Visualizing wetland water: Watershed and buffer conditions organize cross-USA wetland water quality

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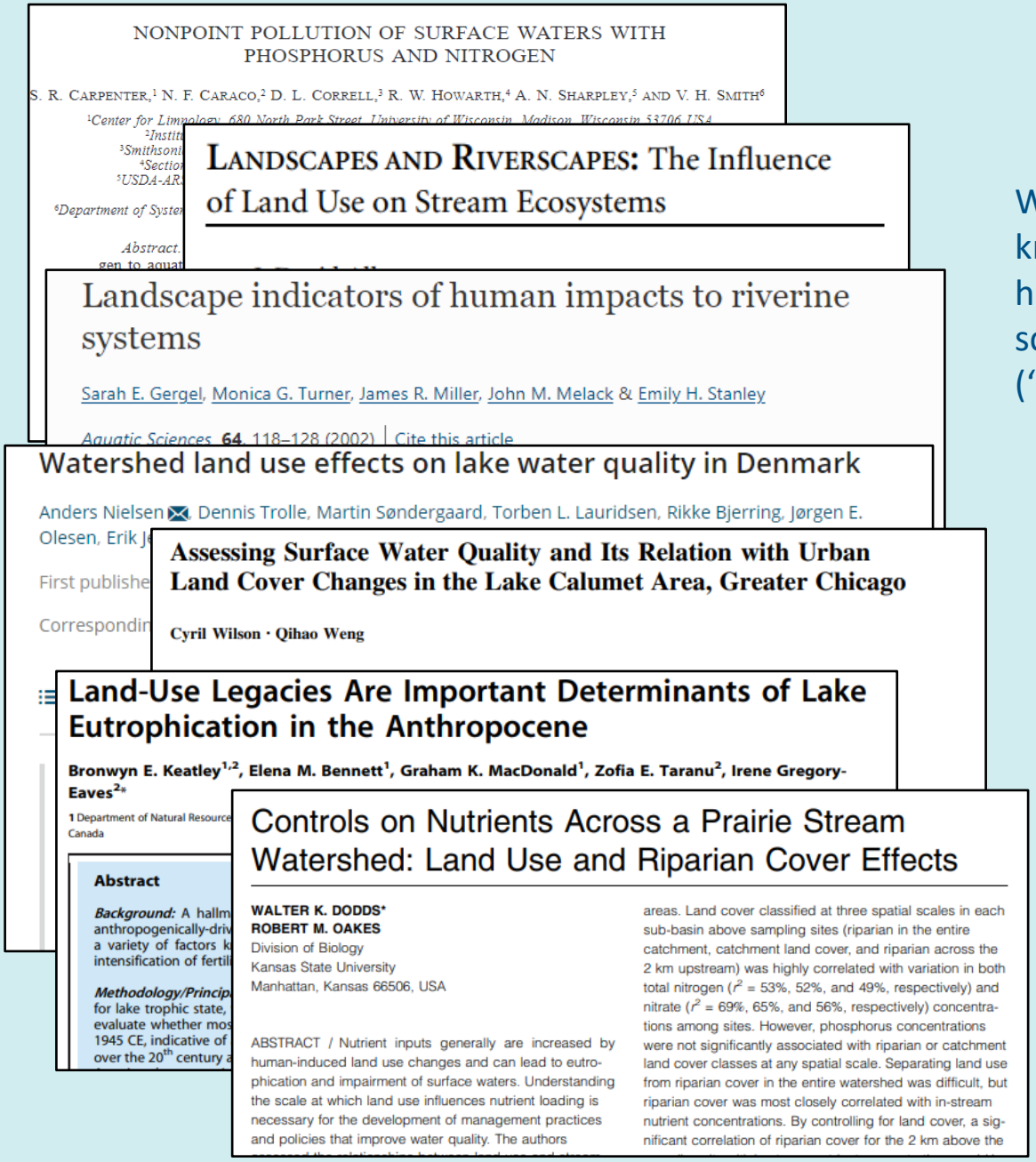
Background


NONPOINT POLLUTION OF SURFACE WATERS WITH PHOSPHORUS AND NITROGEN

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LANDSCAPES AND RIVERSCAPES: The Influence of Land Use on Stream Ecosystems

Landscape indicators of human impacts to riverine systems

Sarah E. Gergel, Monica G. Turner, James R. Miller, John M. Melack & Emily H. Stanley

Aquatic Sciences 64, 118–128 (2002) | Cite this article

Watershed land use effects on lake water quality in Denmark

Anders Nielsen, Dennis Trolle, Martin Søndergaard, Torben L. Lauridsen, Rikke Bjerring, Jørgen E. Olesen, Erik J

Assessing Surface Water Quality and Its Relation with Urban Land Cover Changes in the Lake Calumet Area, Greater Chicago

Cyril Wilson · Qihao Weng

Land-Use Legacies Are Important Determinants of Lake Eutrophication in the Anthropocene

Bronwyn E. Keatley[1,2], Elena M. Bennett[1], Graham K. MacDonald[1], Zofia E. Taranu[2], Irene Gregory-Eaves[2]*

Abstract

Controls on Nutrients Across a Prairie Stream Watershed: Land Use and Riparian Cover Effects

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ABSTRACT / Nutrient inputs generally are increased by human-induced land use changes and can lead to eutrophication and impairment of surface waters. Understanding the scale at which land use influences nutrient loading is necessary for the development of management practices and policies that improve water quality. The authors

areas. Land cover classified at three spatial scales in each sub-basin above sampling sites (riparian in the entire catchment, catchment land cover, and riparian across the 2 km upstream) was highly correlated with variation in both total nitrogen (r^2 = 53%, 52%, and 49%, respectively) and nitrate (r^2 = 69%, 65%, and 56%, respectively) concentrations among sites. However, phosphorus concentrations were not significantly associated with riparian or catchment land cover classes at any spatial scale. Separating land use from riparian cover in the entire watershed was difficult, but riparian cover was most closely correlated with in-stream nutrient concentrations. By controlling for land cover, a significant correlation of riparian cover for the 2 km above the

Water quality of lakes and streams is known to be substantially related to human activity adjacent to them ('local' scale) and in the surrounding watersheds ('landscape' scale).

