Illinois Nutrient Loss Reduction Strategy

Nutrient Monitoring Council

13th Meeting, September 10, 2019, Urbana, IL

Welcome/Housekeeping

- Important Stuff – bathrooms, lunch, other
- Member and Guess Introductions
- Newsworthy Notes:
  - Hold the Date – NLRS Partnership Conference

    12/3-4/19

Nutrient Monitoring Council Members

Illinois EPA
Gregg Good, Rick Cobb

Illinois State Water Survey
Laura Keefer

Aqua Illinois
~~Kevin Culver~~

~~**Illinois Natural History Survey**~~
~~Andrew Casper~~ (Need Replacement?)

Illinois Dept. of Natural Resources
Ann Holtrop or Brian Metzke???

Univ. of IL – Dept. of Agriculture and Biological Engineering
Paul Davidson

Sierra Club
Cindy Skrukrud

MWRDGC
Justin Vick

Illinois Corn Growers Association
Laura Gentry

U.S. Army Corp of Engineers-Rock Island
~~Chuck Theiling~~ Nicole Manasco?

U.S. Geological Survey
Kelly Warner

National Center for Supercomputing Apps
Jong Lee

Univ. of IL – Dept. of Natural Resources and Environmental Sciences (Emeritus)
Greg McIsaac

NLRS Coordinator – Illinois EPA
Trevor Sample

NMC Charges *(Revised 10/26/15)*

1. Coordinate the development and implementation of monitoring activities (e.g., collection, analysis, assessment) that provide the information necessary to:

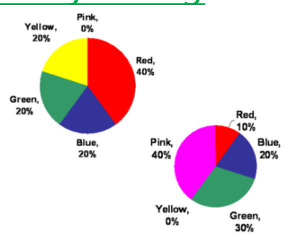
   a. Generate estimations of 5-year running average loads of Nitrate-Nitrogen and Total Phosphorus *leaving the state of Illinois* compared to 1980-1996 baseline conditions; and

   b. Generate estimations of Nitrate-Nitrogen and Total Phosphorus loads *leaving selected NLRS identified priority watersheds* compared to 1997-2011 baseline conditions; and

   c. Identify Statewide and NLRS priority watershed *trends in loading over time* using NMC developed evaluation criteria.

2. Document *local water quality outcomes* in selected NLRS identified priority watersheds, or smaller watersheds nested within, where future nutrient reduction efforts are being implemented (e.g., increase in fish or aquatic invertebrate population counts or diversity, fewer documented water quality standards violations, fewer algal blooms or offensive conditions, decline in nutrient concentrations in groundwater).

3. Develop a *prioritized list of nutrient monitoring activities and associated funding* needed to accomplish the charges/goals in (1) and (2) above.

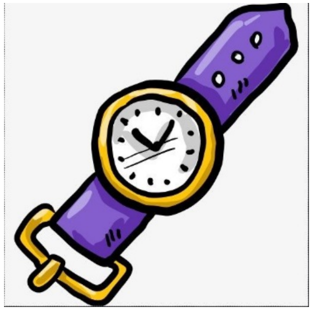


March 19, 2019, NMC #12 Meeting

- Review of Meeting
- Minutes (review and approve)

5 minute updates

- NSAC Report Update – Gregg Good
- Havana Lowlands Groundwater Monitoring Project Update – Kelly Warner
- NLRS Data Portal Update – Jong Lee



Water Quality Trends in Illinois Rivers – Tim Hodson

Trends in nutrient and soil loss in Illinois rivers

Tim Hodson[1]

[1] thodson@usgs.gov

Acknowledgments

USGS

- Paul Terrio (coauthor)
- Advanced Research Computing (ARC) group

IEPA

- Matt Short, Gregg Good, Trevor Sample, Roy Smogor, and Missy Cain

Problem

In the US alone, billions of dollars are spent each year on reducing nutrient pollution and soil erosion.

- CWA, CRP, CSP, to name a few large federal programs

. . . but the efficacy of these efforts is difficult to quantify.

- population and economic trends, lag times, climate

Question

Have nutrient and soil losses to rivers attenuated since these efforts began and are they attenuating today?

Plan

The State of Illinois has one of the longest-running and most extensive water quality monitoring networks in the US.

Use data from that network to assess trends in nutrient and soil loss

1. during two periods: '78–'17 and '08–'17
2. distinguish artificial from *natural*
3. estimate uncertainty in those trends

Illinois Ambient Network

- began in 1957, reorganized in 1978
- 146 active monitoring sites (approx 80 w/ streamflow)
- sampled at 6-week intervals
- various parameters including nutrients, major ions, trace elements, and organic compounds.

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Trend analysis

Generalized flow normalization filters out year-to-year variability in streamflow then subdivides the remaining trend into two components:

Water-quality trend	WT
Concentration-discharge trend component	CQTC
Streamflow trend component	QTC

$$WT = CQTC + QTC$$

Trend analysis

Journal of Great Lakes Research 45 (2019) 21–39

Contents lists available at ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

ELSEVIER

IAGLR

Tracking changes in nutrient delivery to western Lake Erie: Approaches to compensate for variability and trends in streamflow

Check for updates

A.F. Choquette [a,*], R.M. Hirsch [b], J.C. Murphy [a], L.T. Johnson [c], R.B. Confesor Jr. [c]

[a] U.S. Geological Survey, Nashville, TN, USA
[b] U.S. Geological Survey, Reston, VA, USA
[c] National Center for Water Quality Research, Heidelberg University, Tiffin, OH, USA

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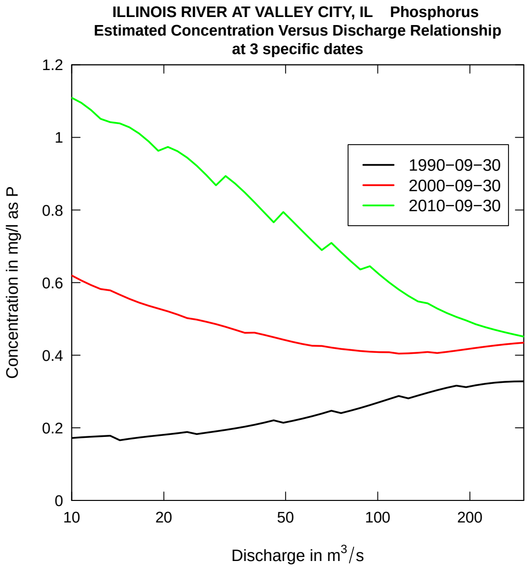
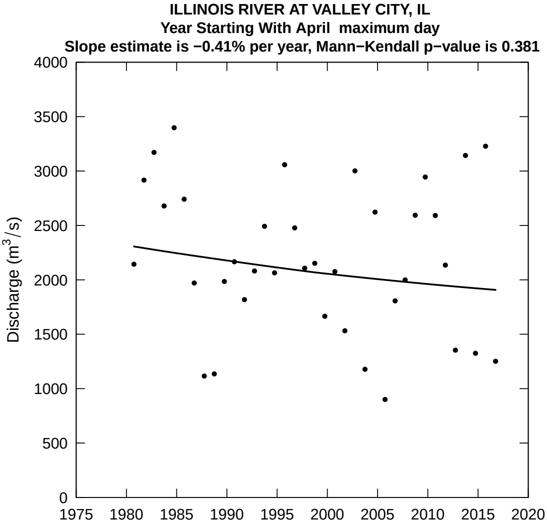
Trend analysis (CQTC)



Trend analysis (QTC)



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Trend analysis

CQTC and QTC can help distinguish what changes may be controllable by watershed management versus those resulting from climate.

. . . sort of

Trend analysis

CQTC is the portion of change due to changes in nutrient availability, which can result from

- land-management
- waste-water treatment
- changes in streamflow (supply-limited)
- climate (denitrification)

Trend analysis

QTC is the portion of change due to multi-decadal changes in streamflow, which can result from

- climate
- management of water impoundments
- construction of tile drains
- construction of impervious surfaces
- groundwater use

Uncertainty analysis

Trend uncertainty estimated by bootstrapping

- rerun the analysis 2000x
- *likely* trends occur in >66%
- *very likely* trends occur in >90%

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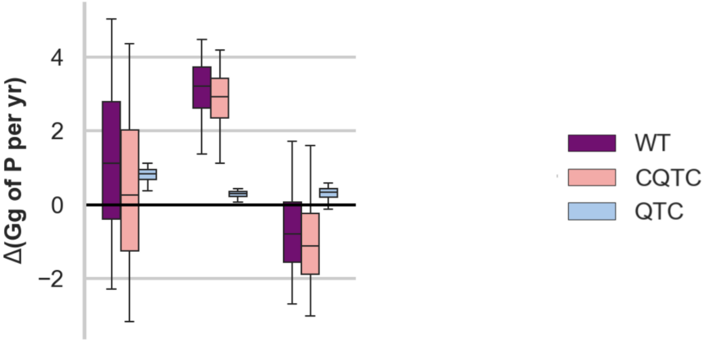
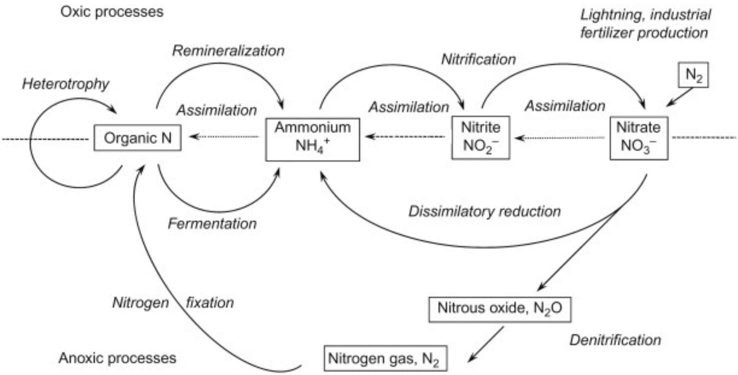
Uncertainty analysis



