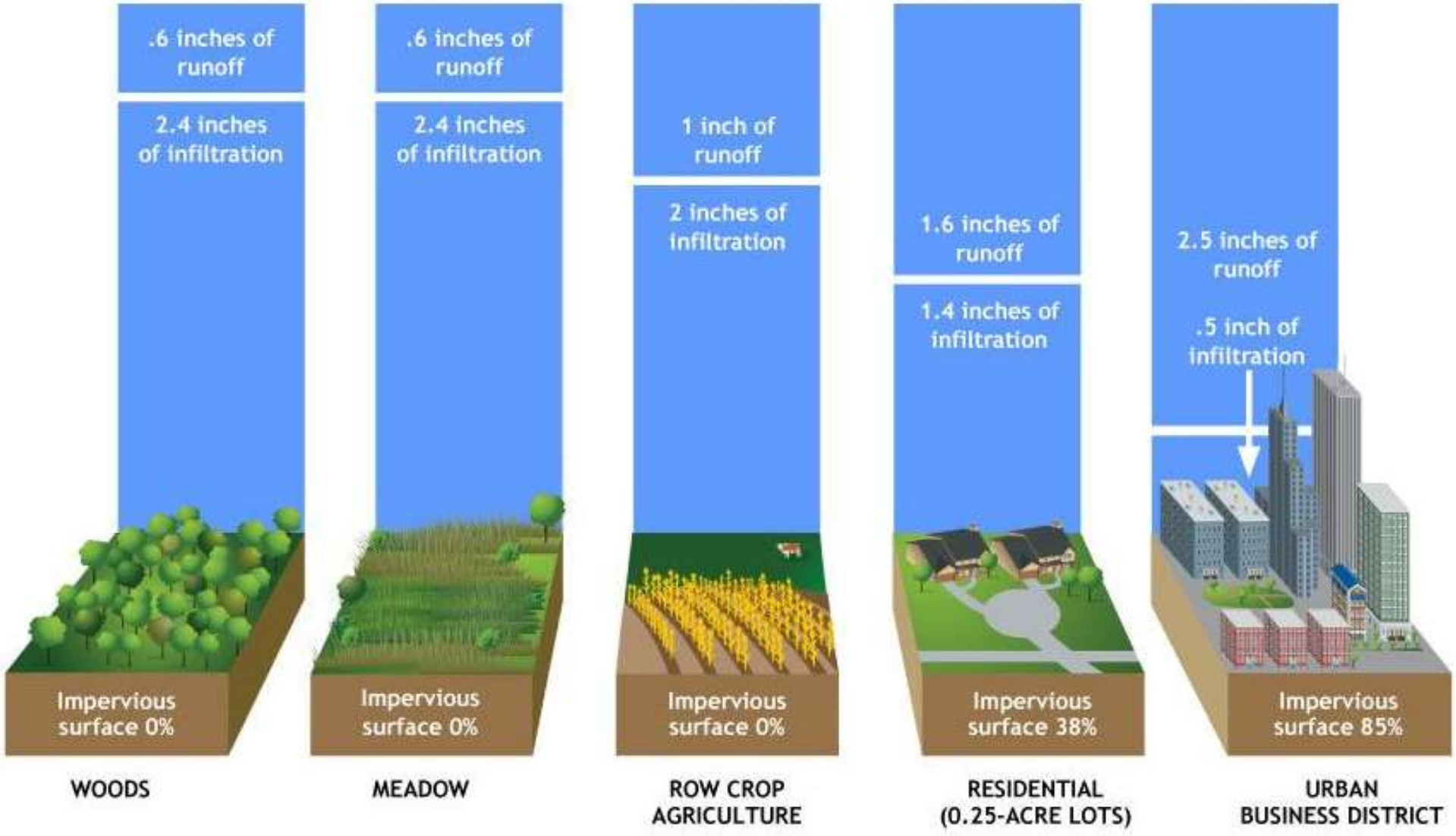
WDNR. Wisconsin Water Quality Report to Congress 2018.

- *Point source*: Pollutants discharged from a concentrated and recognizable source.
- *Non-point source*: Water flows on the surface dissolving and washing away pollutants and sediments along its path and finally discharging into receiving waters

Sources of Pollution



Hydrologic Changes Associated with Land Use



https://lakegeorgeassociation.org

Land Use Activities and Runoff

Agricultural Pollutants

- Sediment
- Nutrients (e.g. N and P) from chemical fertilizers and manure
- Pesticides (insecticides, herbicides, fungicides)
- Pathogens
- Metals
- Salt

Land Use Activities and Runoff

Urban Pollutants

- Sediment
- Oil, grease, and toxic chemicals from motor vehicles
- Pesticides and nutrients from lawns and gardens
- Viruses, bacteria, and nutrients from pet waste and failing septic systems
- Road salts
- Heavy metals from roof shingles, motor vehicles, and other sources
- Thermal pollution from dark impervious surfaces such as streets and rooftops

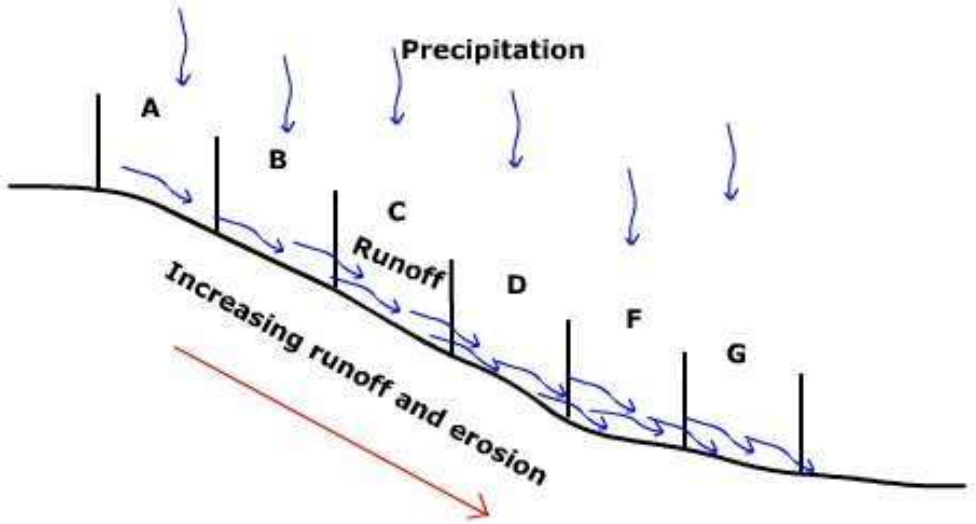
Downstream Effects of Polluted Runoff

- Degraded fish habitat
- Fish kills
- Nutrient loaded waters → heavy weed growth
- Degradation of drinking water supplies
- Siltation of harbors and streams
- Diminished recreational uses
- Changes in natural hydrology of wetlands, streams, rivers and lakes.

http://pubs.usgs.gov/sir/2006/5066/

http://abcnews.go.com/US/caused-toledos-water-contamination/story?id=24825275

Erosion Mechanisms



Land Management Practices

~Contouring, Strip Cropping, Terracing, Cover Crops~

http://photogallery.nrcs.usda.gov/

http://fyi.uwex.edu/fieldcroppathology/2014/04/23/wisconsin-winter-wheat-disease-update-april-16-2014/

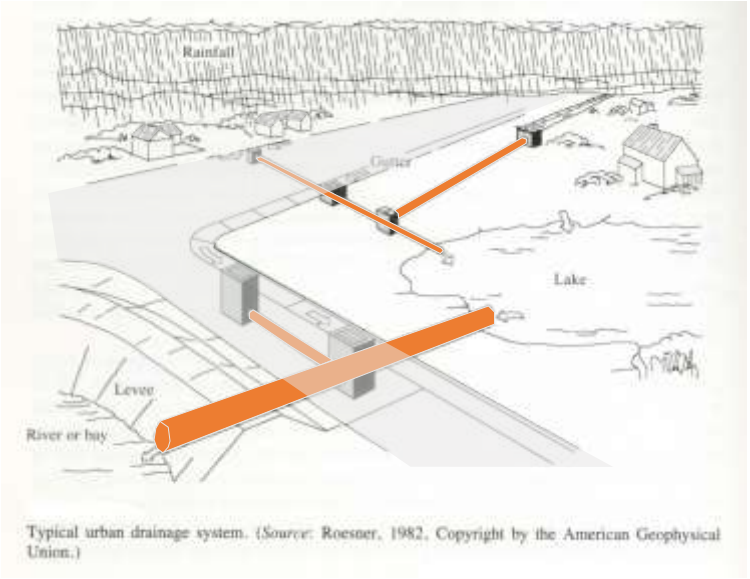
Land Management Practices

~Protecting Riparian Zones, Grassed Waterways, Sediment Basins, Constructed Wetlands~

http://photogallery.nrcs.usda.gov/

Stormwater management

~detention, infiltration~



Typical urban drainage system. (*Source*: Roesner, 1982. Copyright by the American Geophysical Union.)