Studies examining drivers of water quality in wetlands are much less common and primarily local to regional in extent.

NWCA offers opportunity to examine these relationships for wetlands on a *cross-USA* basis.

National Wetland Condition Assessment

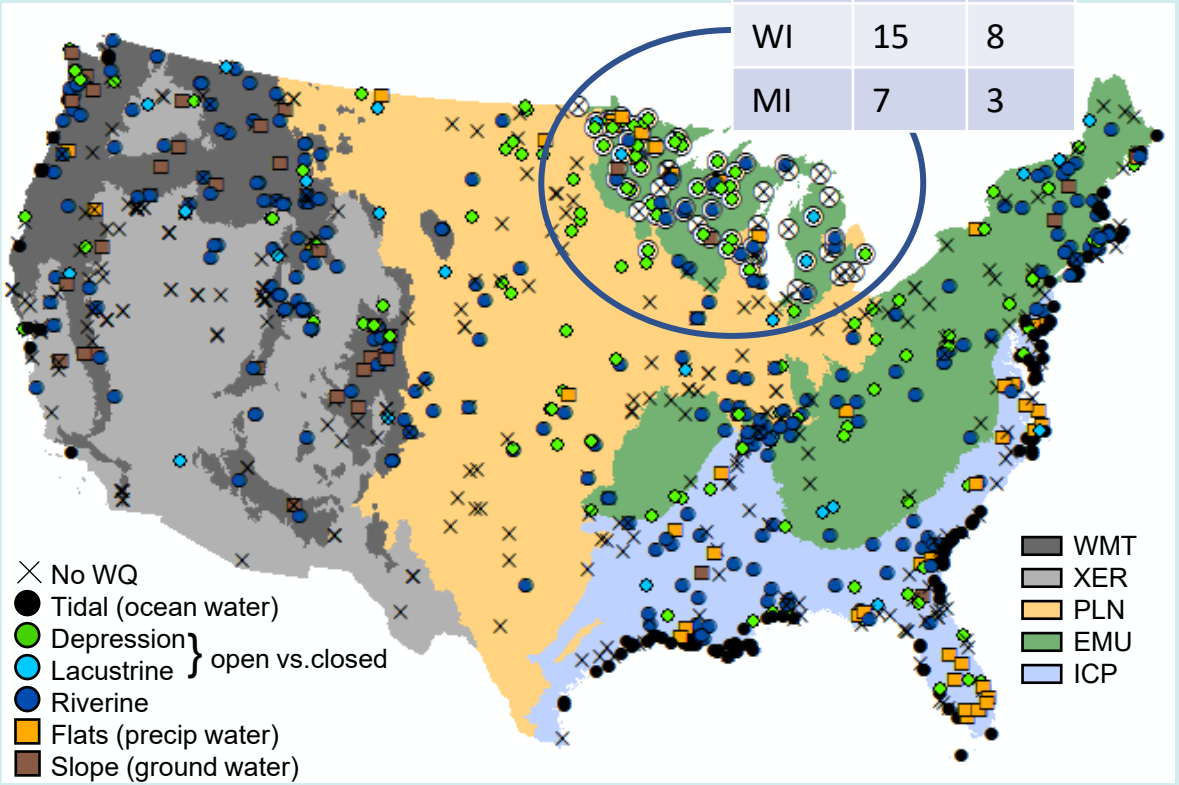
- NWCA is part of EPA's National Aquatic Resource Surveys program
- Sampling every 5 years, starting 2011, then **2016**, then 2021
- Sites (points) randomly selected from National Wetland Inventory or US-FWS Status & Trends polygons, augmented with handpicked sites (former used in pop estimates, latter not)

2016 NWCA:

- 1056 unique sites sampled
- 675 (64%) yielded WQ data
- **525 inland (not tidal), which is focus here**

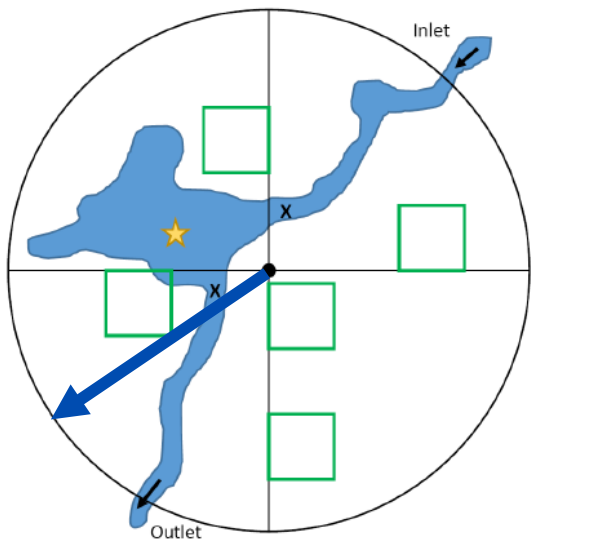
Region	#	HGM type	#
WMT	114	Depression	131
XER	49	Lacustrine	35
PLN	109	Riverine	271
EMU	144	Flats	49
ICP	109	Slope	39
Total (inland) N=525			

N=64	EMU	PLN
MN	28	3
WI	15	8
MI	7	3



NWCA ecological sampling

1-day visit during growing season (large field effort involving many partners)
Assessment Area (AA) of 40m radius, 5026m^2 area (1/2 hectare)