Tracing back to the source

Nutrients are poor tracers



. . . but sometimes poor is good enough

Phosphorus

Total phosphorus	TP
Particulate phosphorus	PP
Dissolved phosphorus	DP

$$TP = DP + PP$$

Nitrogen

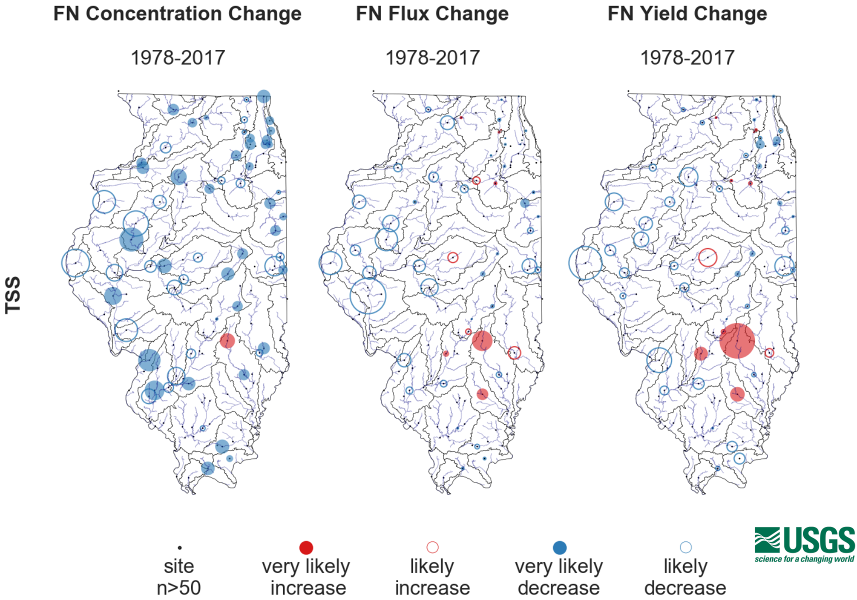
Total nitrogen	TN
Organic N + ammonia	TKN
Nitrate and nitrite	NO23

$$TN = NO23 + TKN$$

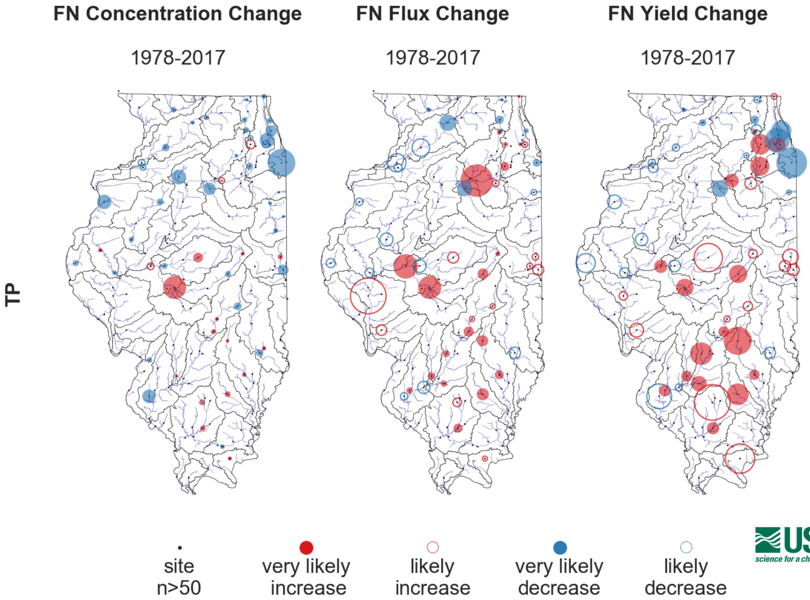
Total Suspended Solids

Although TSS is comprised of more than just soil, when soil erosion occurs, some of the eroded soil particles are carried by runoff into nearby rivers, which will increase TSS in that water body.

TSS (1978 - 2017)



Phosphorus (1978 - 2017)



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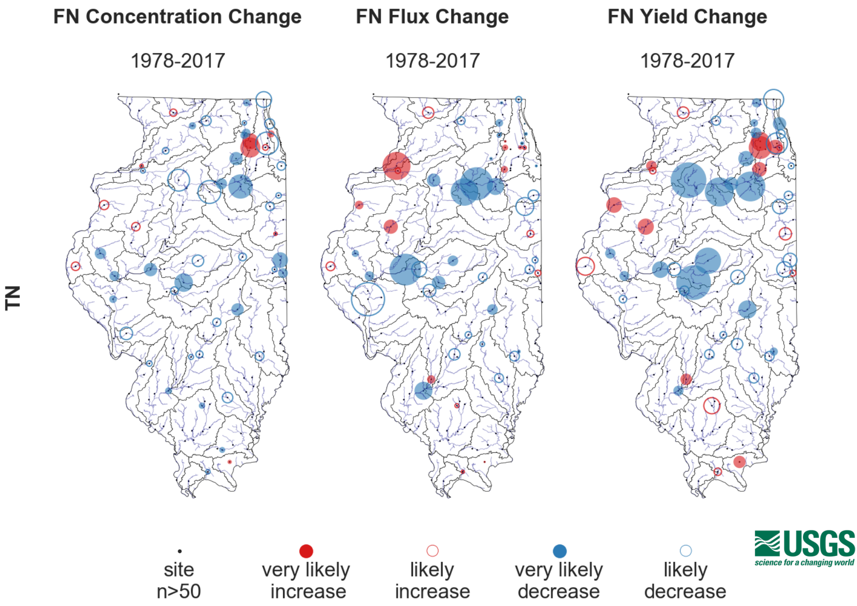
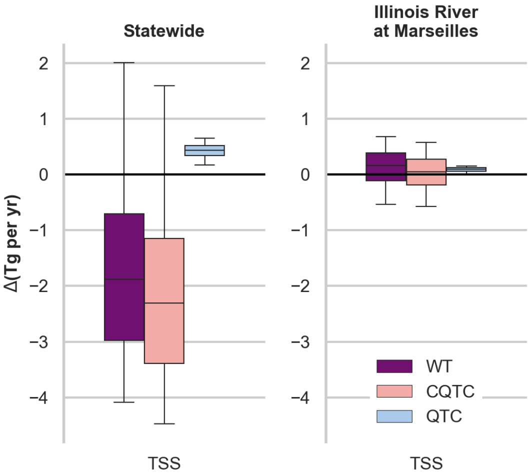
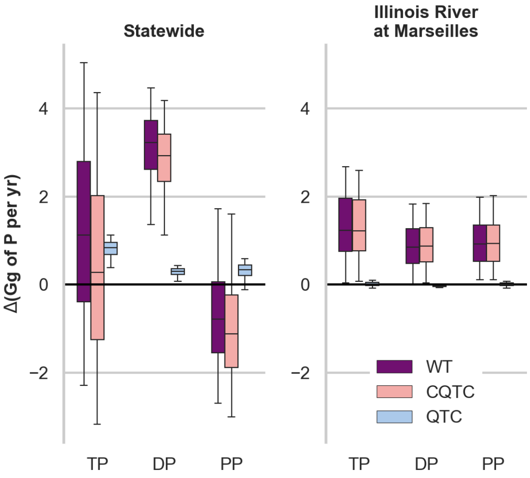
Nitrogen (1978 - 2017)



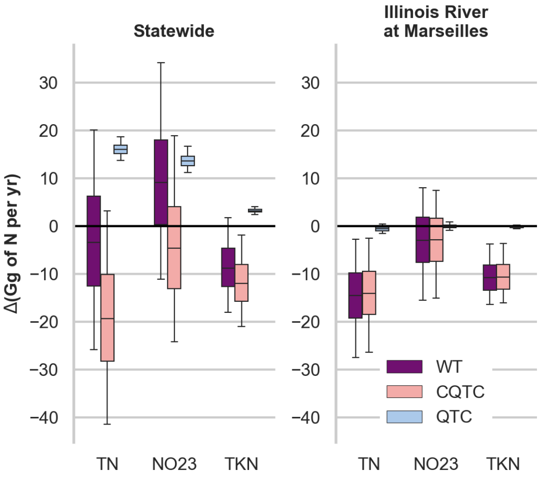
TSS (1978 - 2017)



Phosphorus (1978 - 2017)



Nitrogen (1978 - 2017)



Summary (1978 - 2017)

- TSS *likely* decreased 23% (-63 – +32 CI)
- No significant change in N overall
- P *likely* increased 10% (-16 – +36 CI)
- Decreasing soil erosion

- corn and soybean production increased 86%
- population increased 18%

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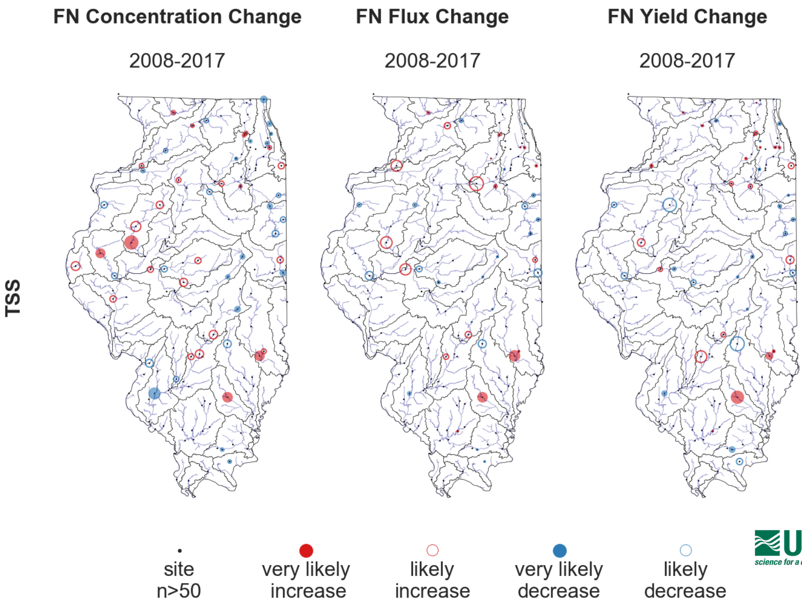
TSS (2008 - 2017)



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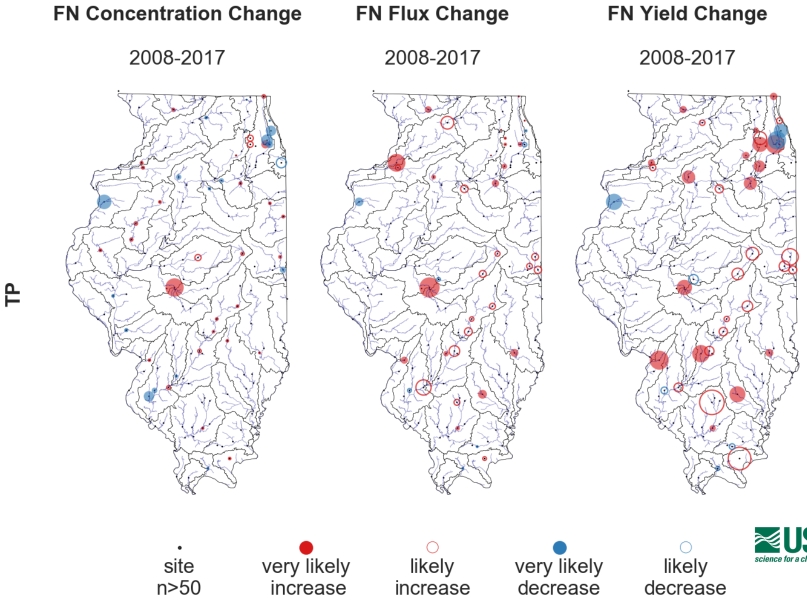
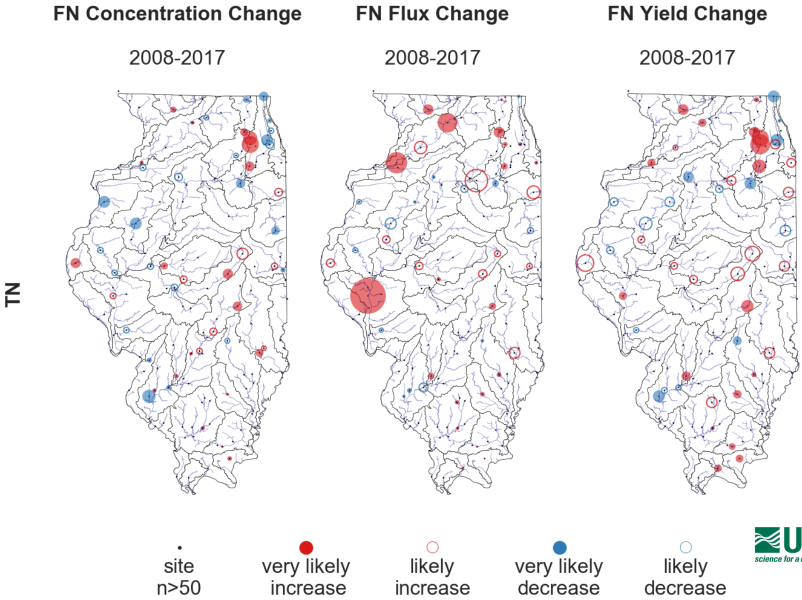
Phosphorus (2008 - 2017)