Erosion and Sediment Control

Photos:
Jeremy
Balousek

https://blog.savatree.com/wp-content/uploads/LAKEART.jpg

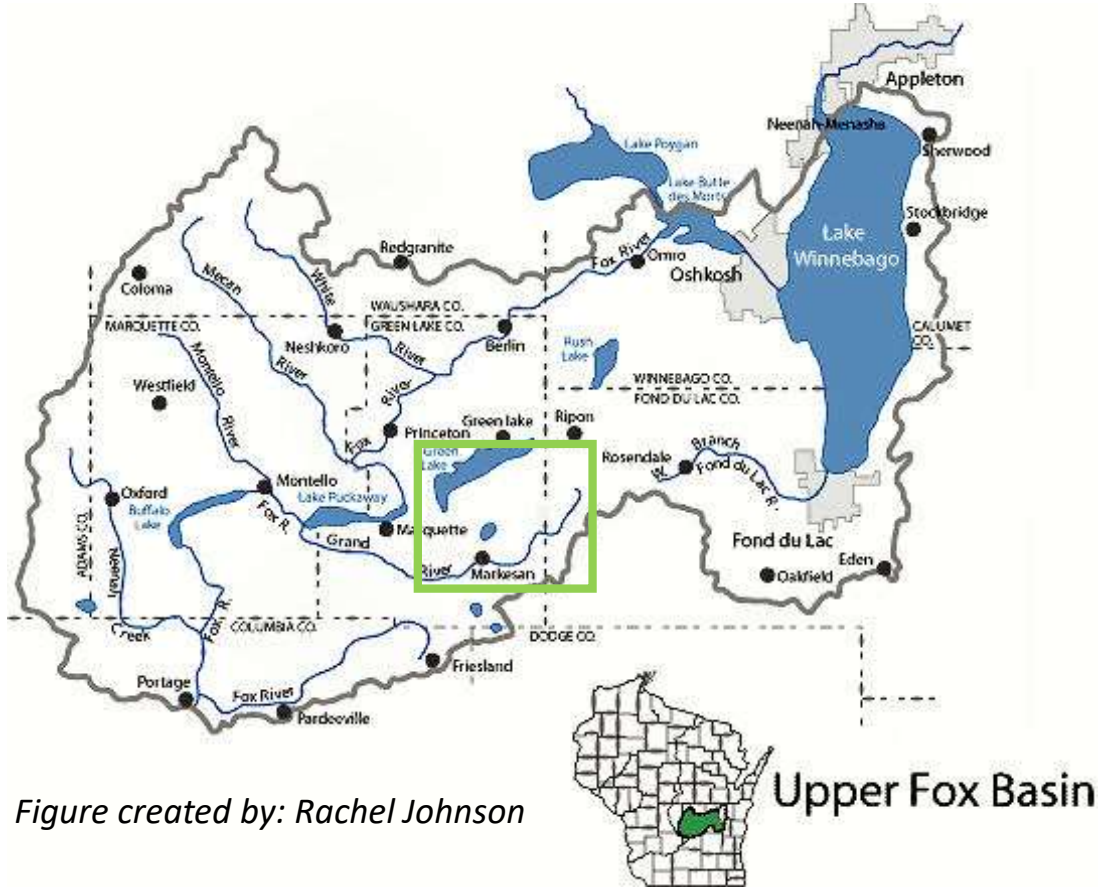


Figure created by: Rachel Johnson

Upper Fox Basin

Green Lake

- Wisconsin's deepest natural inland lake
- Surface area 30 km^2
- Watershed 241 km^2
- Average depth 31 m (max 72m)
- Residence time 25 years

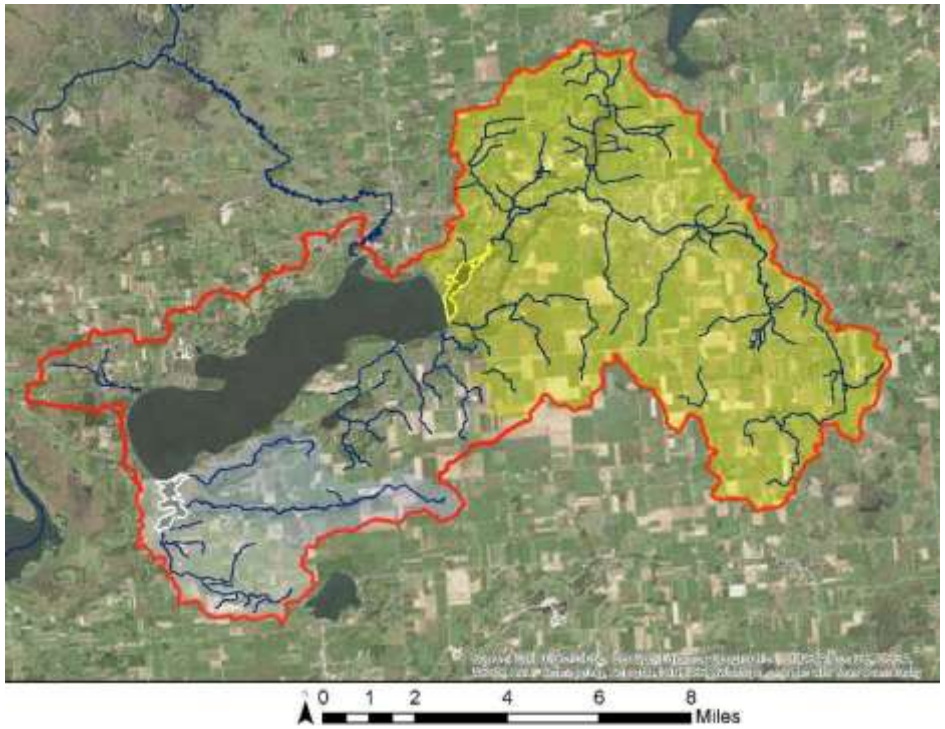


Figure created by: Sarah Fuller

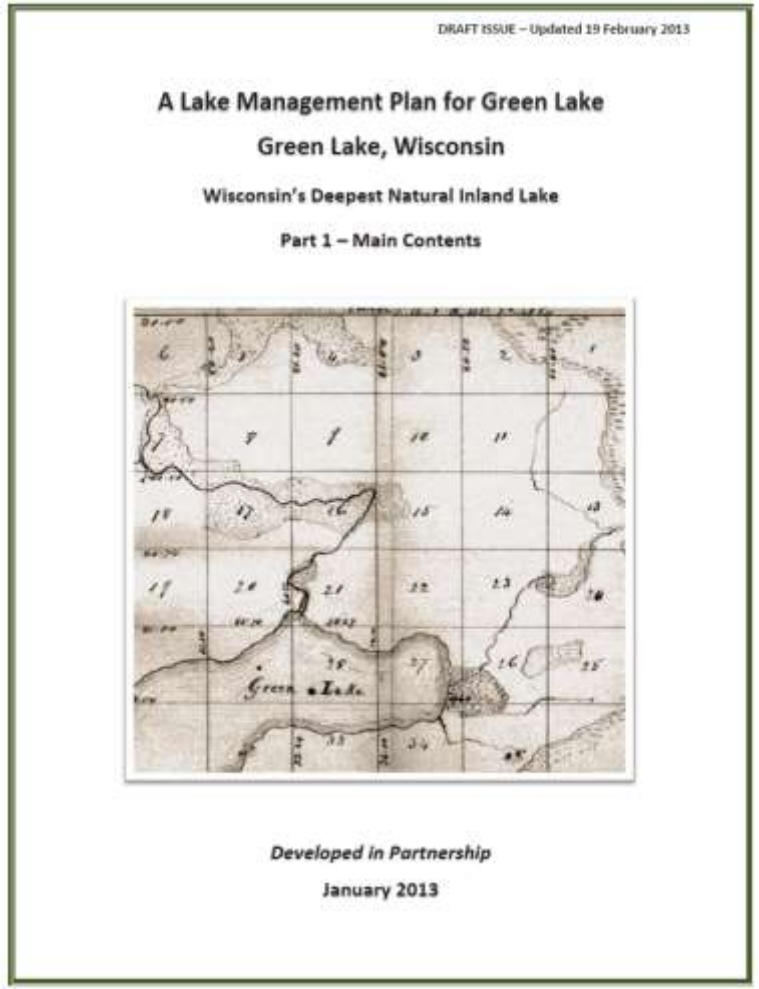
Challenges

- Green Lake is mesotrophic
- Impaired for dissolved oxygen
- Phosphorus (P) is major pollutant

Lake Management Planning Team

- Established 2011
- Lake Management Plan (Sesing *et al.*, 2015)
- P reduction goal of 15% by 2023

Green Lake Sanitary District
Green Lake Association
Green Lake Conservancy
Green Lake and Fond du Lac County Land Conservation Departments
Cities of Green Lake and Ripon
Wisconsin Department of Natural Resources
United States Geological Survey