<u>Soils</u>: profile for physical and chemical analysis in 1 plot within AA

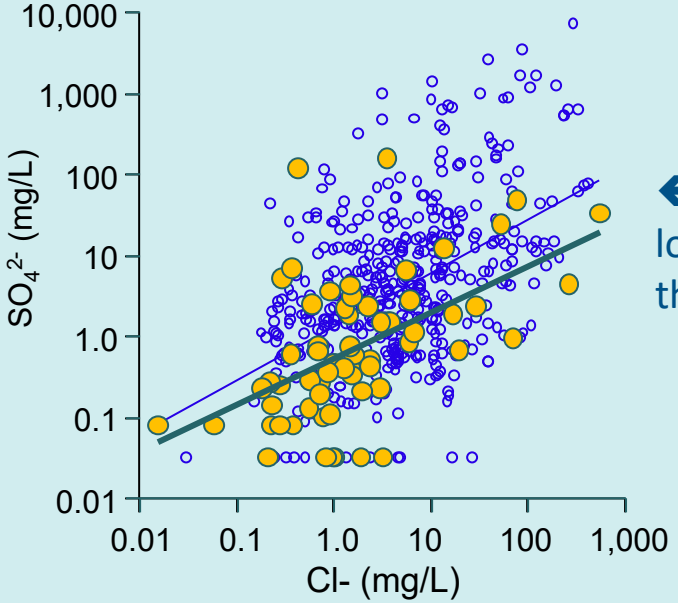
<u>Vegetation</u> : assess cover & composition in 5 plots within AA

<u>Water quality</u>: If surface water present *in AA*, collect 1 sample for lab to analyze (If not WQ data is missing for this site)

- **COND (conductivity)**
- **Anions Cl^- & SO_4^{2-} (salts)**
- **Nutrients TN, TP, NH_3, NO_x**
- **planktonic CHLA**
- **TURB (turbidity)**
- **DOC (dissolved organic C)**
- **pH**

Water quality intro

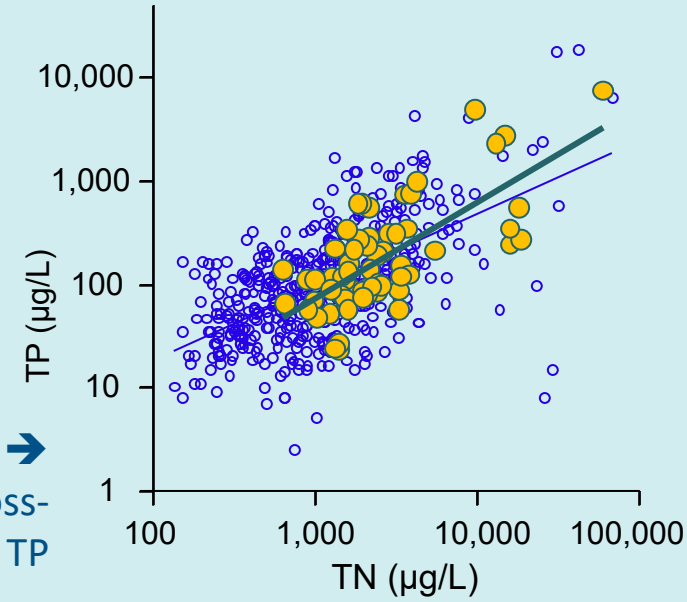
Very large range for all analytes

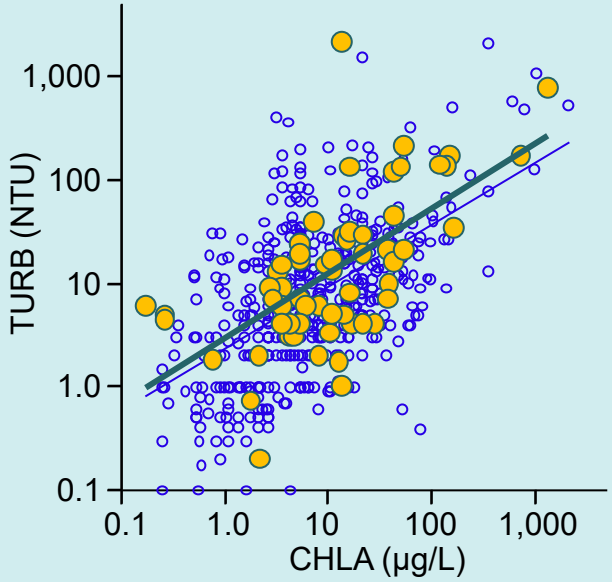


MN, WI, MI
cross USA

← Anions: MN/WI/MI sites lower SO_4^{2-} relative to Cl- than cross-USA

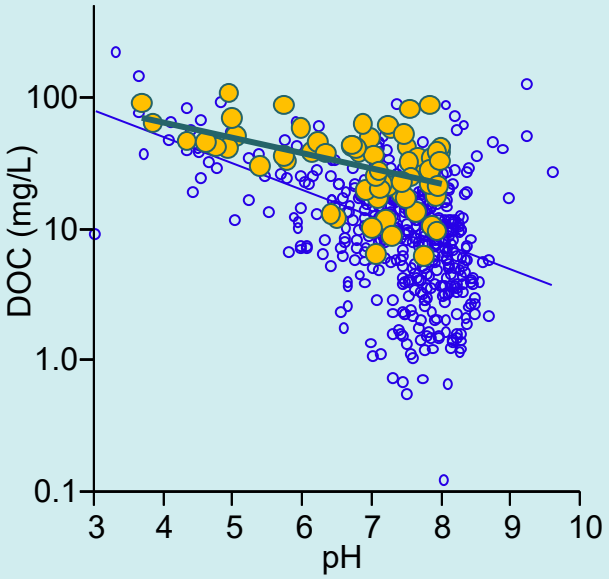
Nutrients: MN/WI/MI → sites lack low end of cross-USA range for TN and TP