Nitrogen (2008 - 2017)



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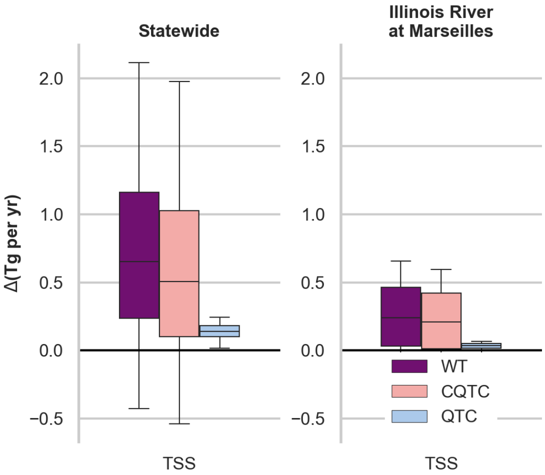
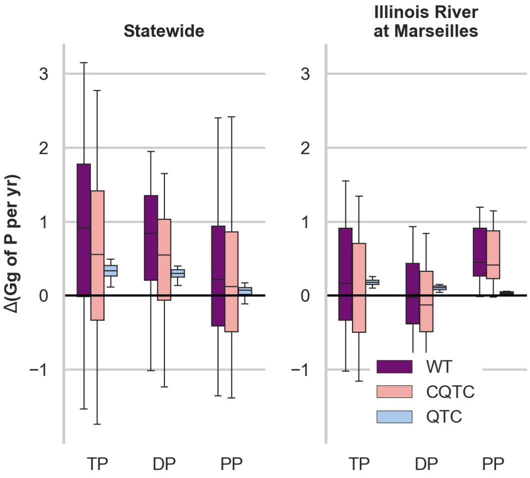
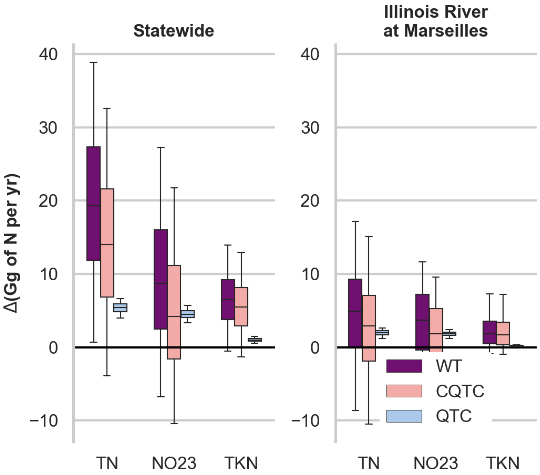
TSS (2008 - 2017)



Phosphorus (2008 - 2017)



Nitrogen (2008 - 2017)

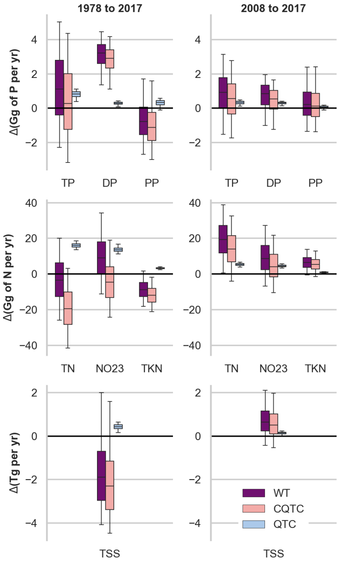


Summary (2008 - 2017)

- TSS *likely* increased 17% (-10 – 50 CI)
- Nitrogen *v. likely* increased 11% (0 – 20 CI)
- Phosphorus *likely* increased 8% (-10 – 22 CI)
- Increasing soil erosion

- Corn and soy production increased 18%
- Population was stable

Summary


1978 to 2017
2008 to 2017
Δ(Gg of P per yr)
4
2
0
−2
TP
DP
PP
Δ(Gg of N per yr)
40
20
0
−20
−40
TN
NO23
TKN
Δ(Tg per yr)
2
0
−2
−4
TSS
WT
CQTC
QTC

Conclusion

Have nutrient and soil losses to rivers attenuated?

Conclusion

Have nutrient and soil losses to rivers attenuated?

In some ways, but that progress might be eroding.

Potential future work

1. investigate recent degradation
2. look at finer-scale changes in time and space.
3. and large-scale changes (Upper Mississippi).
4. combine watershed modeling and climate data to tease out climate component of QTC.

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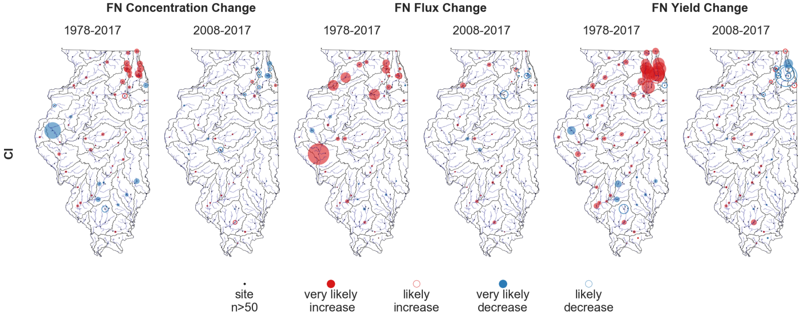
Methods

- Compile data from EPA, USGS, and IEPA
- Screen for trends with SMK.
- Analyze potential trends (2000x)

Chloride



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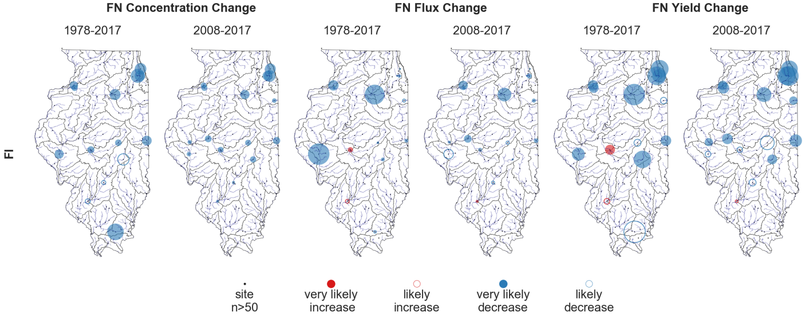
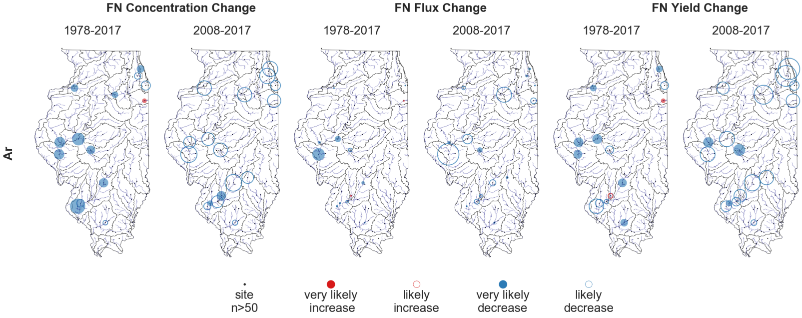
Fluoride

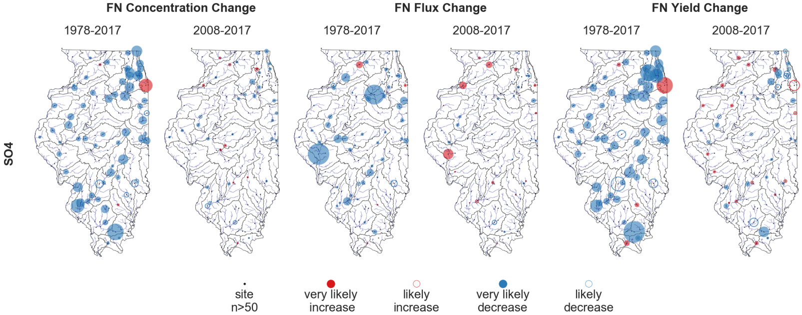

FN Concentration Change
FN Flux Change
FN Yield Change
1978-2017
2008-2017
1978-2017
2008-2017
1978-2017
2008-2017
Fl
site
n>50
very likely
increase
likely
increase
very likely
decrease
likely
decrease

Arsenic

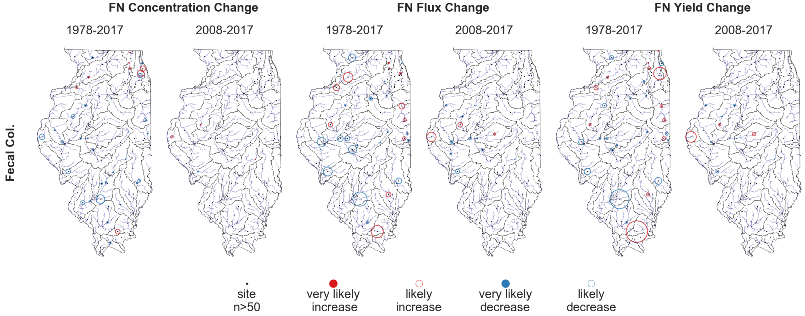


FN Concentration Change
FN Flux Change
FN Yield Change
1978-2017
2008-2017
1978-2017
2008-2017
1978-2017
2008-2017
Ar
site
n>50
very likely
increase
likely
increase
very likely
decrease
likely
decrease