DRAFT ISSUE – Updated 19 February 2013

A Lake Management Plan for Green Lake

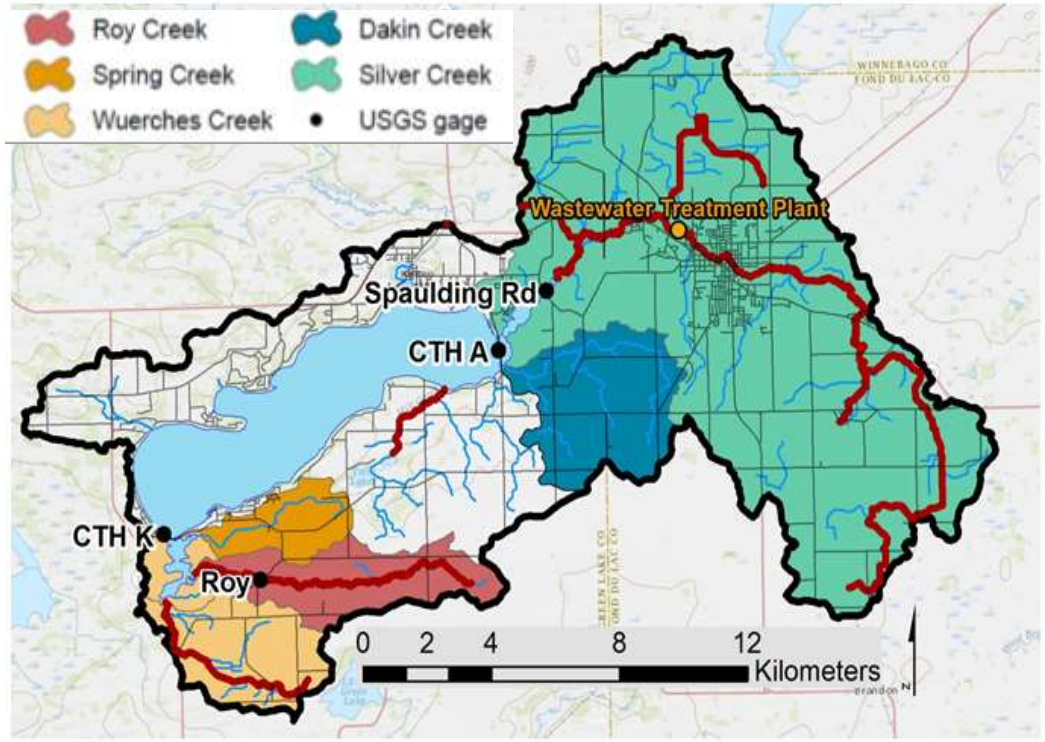
Green Lake, Wisconsin

Wisconsin's Deepest Natural Inland Lake

Part 1 – Main Contents

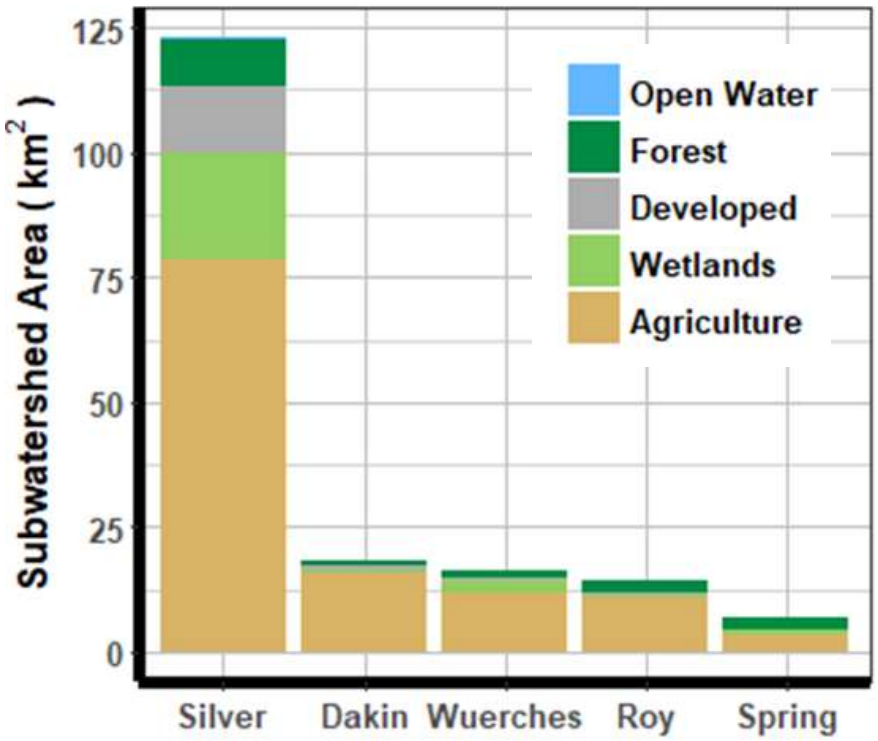
Developed in Partnership

January 2013



Figures created by: Sarah Fuller

Predominantly agricultural



Several tributaries impaired
Shallow open-water marshes
Gateways to Green Lake

Understanding role of watershed land use, marshes, and point discharges important

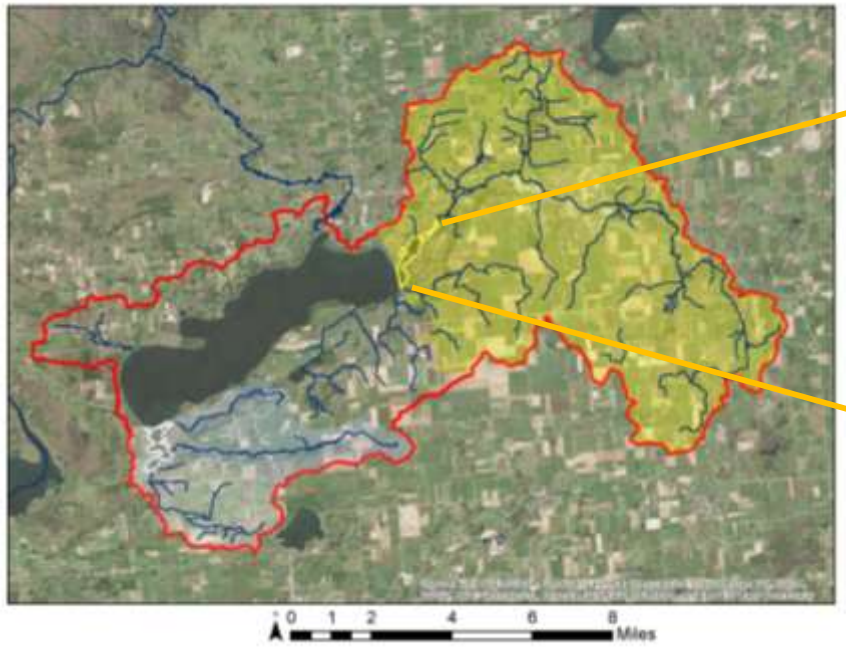


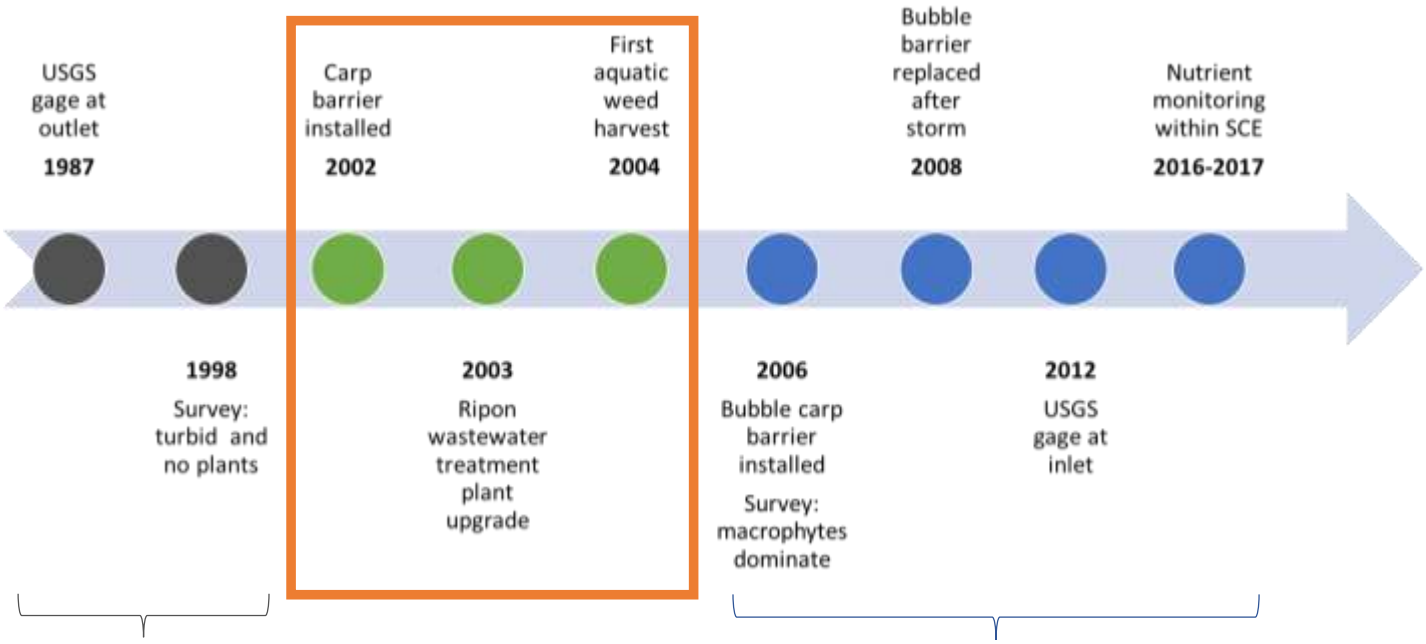
Figure created by: Sarah Fuller

Photo by: Sarah Fuller

Silver Creek Estuary

Restoration efforts 2002 now clear water & macrophyte-dominated

https://www.thegreenlaker.com/2016/06/20/30-tons-of-carp-pulled-from-sw-side-of-big-green/