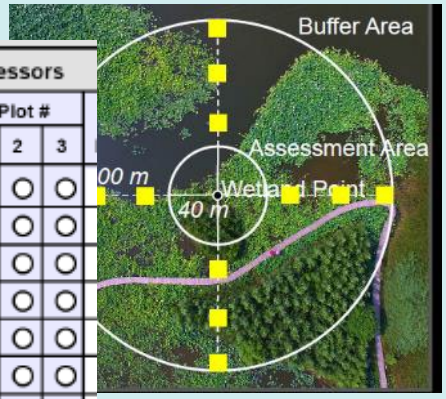
← Clarity: MN/WI/MI sites have similar CHLA and TURB pattern as cross-USA

Boggy-ness: MN/WI/MI → sites on high end of DOC and low end of pH range



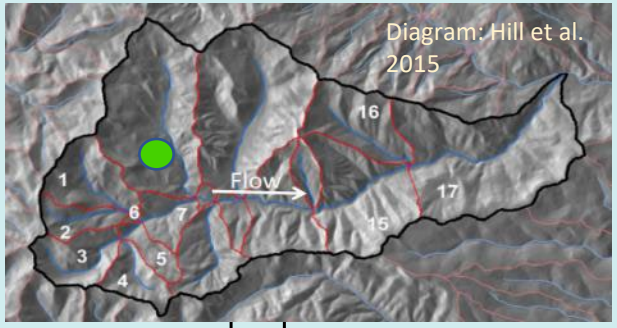
Anthropogenic pressure scoring

Agricultural & Rural Stressors			
Fill bubble if present	Plot # 1	2	3
Pasture/Hay	○	○	○
Range	○	○	○
Row Crops - Tilling	○	○	○
Fallow Field (RECENT-RESTING ROW CROP FIELD)	○	○	○
Fallow Field (OLD - GRASS, SHRUBS, TREES)	○	○	○
Drain Tiling	○	○	○
Livestock or Domesticated Animals	○	○	○



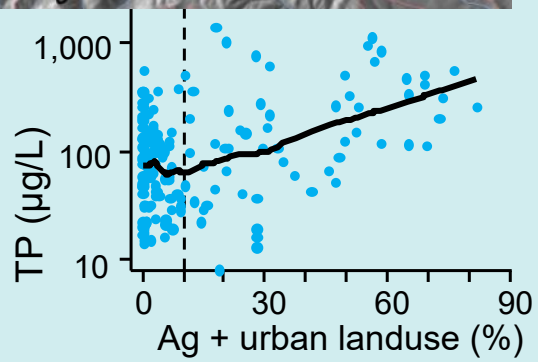
← Local (in or close to wetland):

- From field check-list, collect those that potentially elevate salts, nutrients, sediments
- Weight by intensity in AA (low/med/hi) and distance in buffer (inner/middle/outer); then standardize
- Classify as none (0), low (1-33), medium (34-66), high (67-100)



Pressure scores at the two spatial scales are independent

Pearson correlations			
	local Nut	local Sed	local Sal
L'scape % ag	0.049	0.057	0.174
L'scape % urb	-0.104	-0.022	0.023



← Landscape (watershed wetland falls in)

- Intersect AA coordinates with nearest StreamCat watershed
- Compute % of area in ag or urban landcover (per NLCD)
- Classify as none (<10%), low (10-40%), medium (40-70%), high (70-100%)

Examples of MN/WI/MI sites in 2016 NWCA

Minnesota →

Wisconsin →

Michigan ↘

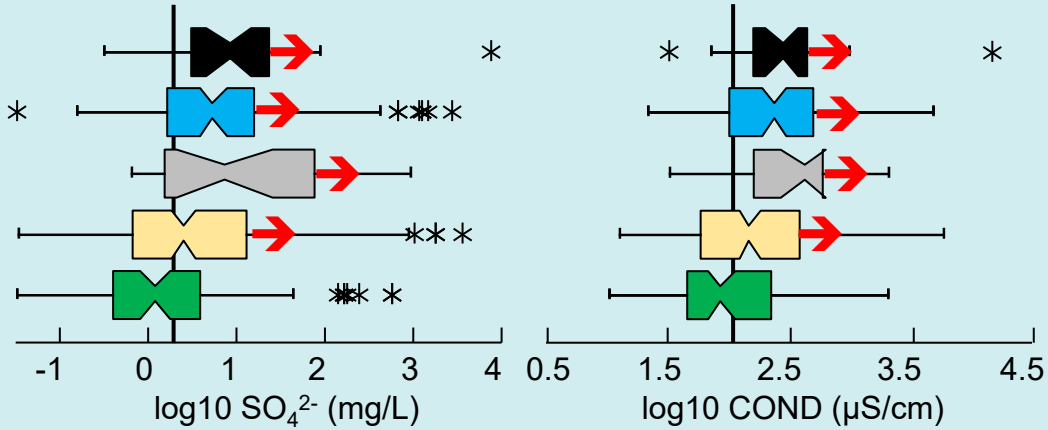
MN/WI/MI sites:

- Local pressure mostly low
- L'scape pressure mostly ag, not urb
- EMU (north) generally better than PLN (south)

USA-wide pattern: Anions/Conductivity

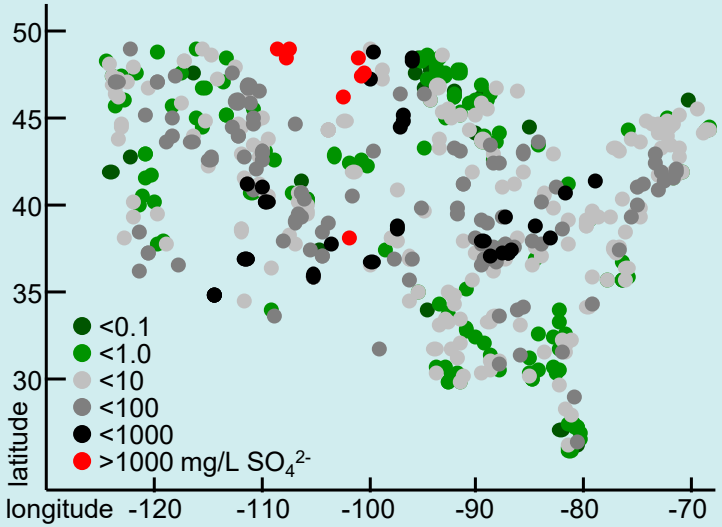
Pearson correlations		
Pressure	none	med/hi
COND vs Cl-	0.55	0.65
COND vs SO_4^{2-}	**0.41** →	**0.75**