Sulfate


FN Concentration Change
FN Flux Change
FN Yield Change
1978-2017
2008-2017
1978-2017
2008-2017
1978-2017
2008-2017
SO4
site
n>50
very likely
increase
likely
increase
very likely
decrease
likely
decrease

Fecal Coliform



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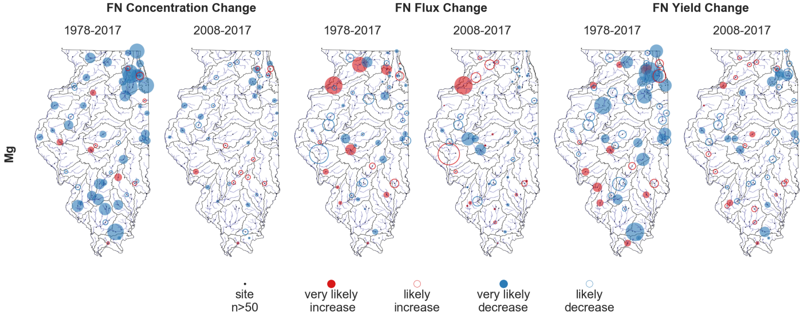
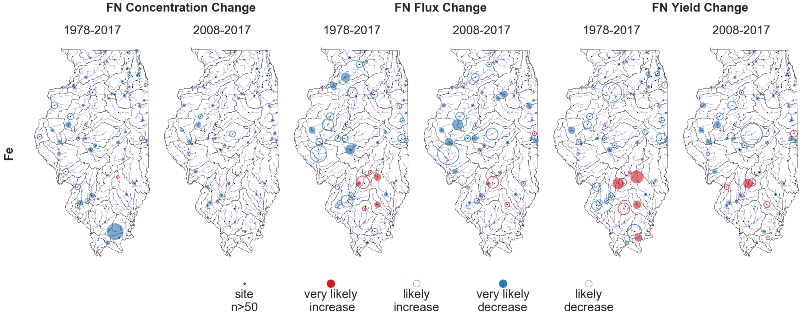
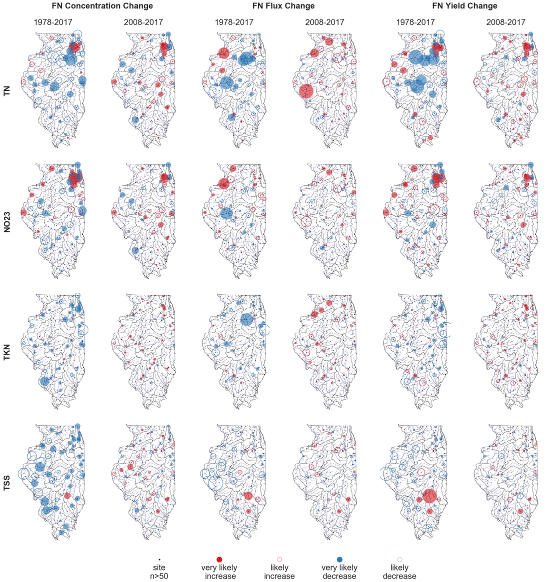
Magnesium


FN Concentration Change
FN Flux Change
FN Yield Change
1978-2017
2008-2017
1978-2017
2008-2017
1978-2017
2008-2017
Mg
site
n>50
very likely
increase
likely
increase
very likely
decrease
likely
decrease

Iron

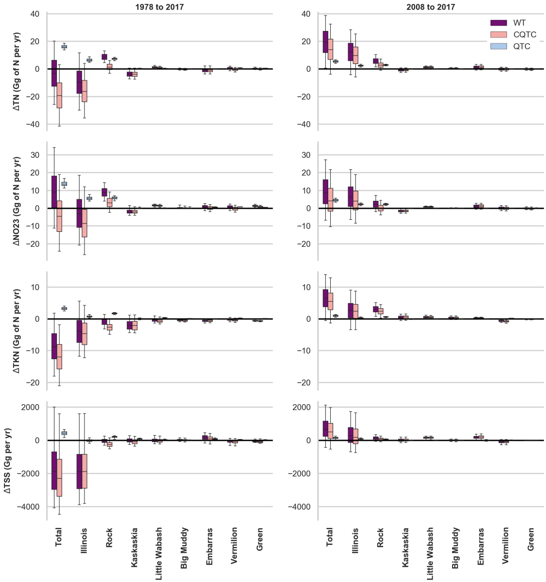

FN Concentration Change
FN Flux Change
FN Yield Change
1978-2017
2008-2017
1978-2017
2008-2017
1978-2017
2008-2017
Fe
site n>50
very likely increase
likely increase
very likely decrease
likely decrease

Nitrogen



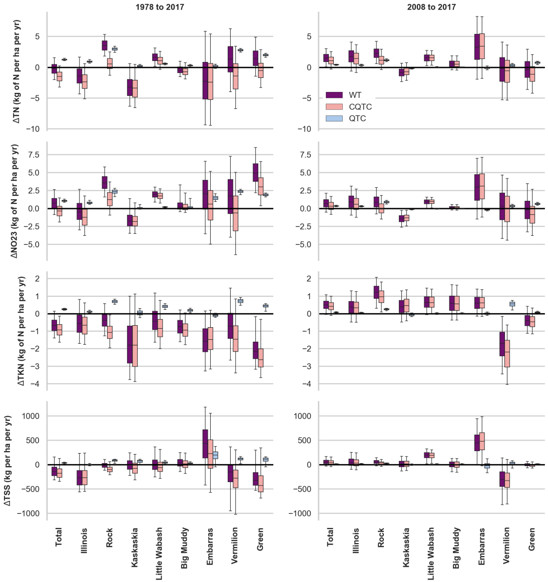
FN Concentration Change
FN Flux Change
FN Yield Change
1978-2017
2008-2017
1978-2017
2008-2017
1978-2017
2008-2017
TN
NO23
TKN
TSS
site
n>50
very likely
increase
likely
increase
very likely
decrease
likely
decrease

Nitrogen



1978 to 2017
2008 to 2017
WT
CQTC
QTC
ΔTN (Gg of N per yr)
ΔNO23 (Gg of N per yr)
ΔTKN (Gg of N per yr)
ΔTSS (Gg per yr)
Total
Illinois
Rock
Kaskaskia
Little Wabash
Big Muddy
Embarras
Vermilion
Green

Nitrogen



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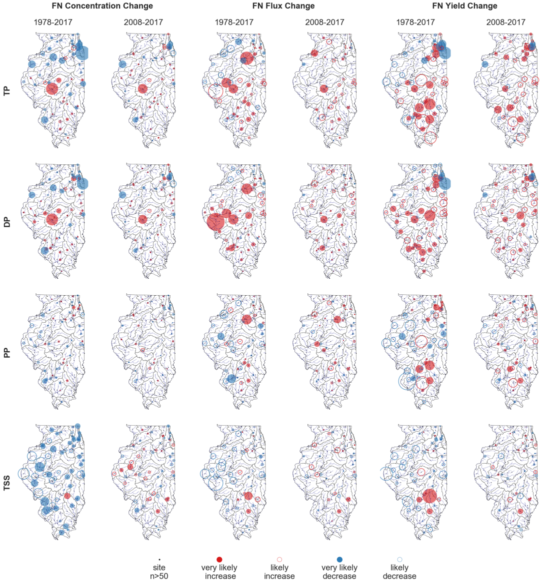
Phosphorus



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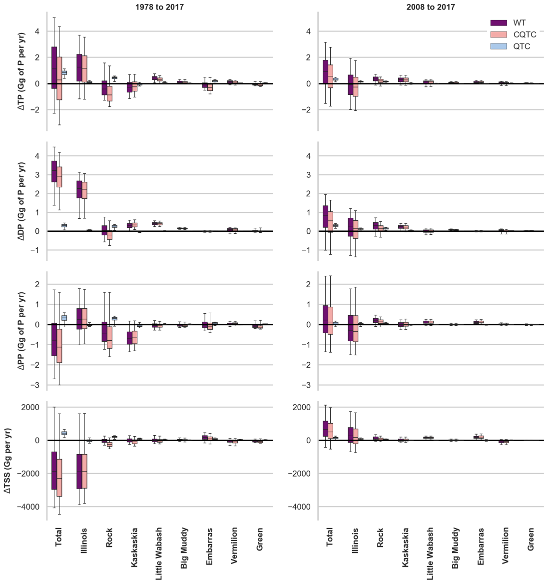
Phosphorus



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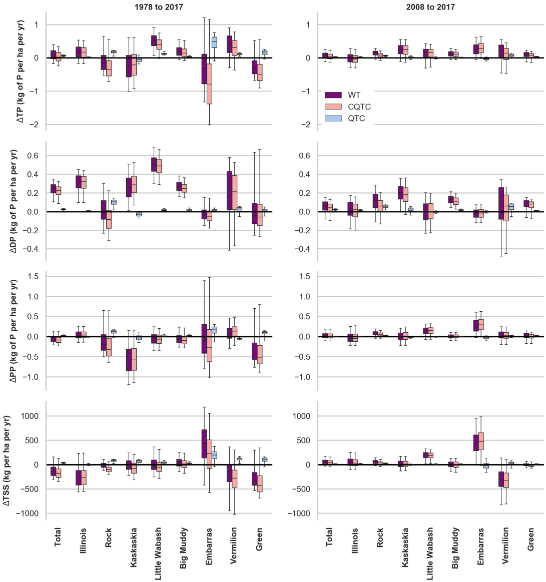
Phosphorus



1978 to 2017
2008 to 2017
ΔTP (kg of P per ha per yr)
ΔDP (kg of P per ha per yr)
ΔPP (kg of P per ha per yr)
ΔTSS (kg per ha per yr)
WT
CQTC
QTC
Total
Illinois
Rock
Kaskaskia
Little Wabash
Big Muddy
Embarras
Vermilion
Green

Miscellaneous N Topics

Rock River Between Joslin and Rockton
Preliminary Nitrate Budget for the Illinois River
Legacy N Model "Discussion"