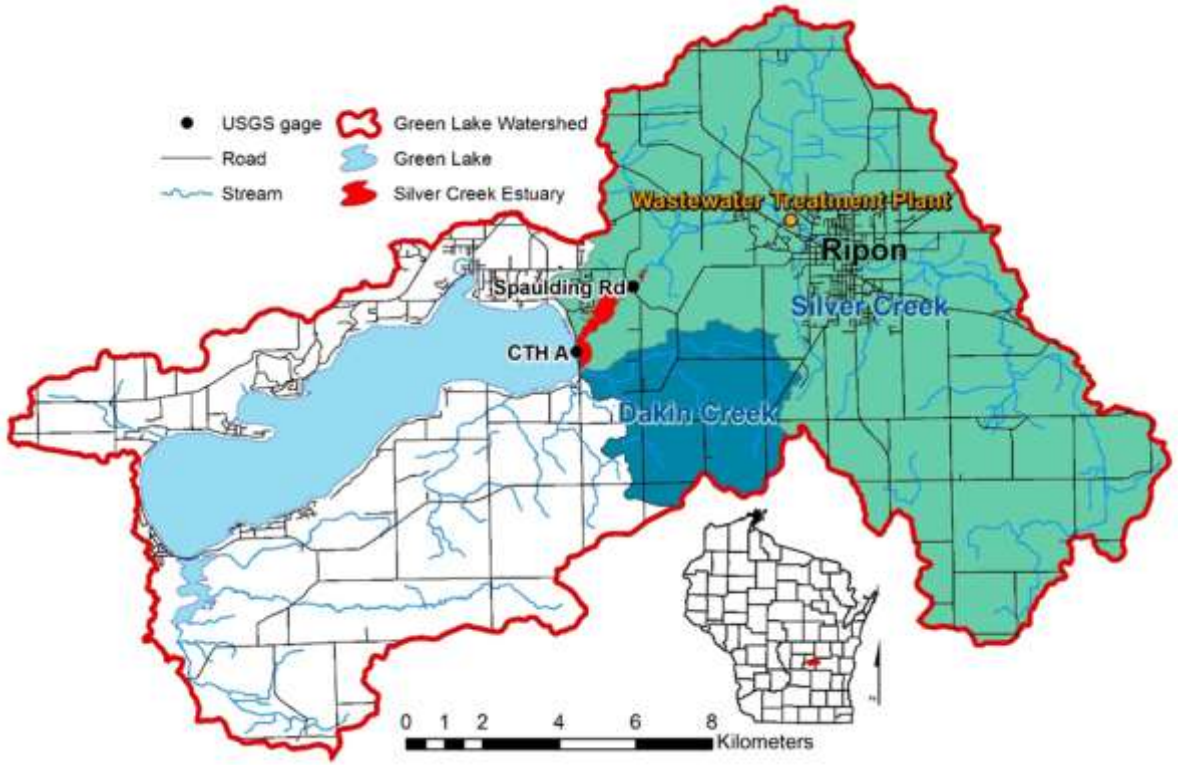


Figure created by: Sarah Fuller

Possibilities

Precipitation

Upland Management

RWTP Upgrade

Equilibrium shift in SCE

Water Quality at Outlet of SCE

~Pre to Post Management Actions in Marsh~

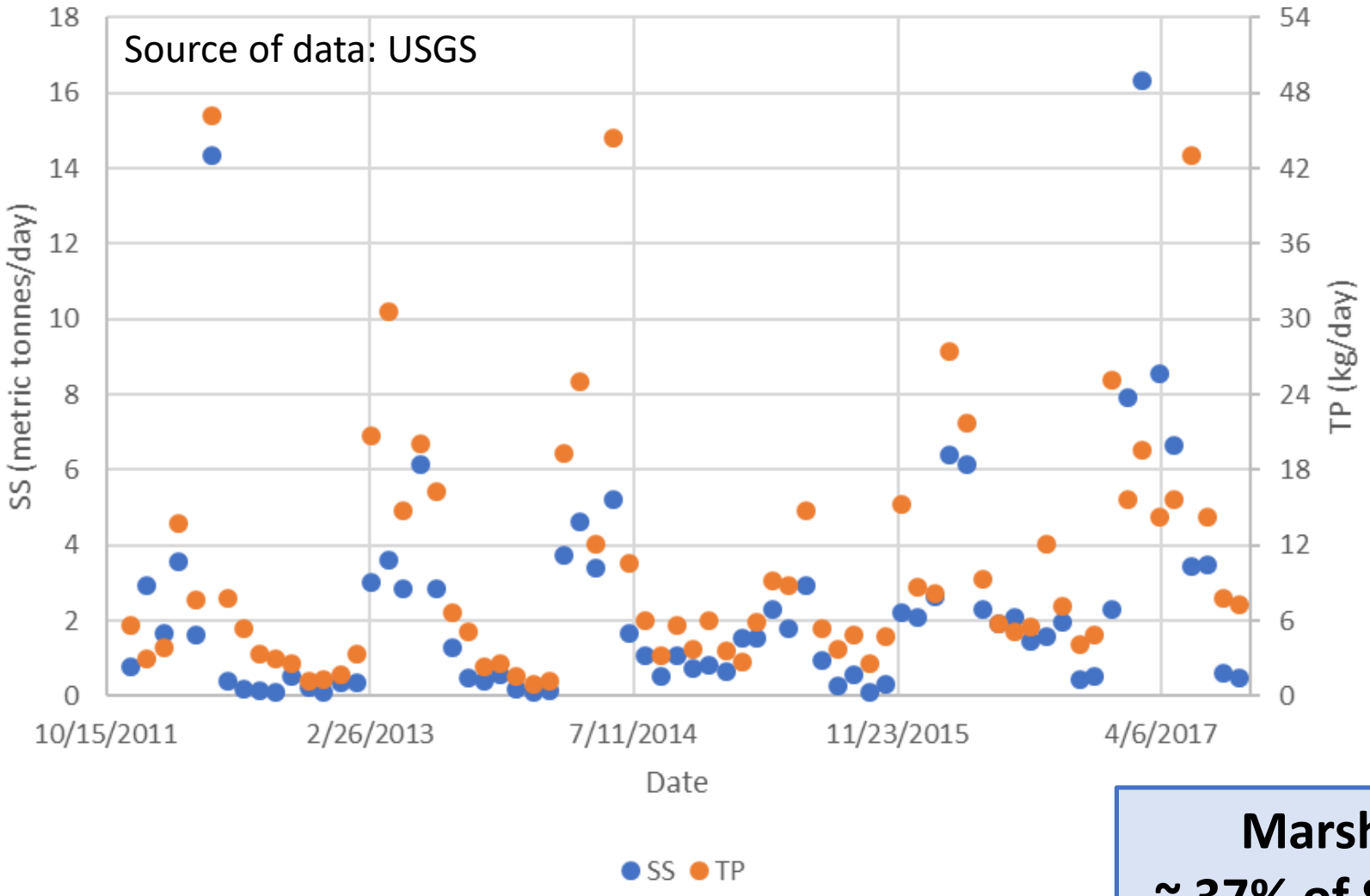
	Winter	Spring	Summer	Fall
TP Load	↓ 22%	↓ 13%	↓ 27%	↓ 41%
SS Load	≈	↓ 12%	↓ 40%	≈

Fuller (2019)

Spring and Summer: carp reductions and macrophytes establishment most noticeable before/after – both impact TP and SS (*Weber and Brown, 2009; Schrage and Downing, 2014*)

Winter and Fall: no change in SS. TP reduction influenced more by RWTP upgrade which reduced P loads 3.4 kg/day to 0.9 kg/day

Sediment and Phosphorus Entering SCE



Marsh retained
~ 37% of SS ~15% of TP
Fuller (2019)