↑ Sulfate becomes stronger contributor to COND with med/hi pressure

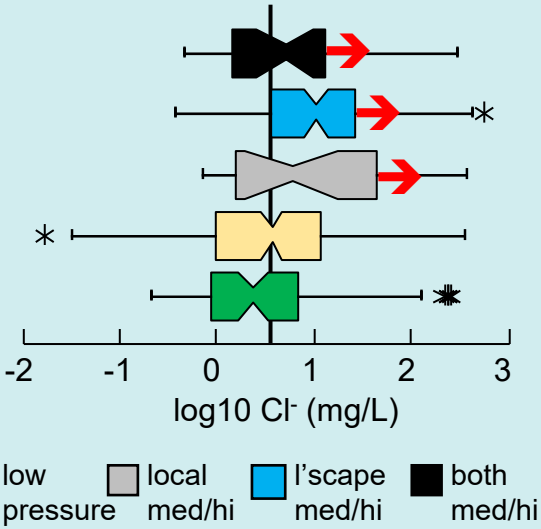


↑ Sulfate and COND elevated in association with both local and landscape pressure (even low-level pressure)

Chloride elevated except with low-level pressure ↓

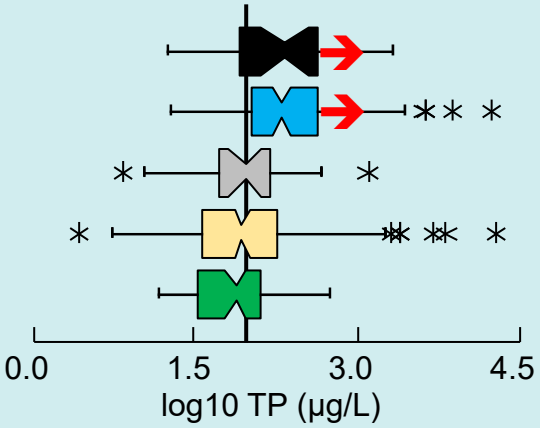


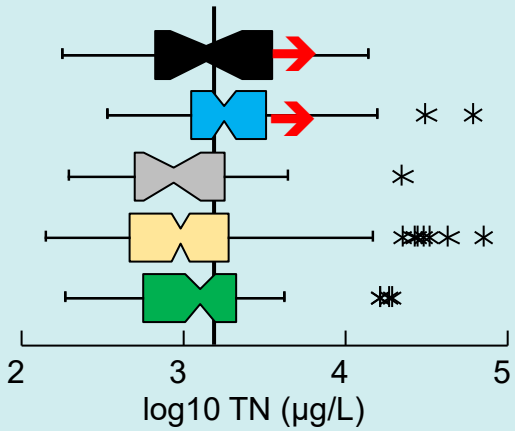
← USA map shows highest sulfate levels in upper plains; MN/WI/MI generally low esp. in north

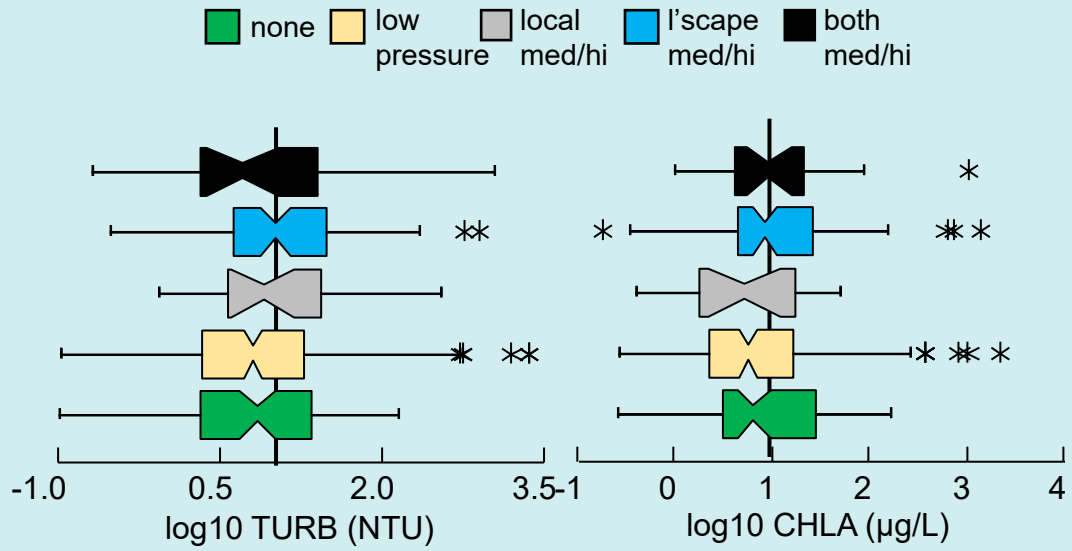


USA-wide pattern: Nutrients

↓ Nutrients elevated in association with landscape pressure, but not local pressure