Greg McIsaac
University of Illinois

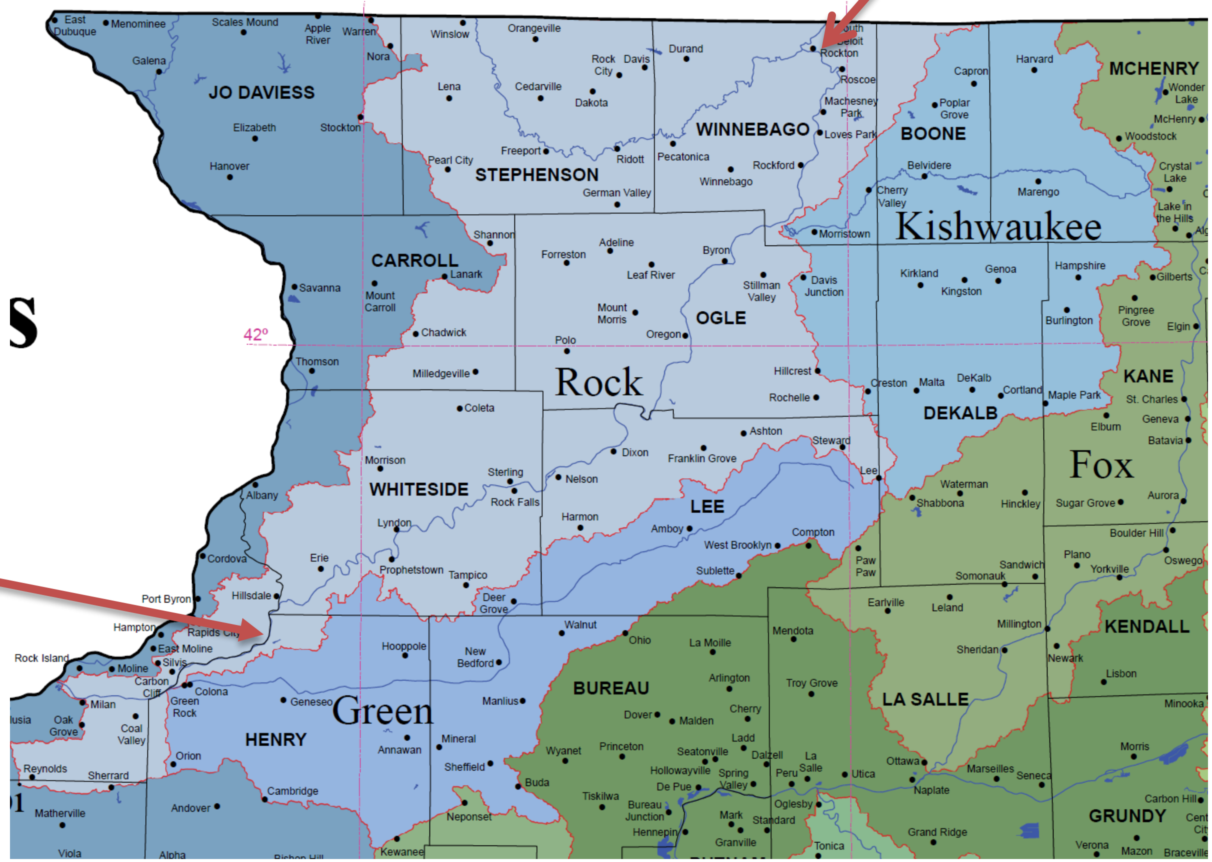
Rock River Basin
Between Rockton and Joslin
Nitrate-N
1980-96 and 2013-17