Soil Water Assessment Tool (SWAT) Results

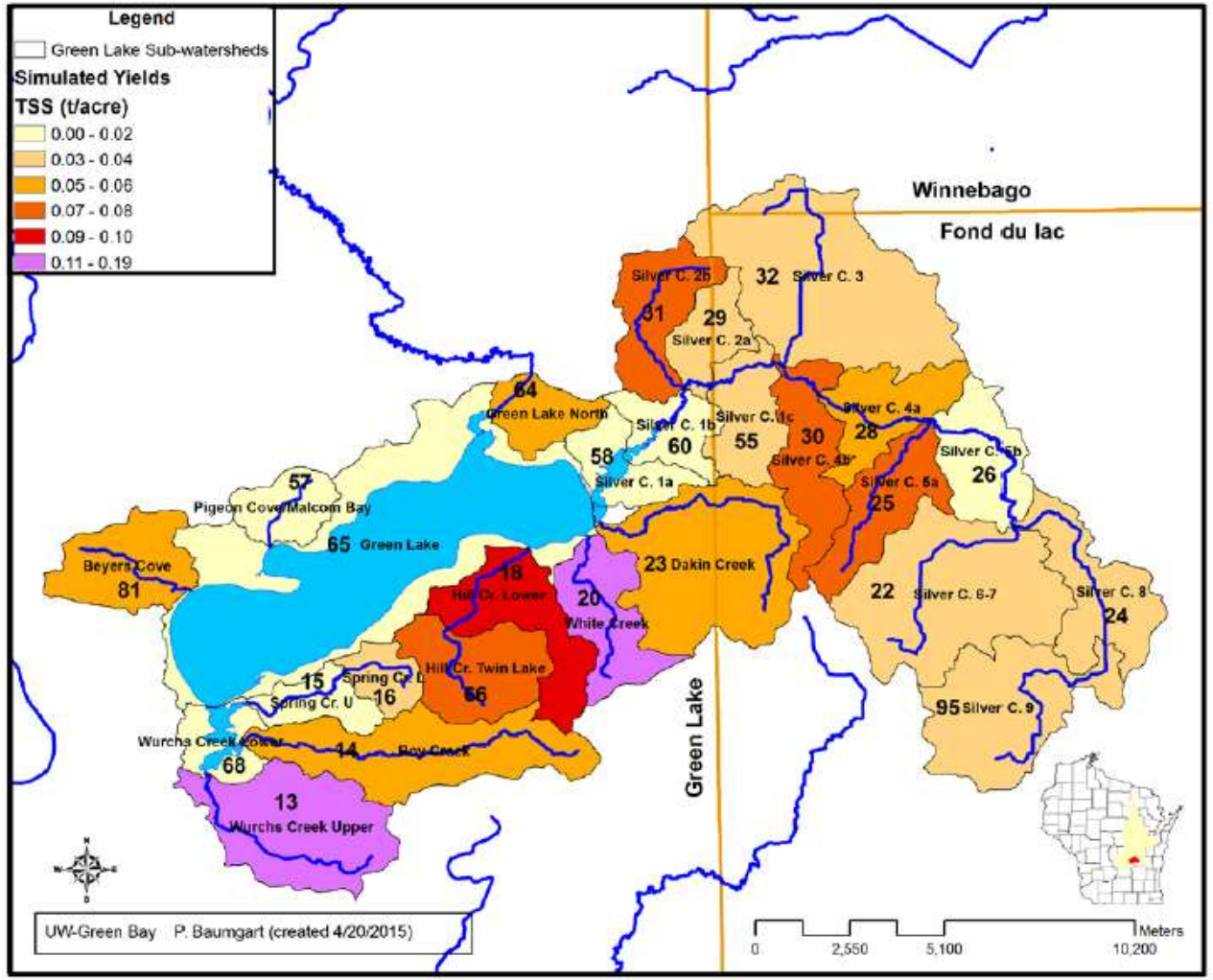
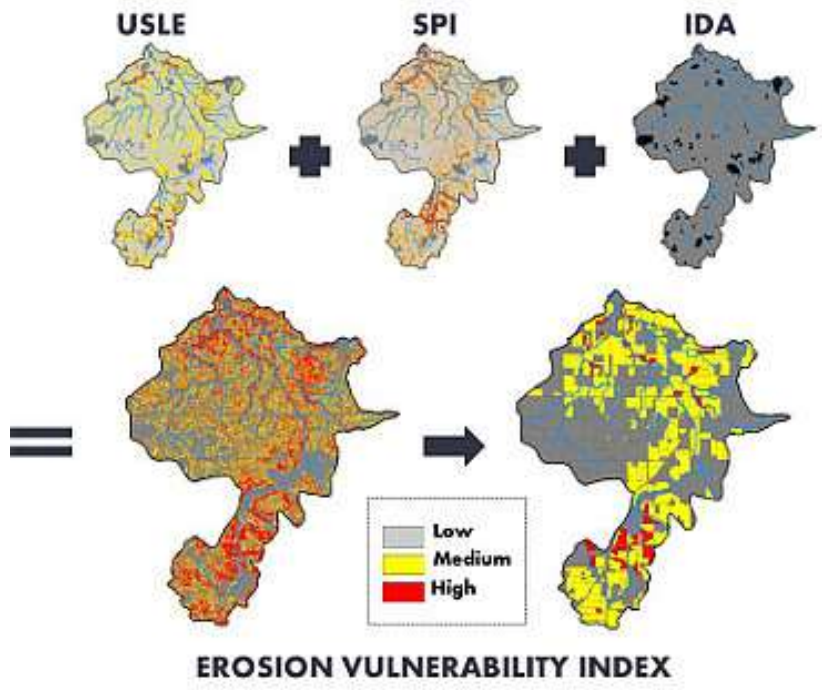


Figure 2. Green Lake simulated non-pt. source sub-watershed average annual TSS yields (ton/acre; 1998-2012 weather).

Baumgart, P. 2015. Application of the Soil and Water Assessment Tool (SWAT) to Evaluate Non-Point Source Phosphorus and TSS Loads in the Big Green Lake Watershed, Wisconsin.

Erosion Vulnerability Assessment for Agricultural Lands (EVAAL)

- Wisconsin Department of Natural Resources
- Identify areas within a watershed that may be vulnerable to water erosion and thus may contribute to downstream surface water quality problems
- Separately assesses risk for sheet/rill erosion (Universal Soil Loss Equation, USLE), and gully erosion (Stream Power Index, SPI), while de-prioritizing areas not hydrologically connected to surface waters (Internally Drained Areas, IDA)
- https://dnr.wi.gov/topic/Nonpoint/EVAAL.html



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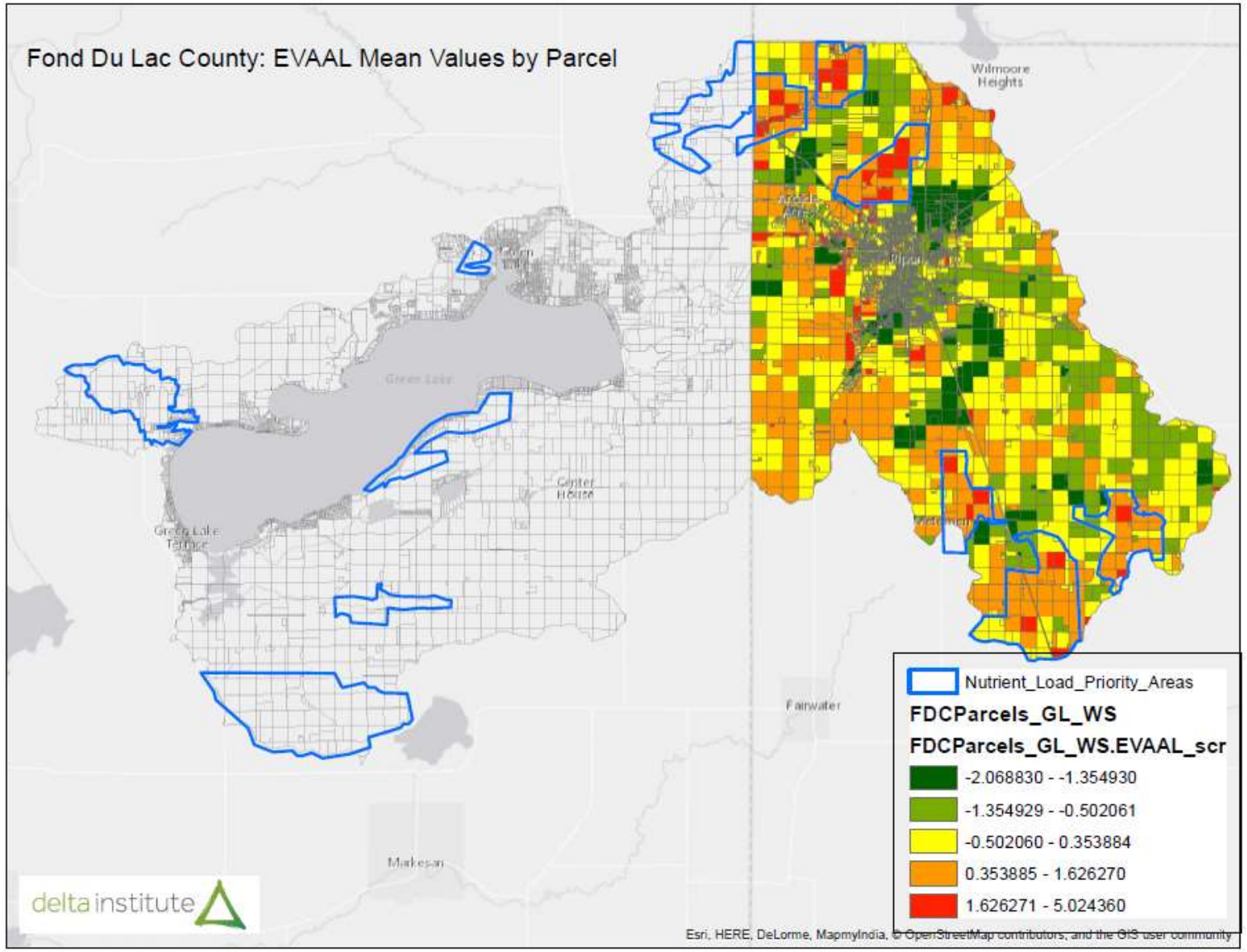
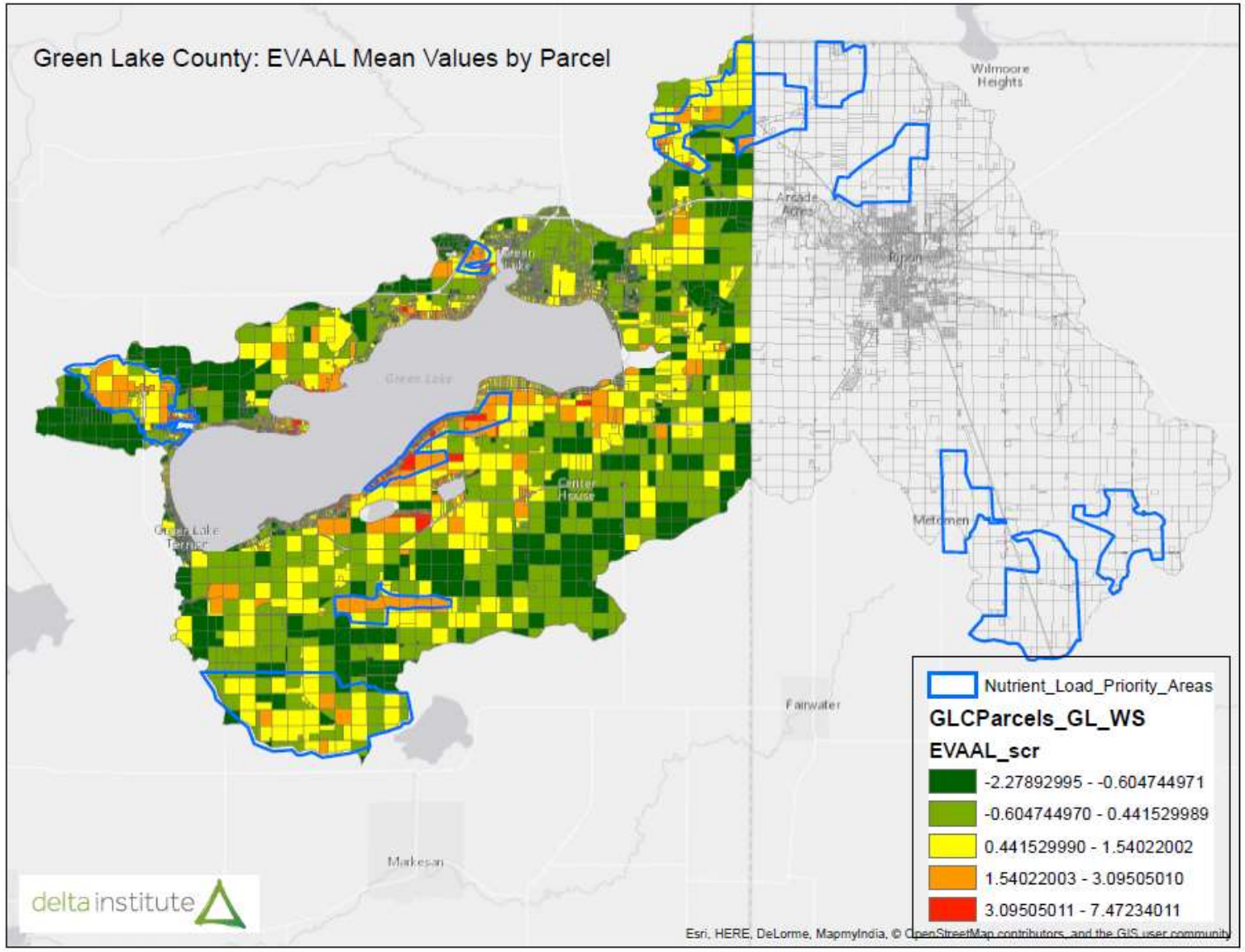