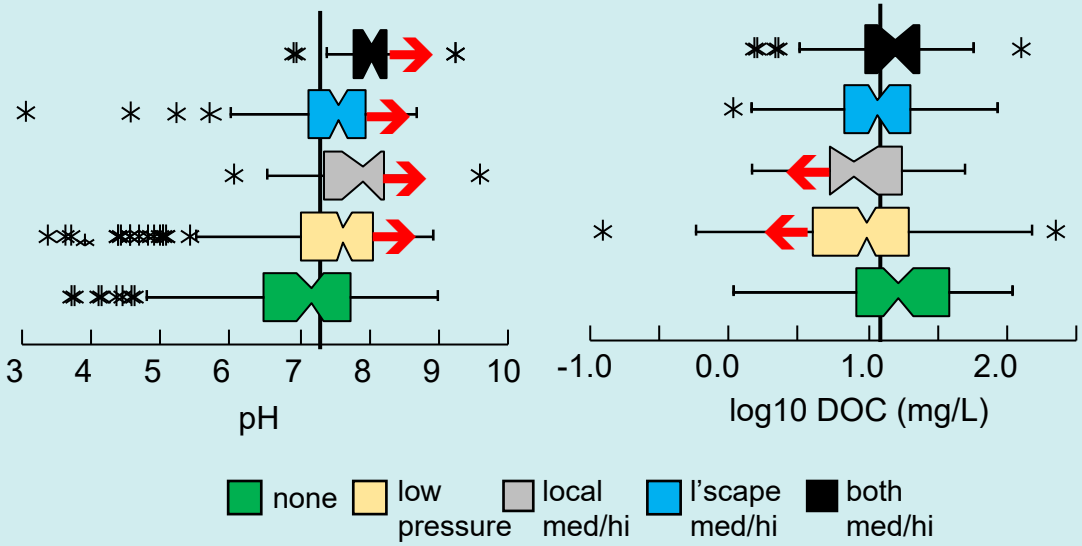
↑ But TURB and planktonic CHLA are not elevated in response to nutrients

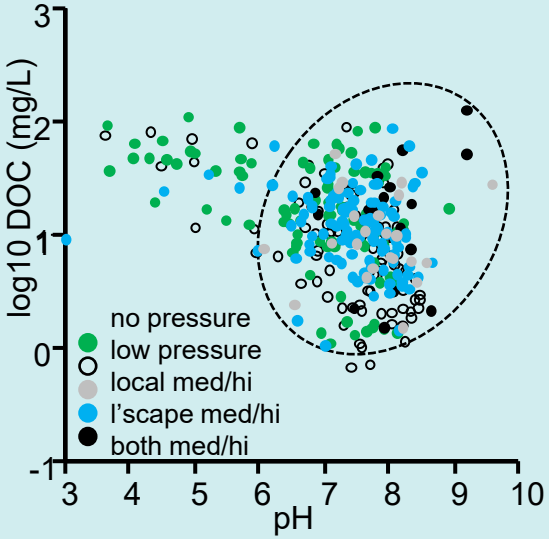
- **Does physical setting prevent CHLA & TURB response to nutrients?**
- **Are nutrients instead channeled to vascular plants & periphyton?**
- **Contrary to data from Great Lakes coastal wetlands where CHLA & TURB are elevated along with nutrients**

USA-wide pattern: pH & DOC:

pH elevated in association with both local and landscape pressure ↓

DOC reduced, particularly in association with local pressure ↓

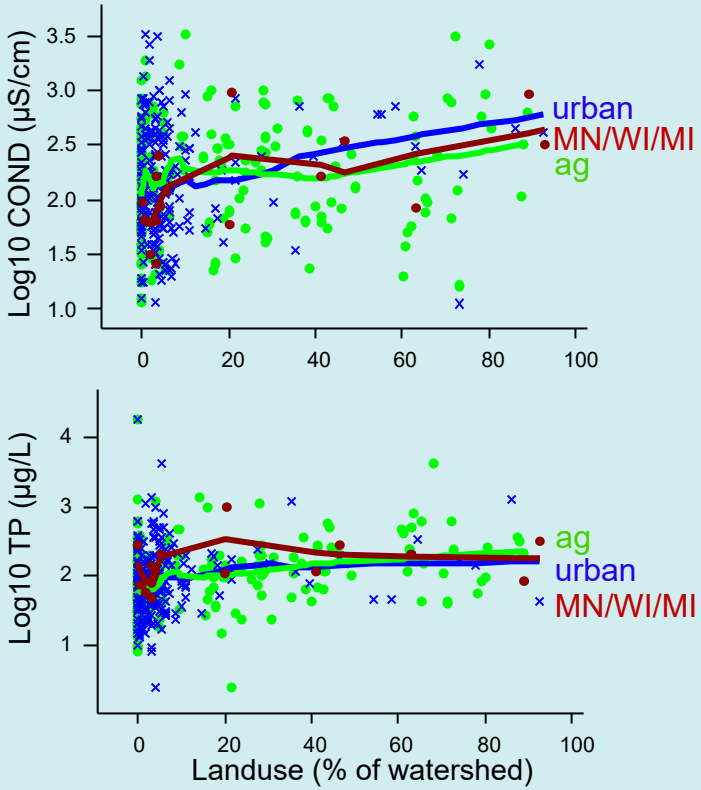


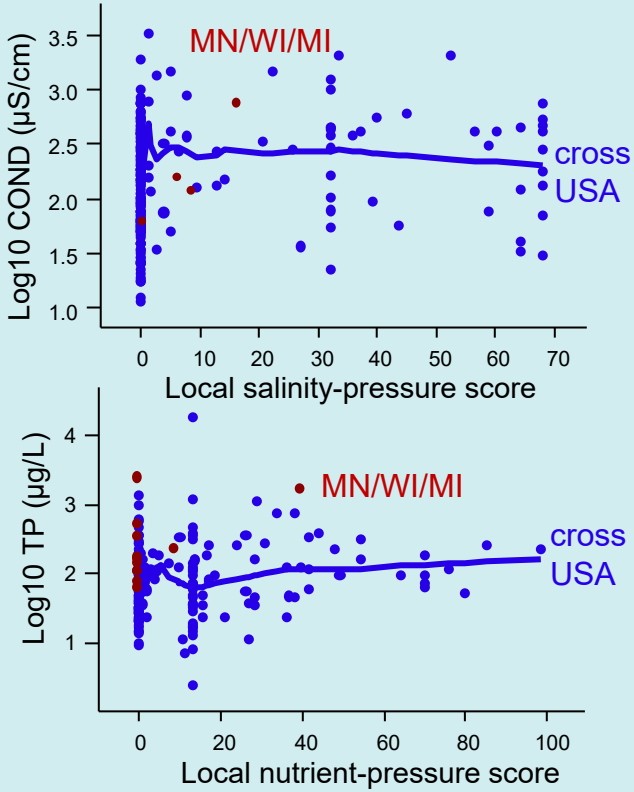


↑ Sites with med/hi pressure don't have low pH

- **Is pH is sufficiently raised & DOC lowered that water ceases to be boggy? (unlikely)**
- **Are boggy sites are physically eliminated? (possibly)**
- **Are boggy sites not locations getting med/hi pressure? (likely)**

Pattern in riverine wetlands: (n=271)



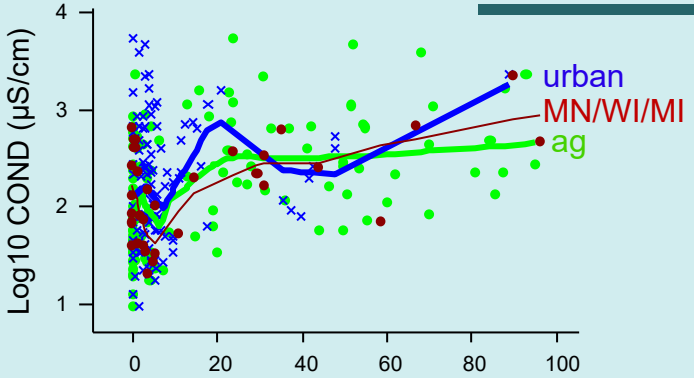


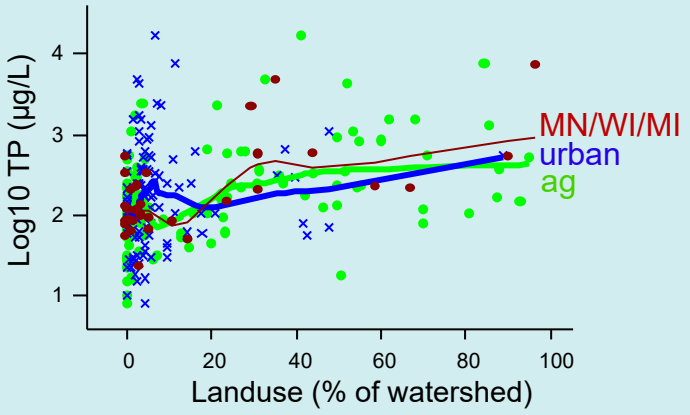
↑ Association to landscape pressure whether landuse is ag or urban. MN/WI/MI sites have same trend as USA-wide. (Showing sites with local pressure absent/low)

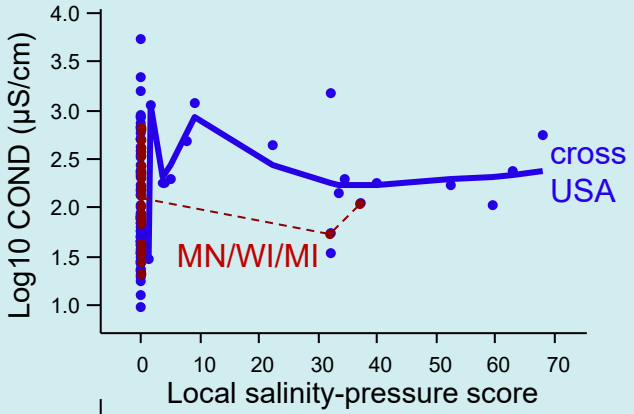
↑ No association to local pressure in riverine sites (contrary to pattern across all HGM types combined). MN/WI/MI sites don't have much local pressure. (Showing sites with landscape pressure absent/low)

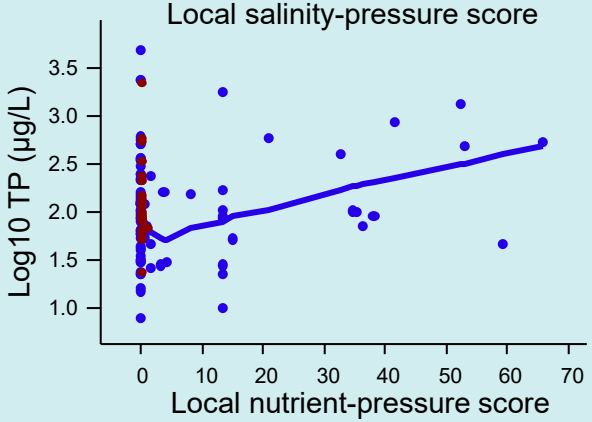
Is lack of response to local pressure because riverine wetlands receive water from upstream?