Sept 9, 2019 Draft

Rock River Watershed
USGS and IEPA monitoring locations at Rockton and Joslin

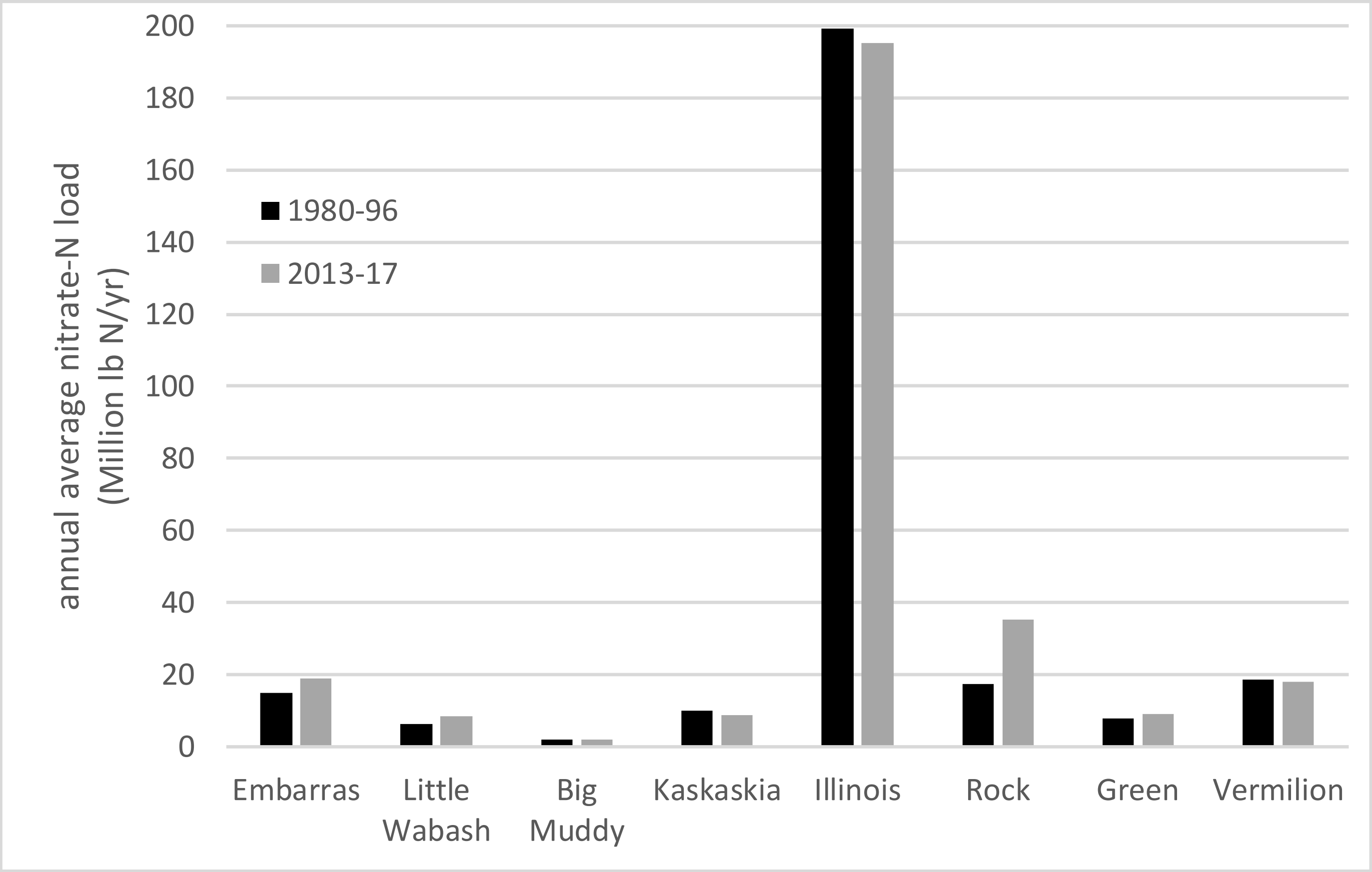
Rockton

Joslin

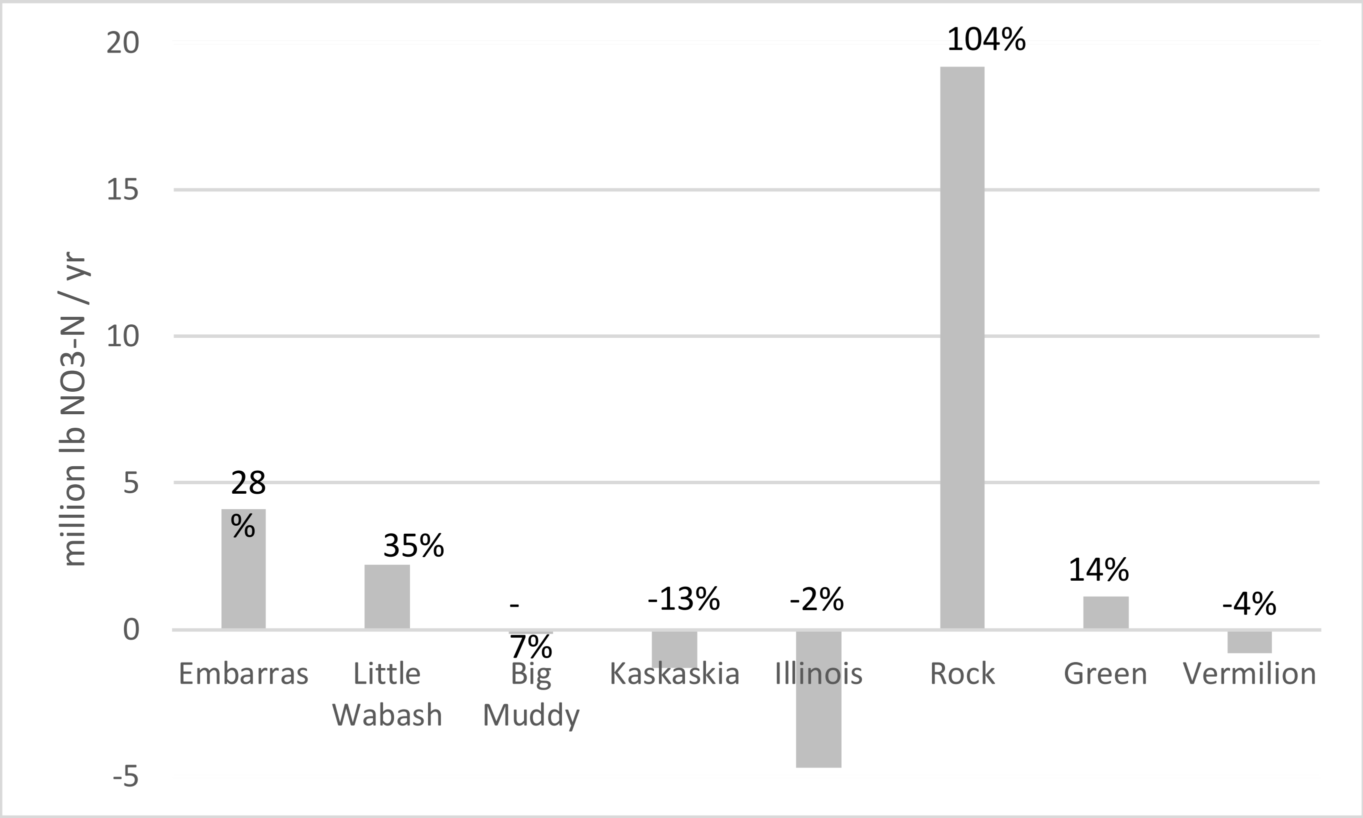


Modified from ISWS

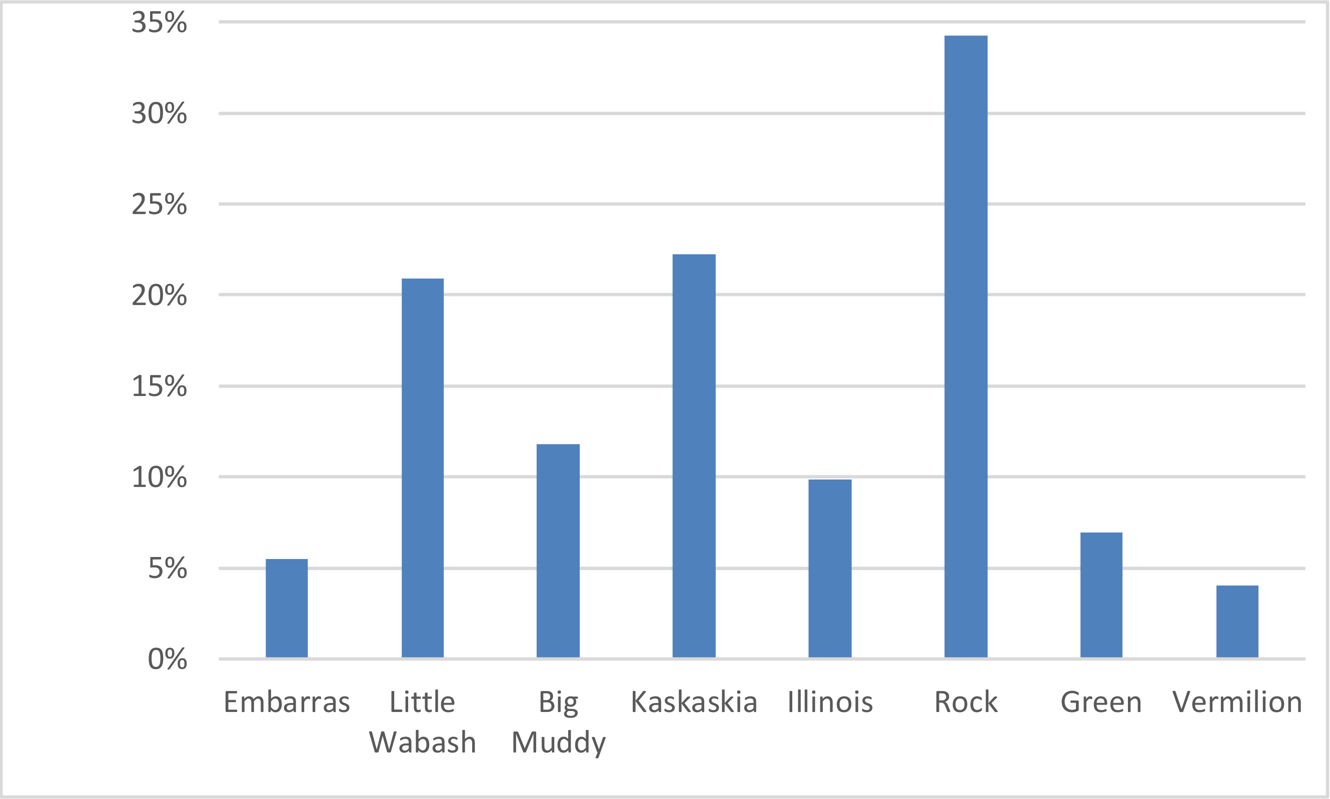
Nitrate-N Load Estimates in Major Rivers in Illinois 1980-96 and 2013-17



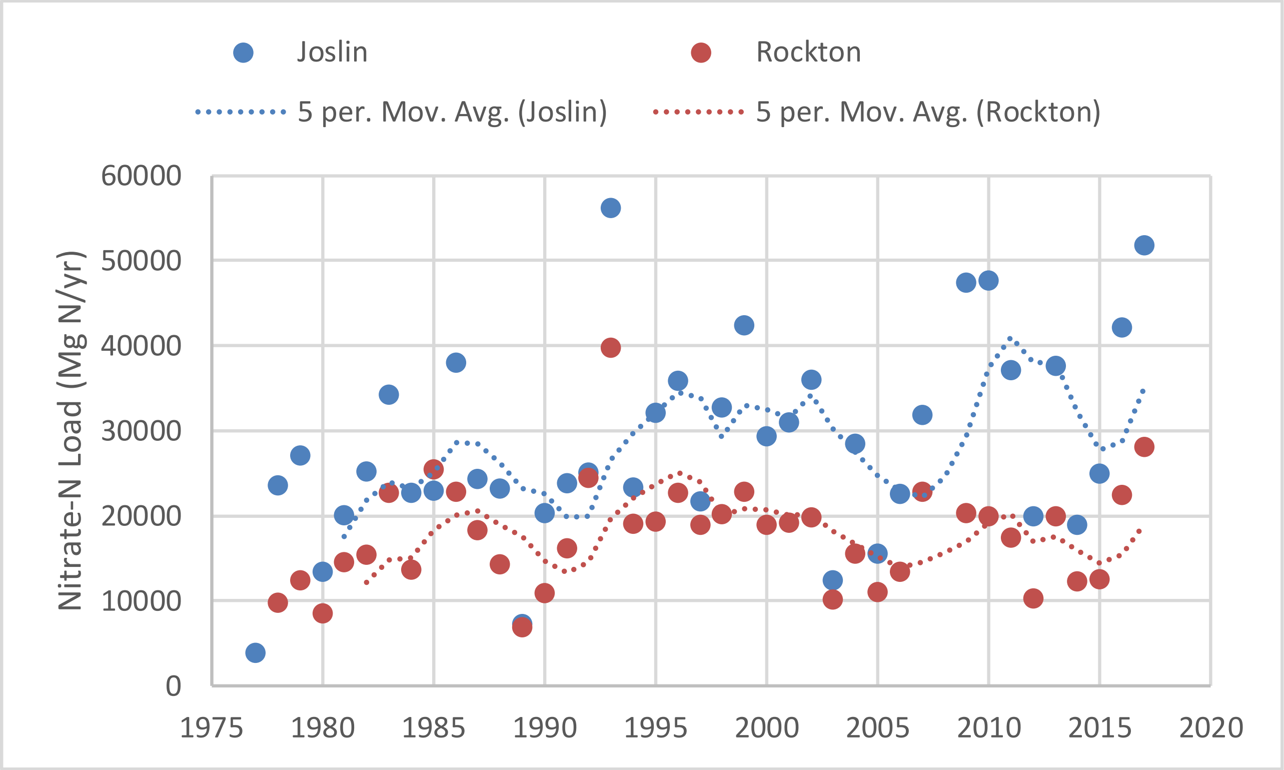
Changes in Riverine Nitrate-N Loads from 1980-96 to 2013-17 for major rivers in Illinois



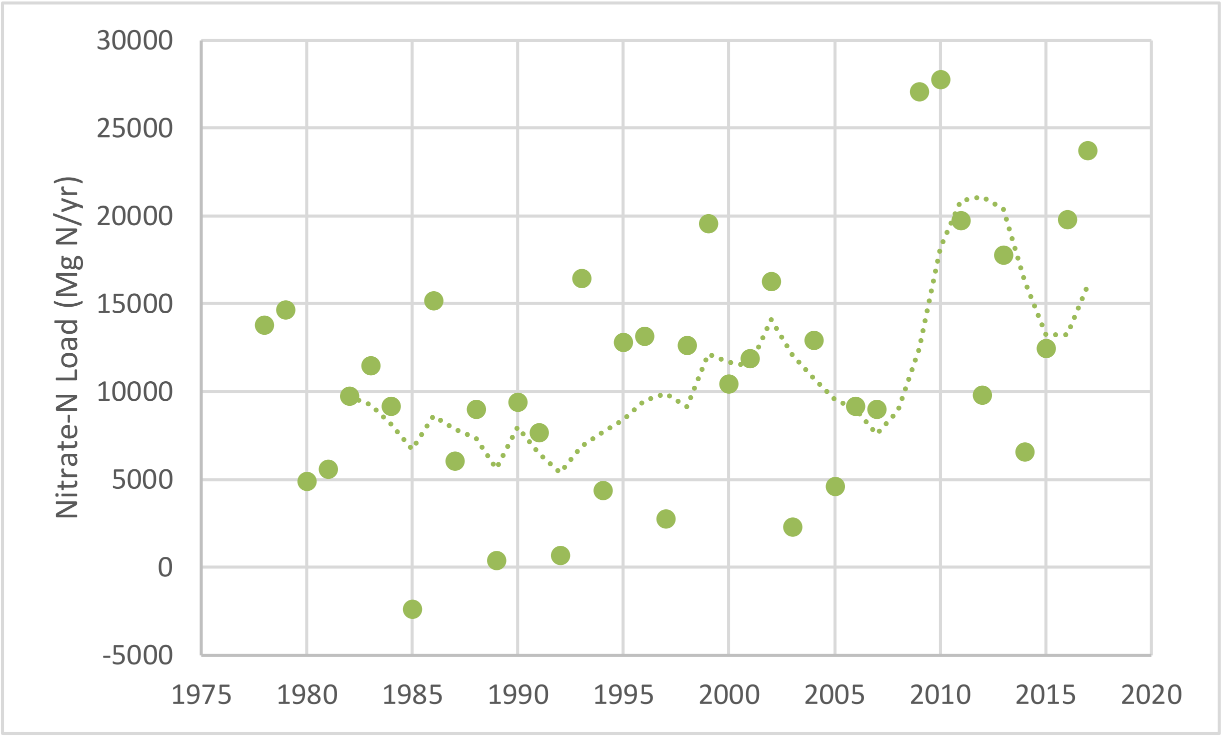
% Changes in water flow from 1980-96 to 2013-17 for major rivers in Illinois



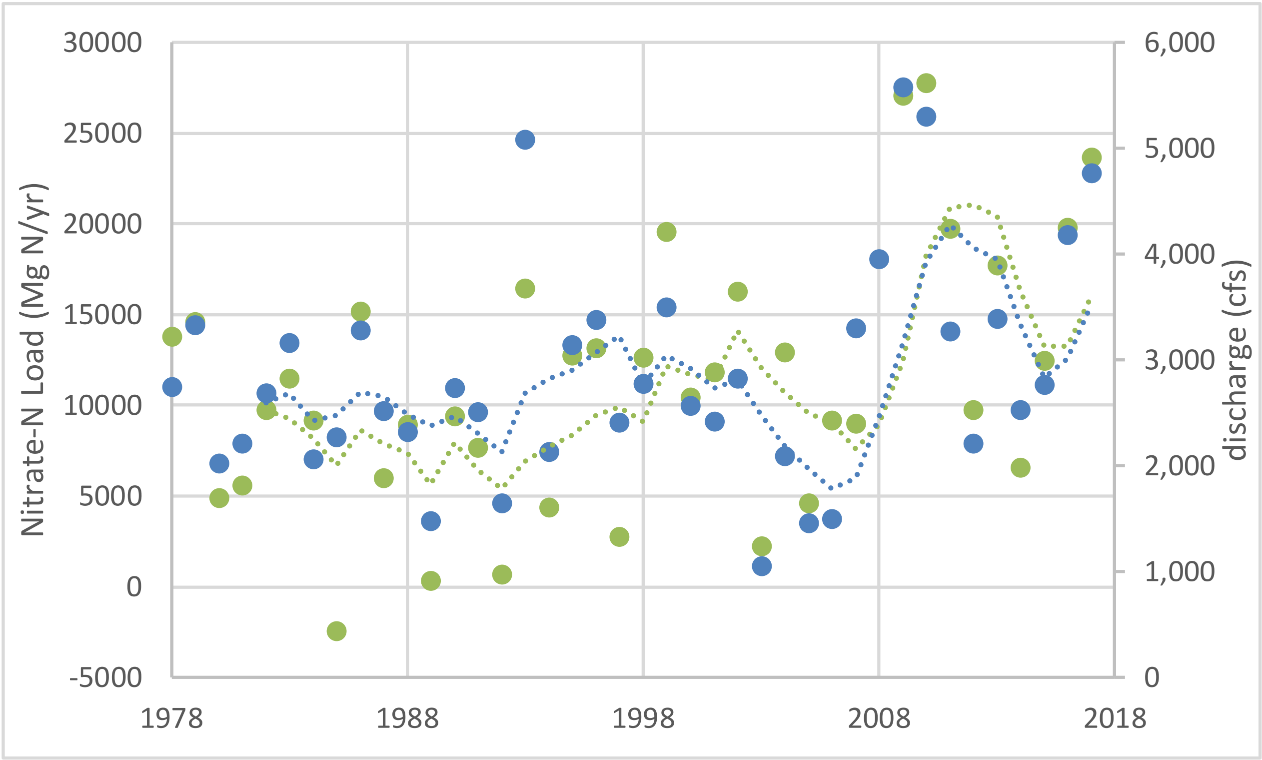
Annual Nitrate-N loads in the Rock River at Joslin (downstream) and Rockton (upstream)