<u>Nutrient Loading Priority Areas</u>:

High density clusters of high nutrient loading
+
Low density clusters of existing Best Management Practices (BMPs)

Figure taken from: Delta Institute (2016) The Green Lake Watershed Phosphorus Prioritization Tool.



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University of Wisconsin-Stevens Point
College of Natural Resources

Green Lake Watershed
Social Science Assessment

FARMER SURVEY REPORT

Survey Invitation Letter

We're asking for your help! A group in your community – the Green Lake Management Planning (LMP) Team is working hard to protect the health of Big Green Lake. The multi-organization team works around Green Lake's shorelines, urban and agricultural areas in their effort to improve lake water quality. As highlighted in green in the map shown here, this lake is part of an agricultural landscape, which means that problem solving help from the farming community is critical to the success of community efforts.

We want your input on the priorities of those who know the land best: agricultural producers and landowners in the Green Lake watershed. We are asking you to complete this survey, which should take about 20 minutes of your time. The survey is being conducted by the UW-Extension Center for Land Use Education at UW-Stevens Point that assists communities in understanding the priorities of key stakeholders. Please contribute to this effort by completing the survey and returning it in the enclosed postage paid envelope.

Here are a few important notes about this study:

- All results will be kept confidential; we're just looking for your important perspective about how to better manage Green Lake and the surrounding watershed.
- All responses will be treated as anonymous and records used to contact respondents containing identifying information will be destroyed prior to the research team reviewing data.
- Please skip any questions that make you feel uncomfortable or that you don't know how to answer.
- We do not anticipate any potential for risk or harm due to participation in this study; however, if you have any complaints about your treatment as a participant in this study please contact Dr. Debbie Palmer, IRB Chair at (715) 346-3953, e-mail at irbchair@uwsp.edu, or mail at University of Wisconsin-Stevens Point, Science Building D240, Stevens Point Wisconsin 54481.

While your participation is voluntary your input can help bring local voices into these important efforts to benefit Green Lake! If you have any questions or comments about this project you may contact me using the information provided below.

Thank you for your time and we're looking forward to hearing from you!

Dr. Aaron Thompson, Associate Professor
E-mail: aaron.thompson@uwsp.edu Phone: 715.346.2278

UW Extension
University of Wisconsin-Extension

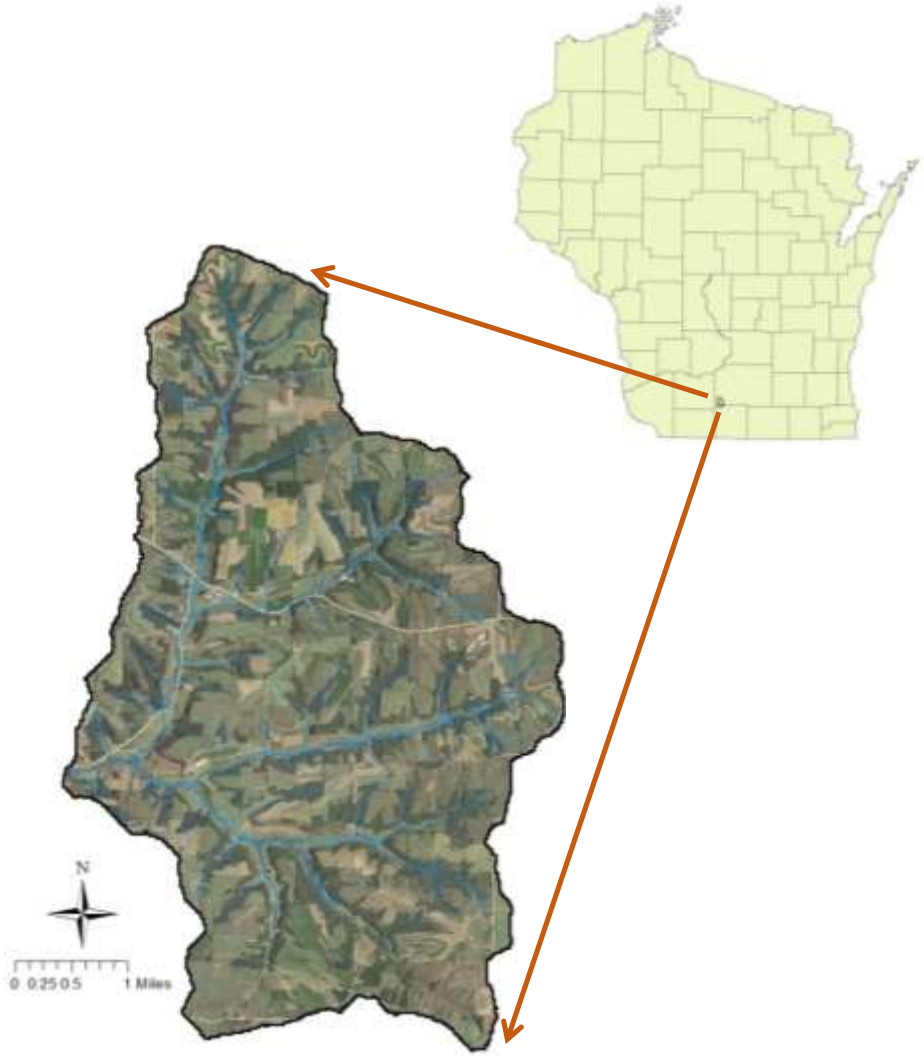
Biological Systems Engineering
UNIVERSITY OF WISCONSIN-MADISON

Experience and interest in conservation practices
Perceived barriers to participation
Trusted partners working within the watershed

Summarized information about landowners in 7 unique areas within the watershed to support the development of landscape strategies that are responsive to the needs of those who live and work the land in these areas

Dr. Aaron Thompson
Formerly UW Stevens Point
Currently Purdue University

Pleasant Valley Watershed



- Dominant land uses
  - Cropland
  - Pasture
  - Forest
  - Grassland
- Area ~19 sq miles
- Average slope is 11%
- Silt loam soils