Pattern in depression/lacustrine-closed wetlands: (n=134)









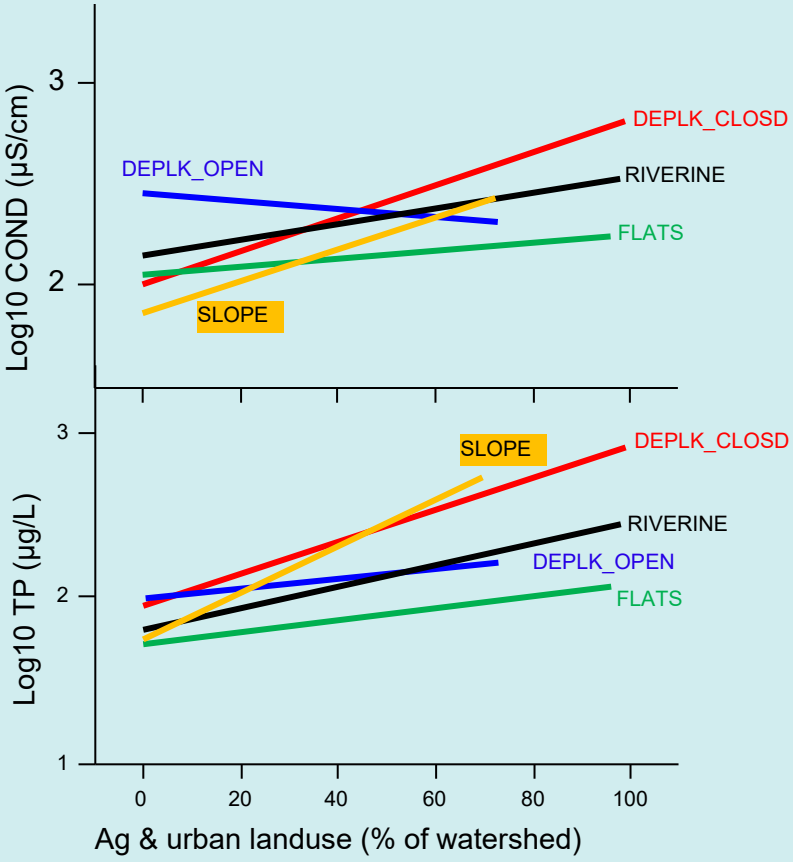
↑ Association to landscape pressure whether landuse is ag or urban. MN/WI/MI sites have same trend as USA-wide.
(Showing sites with local pressure absent/low)

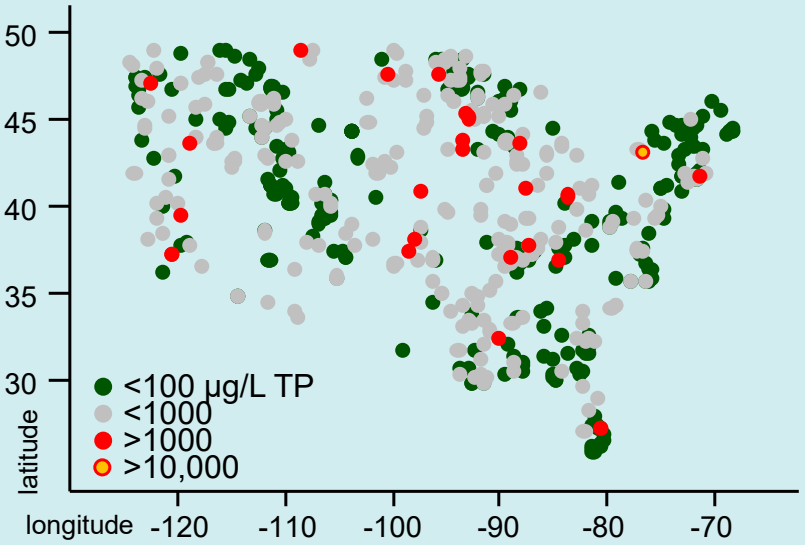
↑ Association to local pressure is evident for nutrients, but not COND. MN/WI/MI sites don't have much local pressure. (Showing sites with landscape pressure absent/low)

'Closed' means no stream inflow, yet association to landscape nevertheless.

Wetlands lacking surface inflow still have WQ association to landscape

USA map of only flats, slope, and depression/lacustrine-closed sites (sites without stream inflows) shows considerable spatially-organized variability in TP →





← Linear regression of COND and TP to landuse is steeper in slope and depression/lacustrine-closed wetlands (which lack stream inflows) than in riverine and depression/lacustrine-open wetlands (which have stream inflows). Slope is positive even in flats (precipitation source).

NO evidence that any HGM types are 'isolated' from the surrounding landscape.

Summary:

- 2016 NWCA gives picture of wetland water quality across USA
- Water quality is associated with anthropogenic pressure on local and landscape scale
- Association is seen even in HGM types lacking surface inflows
- Wetlands of MN/WI/MI are consistent with USA scale patterns, although boggy sites are more common and local pressure tends to be low

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  - MN Pollution Control (logistics), PG Envi and Midwest Biological Institute (field)
  - WI Dept Natural Resources (field), WI State Lab of Hygiene (lab)
  - MI Dept of Environmental Quality (field)

Abstract:

The effects of watershed and riparian anthropogenic activities on lake and stream water quality are well established, but have been much less studied in wetlands. Here we use data from the 2016 National Wetland Condition Assessment, collected via a U.S. EPA partnership with states and tribes, to characterize wetland water quality in relation to adjacent and watershed-scale anthropogenic impacts. The dataset has measures of pH, dissolved organic carbon (DOC), nutrients, salinity, turbidity, and algal chlorophyll for 525 inland wetlands across the continent, including 23 in Wisconsin, 31 in Minnesota, and 10 in Michigan. Wetland-adjacent pressure scores are synthesized from field checklist items (e.g., livestock, vehicle ruts, dredge/fill) and watershed pressure are equated to % agriculture and urban landcover. Only 18% of sampled wetlands had no anthropogenic pressure, but pressure levels were uncorrelated across scales and varied considerably across biogeographic regions and hydrogeomorphic types. Watershed-scale pressure was the best predictor of increased nutrients, while adjacent-scale pressure best predicted changes to DOC and pH and salinity. Water quality responded to landscape pressures even in wetland types lacking inflows (e.g., flats, closed depressions) which suggests that wetlands are generally connected to rather than isolated from the surrounding upland. Water quality in WI/MN/MI wetlands generally followed cross-USA patterns but boggy sites were more common and low-nutrient sites were rare. Our presentation will illustrate these patterns for relevant combinations of wetland types and settings, including for upper midwest wetlands of particular interest to this conference.