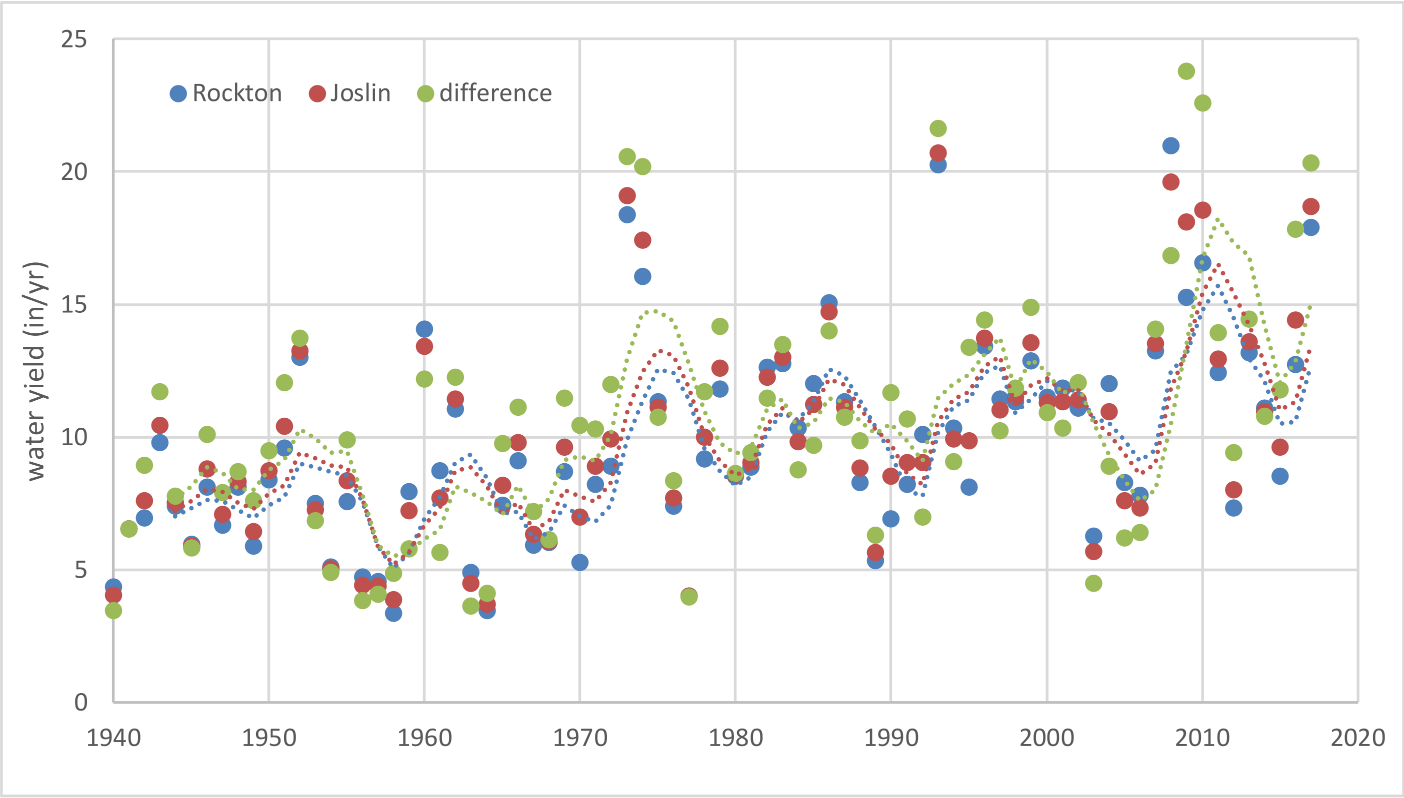
Rock River Nitrate-N load at Joslin minus Rockton



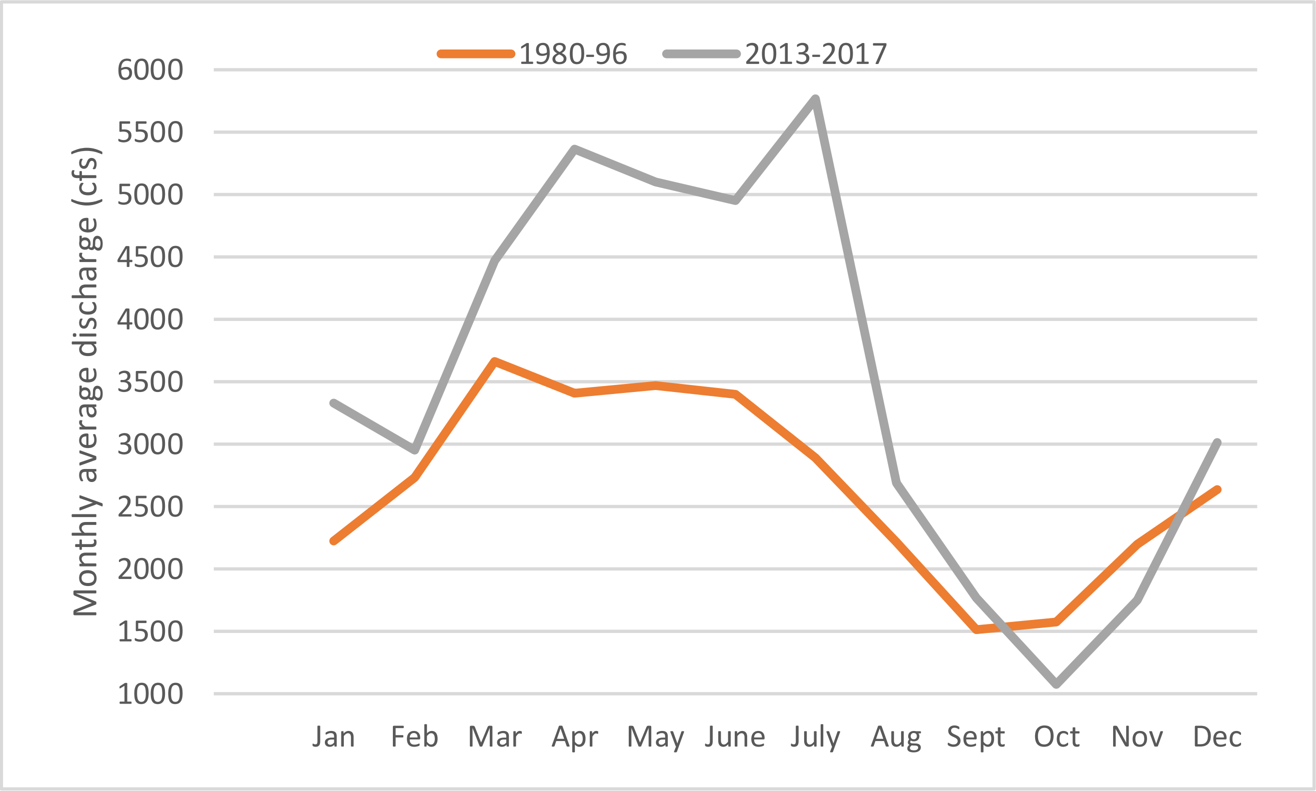
Rock River Nitrate-N load and water flow difference between Joslin and Rockton



Water yield at Rockton, Joslin and the drainage area between them
1940-2017
dashed line is the five year moving average

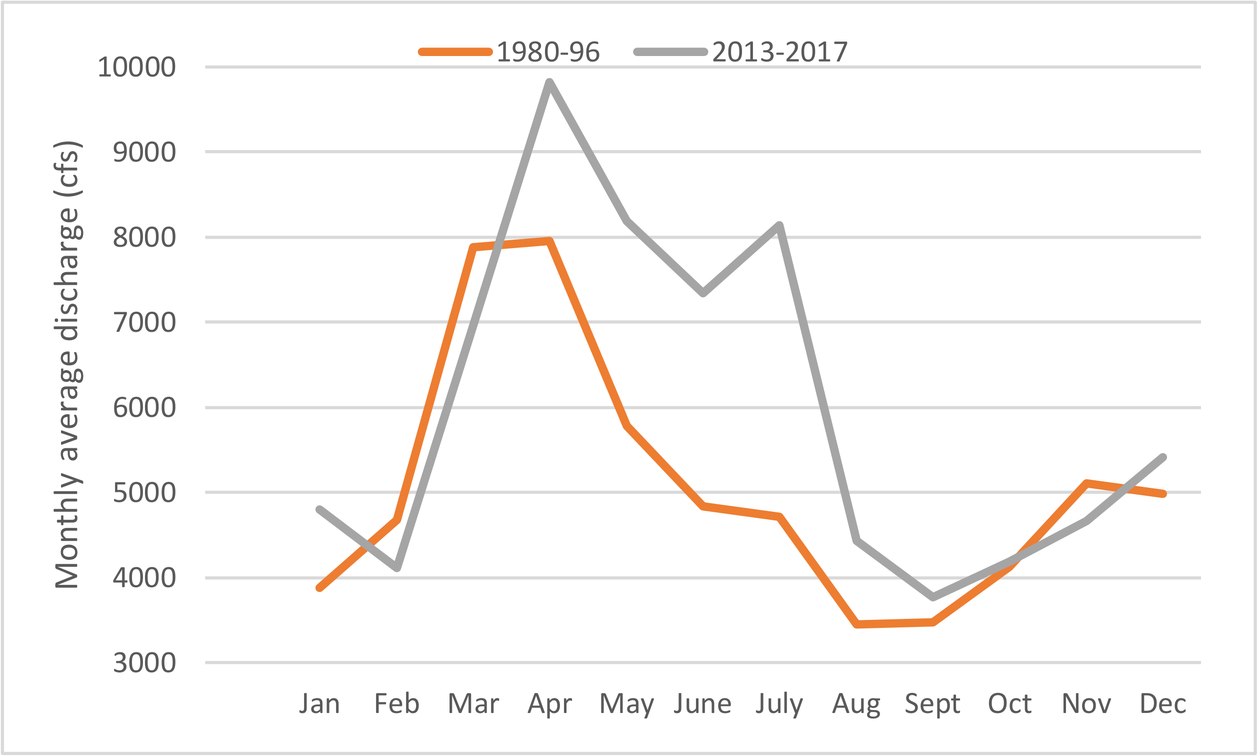


Rock River monthly average discharge at Joslin minus Rockton (33% increase in annual average water flow and 100% increase in nitrate-N load)