Subwatershed Phosphorus and Sediment Yield

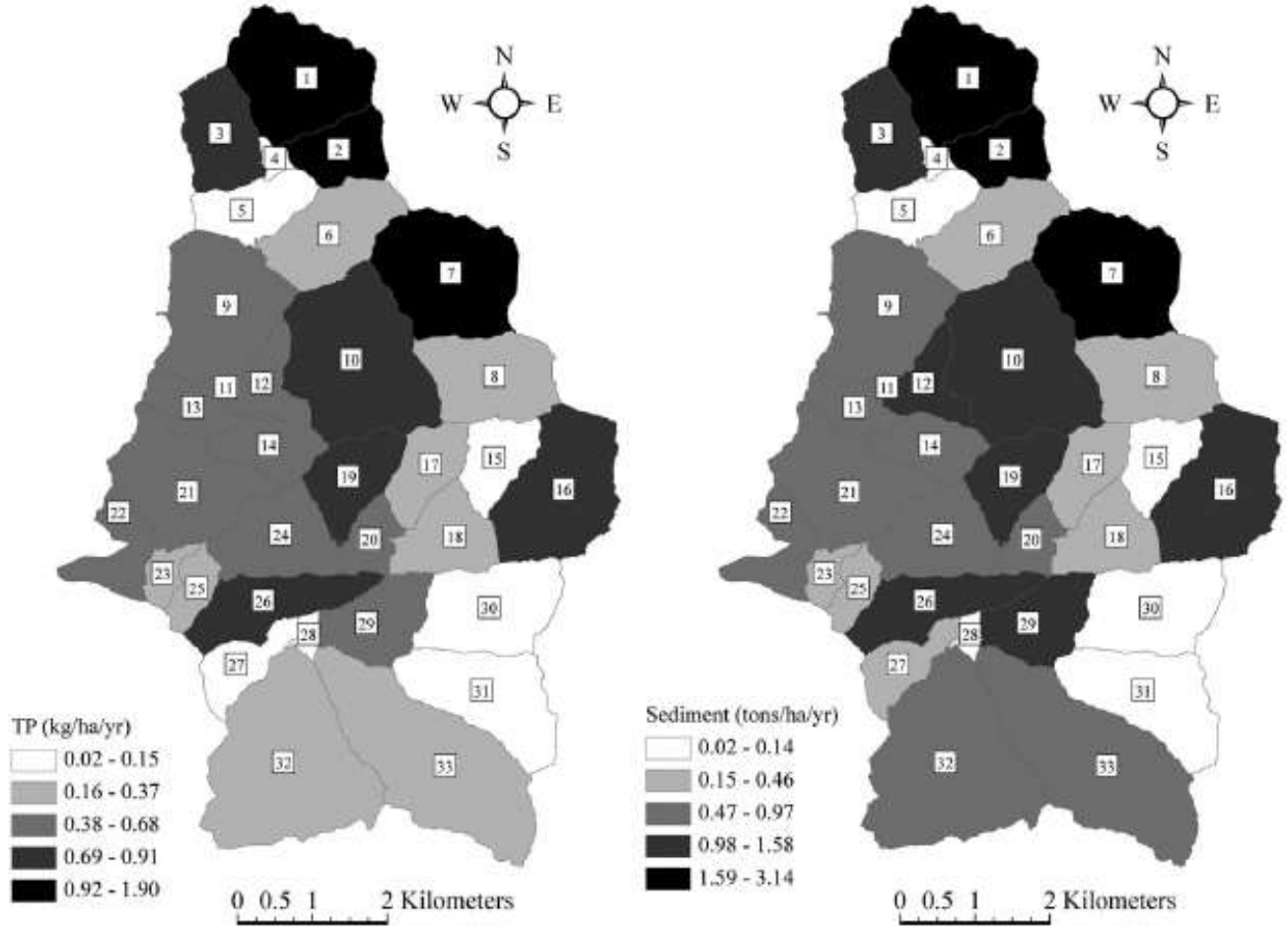


Fig. 3. Total phosphorus (kg $ha^{-1} yr^{-1}$) and sediment yield (tons $ha^{-1} yr^{-1}$) at the subwatershed level on an annual average basis (2006–2012).

Lamba, J., A.M. Thompson, K.G. Karthikeyan, J. Panuska, and L. Good. 2016. Effect of best management practice implementation on sediment and phosphorus load reductions at subwatershed and watershed scale using SWAT model. *International Journal of Sediment Research.* 31(4):386–394.

Cropland to CRP Scenario

Location	Conversion to CRP grasslands Short-Term		Watershed Area Targeted for BMPs (%)
	Sediment Reduction (%)	TP Reduction (%)	
Subwatershed 1	99	84	2.7
Subwatershed 2	98	86	1.3
Subwatershed 7	99	88	3.7
Watershed Outlet	9	15	-

Lamba, J., A.M. Thompson, K.G. Karthikeyan, J. Panuska, and L. Good. 2016. Effect of best management practice implementation on sediment and phosphorus load reductions at subwatershed and watershed scale using SWAT model. *International Journal of Sediment Research.* 31(4):386–394.

Implementing No-till Practices

Location	No-Till Short-Term		Watershed Area Targeted for BMPs (%)
	Sediment Reduction (%)	TP Reduction (%)	
Subwatershed 1	22	21	2.7
Subwatershed 2	22	22	1.3
Subwatershed 7	25	22	3.7
Watershed Outlet	2	3	-

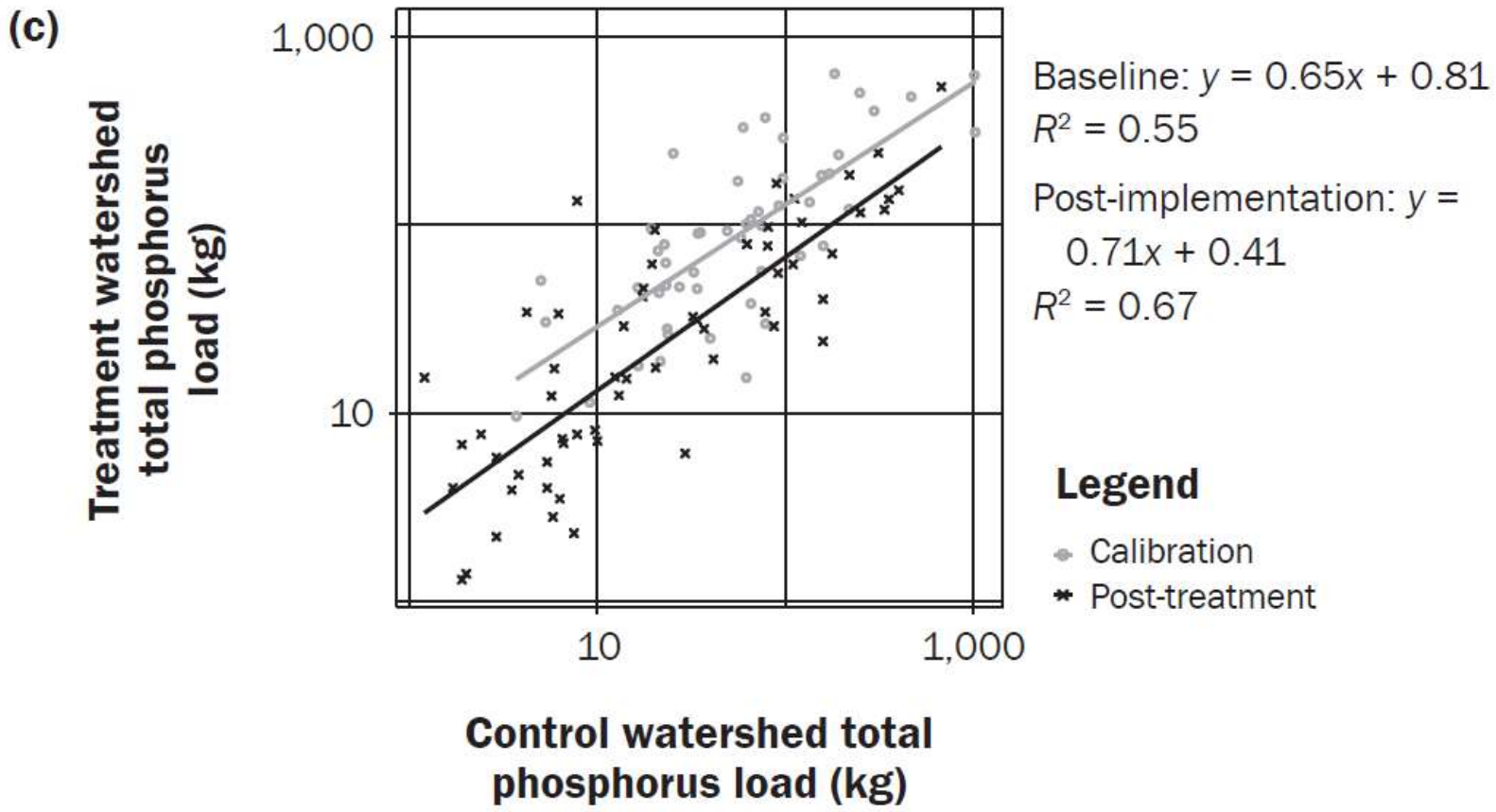
Lamba, J., A.M. Thompson, K.G. Karthikeyan, J. Panuska, and L. Good. 2016. Effect of best management practice implementation on sediment and phosphorus load reductions at subwatershed and watershed scale using SWAT model. *International Journal of Sediment Research.* 31(4):386–394.

Pleasant Valley Paired (Treatment & Control) Watershed Study

Treatment watershed
Field- and farm-based conservation practices in highest contributing areas

Control watershed
No out-of-the-ordinary conservation practices

TP loads significantly reduced ($p < 0.01$) for runoff events
Median reduction 50%



Carvin et al., 2018. Testing a two-scale focused conservation strategy for reducing phosphorus and sediment loads from agricultural watersheds. *Journal of Soil and Water Conservation*. 73(3):298-307.

Land Management and Water Quality: Frozen vs Non-frozen Conditions

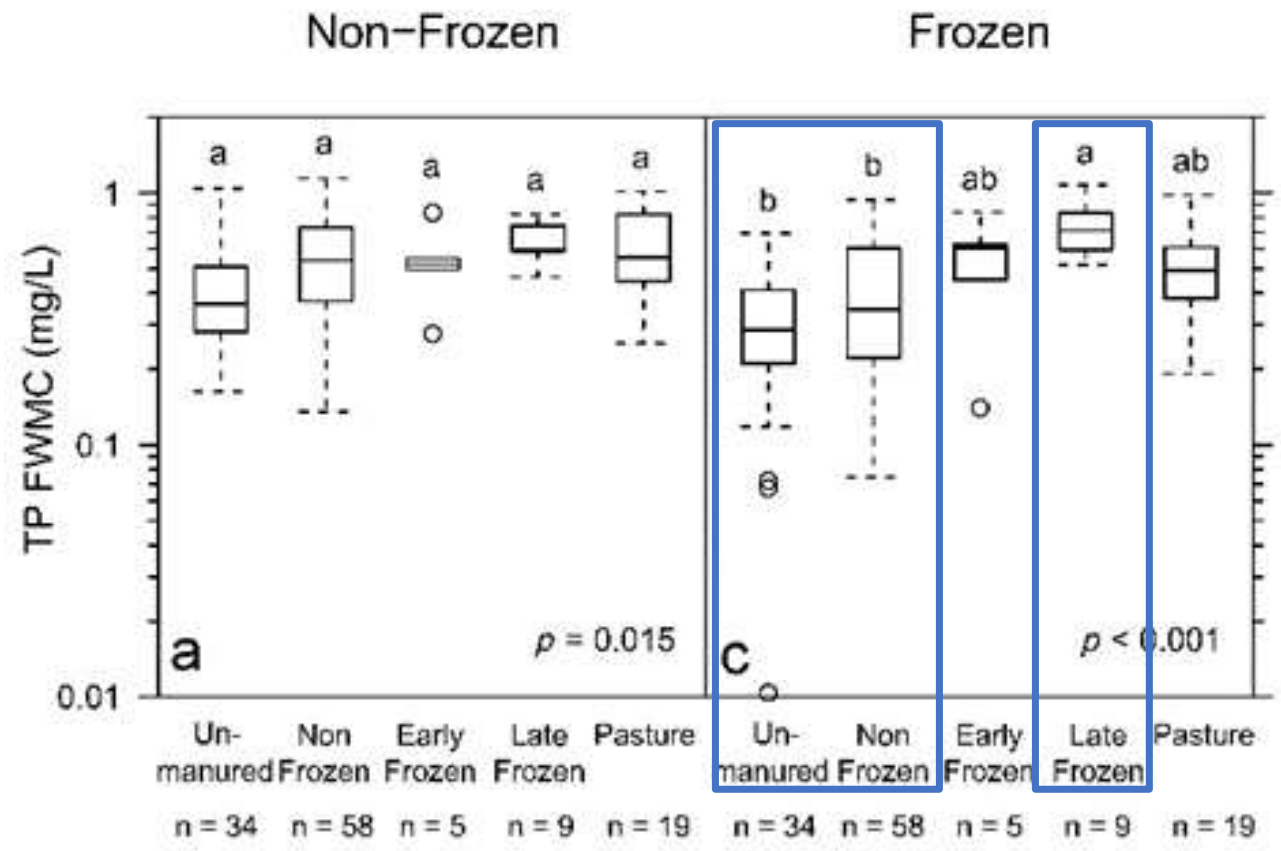
- Discovery Farms Program
  - 125 site years
  - 26 fields (2-17 ha)
  - 13 environmental and 7 management factors
  - 2 states

http://www.uwdiscoveryfarms.org/on-farm-projects/watersheds

http://wbay.com/2015/02/08/environmentalists-manure-spills-endangering-wisconsin-water/

Zopp, Z. , M.D. Ruark, A.M. Thompson, T.D. Stuntebeck , E. Cooley, A. Radatz, T. Radatz. Effects of Field-level Management Practices on Edge-of-field Phosphorus Loading in Cold Climates. *Journal of Environmental Quality*. (In Review)

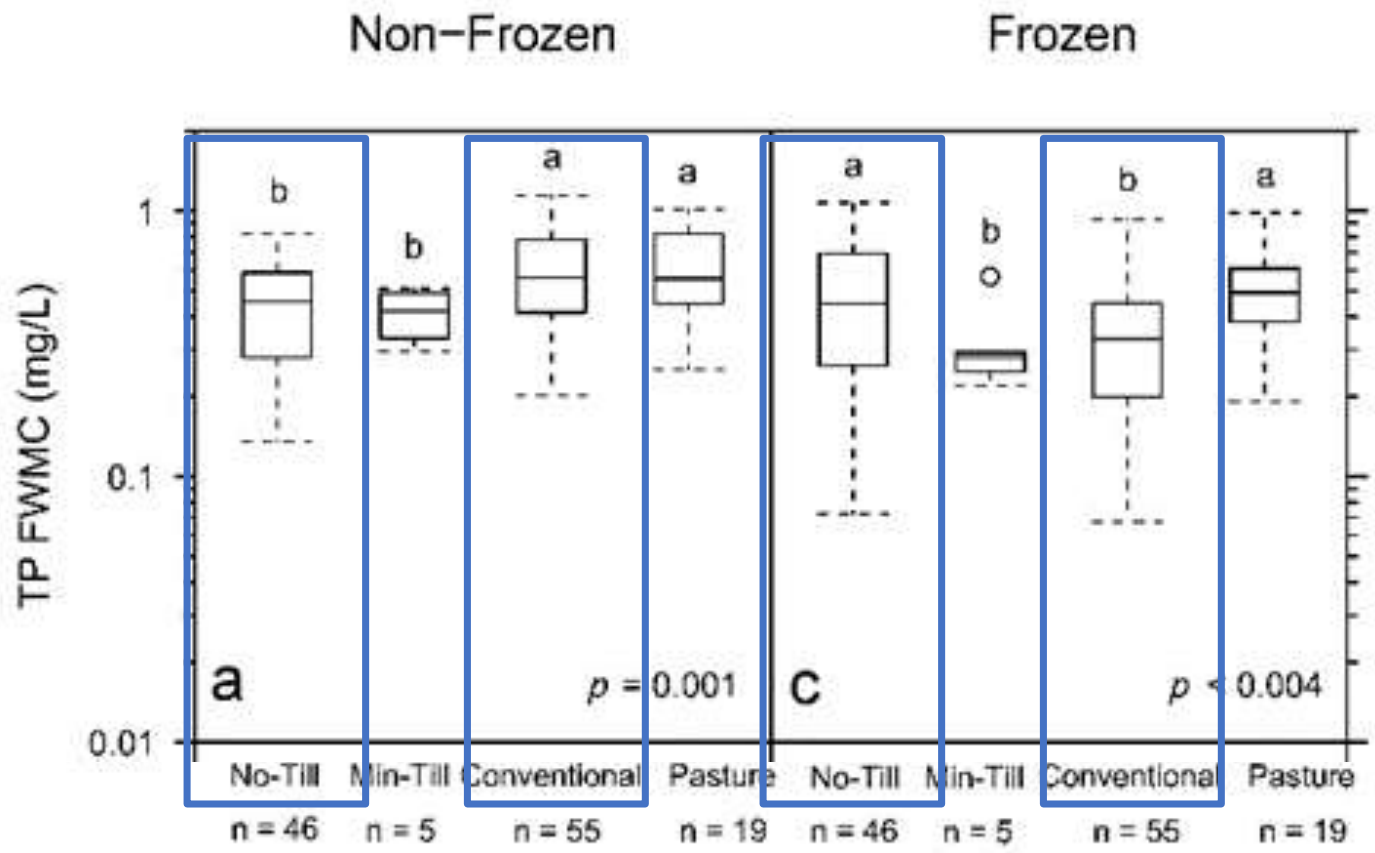
Manure Application



Applying manure through late-frozen soil conditions increased P losses during frozen soil conditions but not during non-frozen conditions.

Zopp, Z. , et al. *Journal of Environmental Quality*. (In Review)

Tillage



Conventional tillage reduced TP and DP losses compared to no-till during frozen condition, yet increased TP losses during non-frozen condition

Zopp, Z. , et al. *Journal of Environmental Quality*. (In Review)

Take Home Points

- Land management and conservation practices important for improving water quality
- Achieving water quality goals requires identifying various sources within watershed
- Cold climates introduce additional variability in effectiveness of practices