February 2017 average flow not included

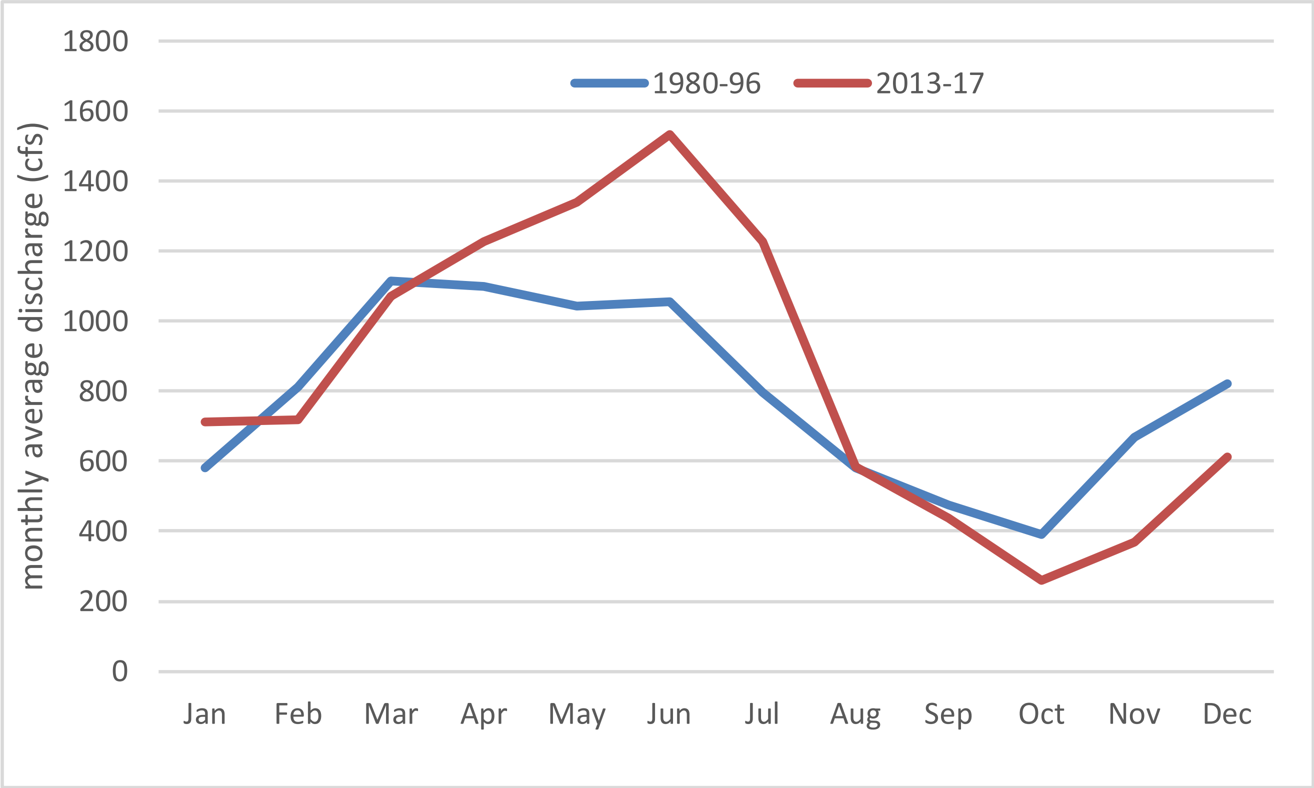
Rock River monthly average discharge at Rockton (18% increase in annual water flow and 3% increase in nitrate-N load)



February 2017 average flow not included

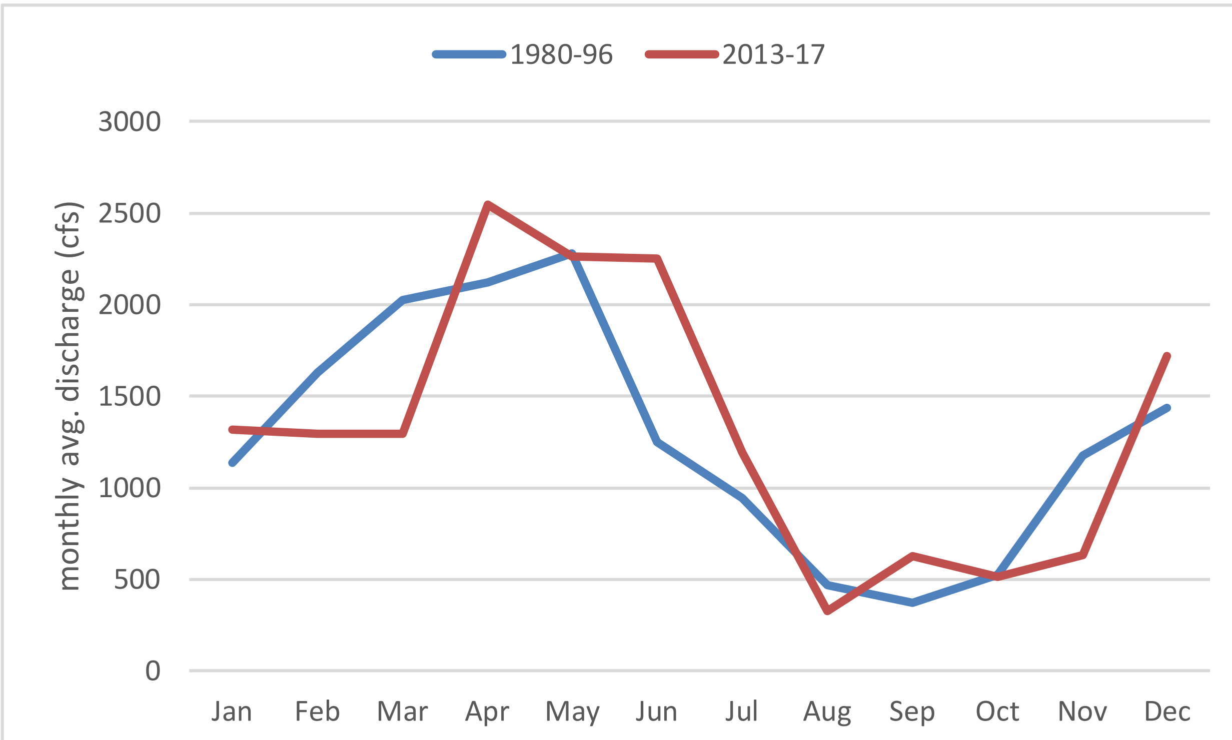
Green River at Geneseo monthly average discharge

~7% increase in annual water flow and 14% increase in annual nitrate-N load



2017 March-August flows are provisional

Vermilion River near Danville Monthly average discharge (4% increase in annual flow and 4% decrease in nitrate-N load)



Summary

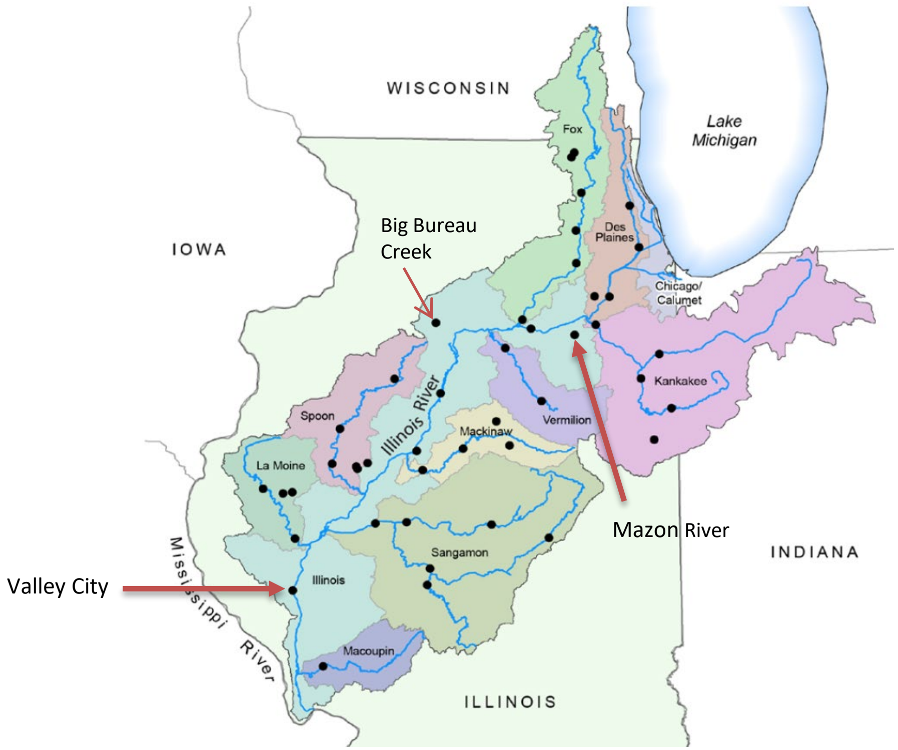
- Estimated nitrate-N yield from the Rock River between Rockton and Joslin 2013-17 was twice as large as the value for the baseline period (1980-96)
- About half of this increase appeared to be related to an increase in annual water yield, with almost all of the increase occurring between March and August.
- Analysis is continuing.

Preliminary Illinois River Nitrate-N Budget

Draft Sept 10, 2019

IL River and Tributaries

River Monitoring location	Drainage Area (sq. mi)	% of IL River at Valley City
Des Plaines R. at Joliet	1502	7.9%
Kankakee R. at Wilmington	5150	18.8%
Mazon R. at Coal City	455	1.7%
Fox R. at Dayton	2642	9.6%
Vermilion R. at Leonore	1251	4.6%
Big Bureau Creek	196	0.7%
Mackinaw R. at Green Valley	1073	3.9%
Spoon R. at Seville	1636	6.0%
Sangamon R. at Oakton	5093	18.6%
La Moine River R. at Ripley	1293	4.7%
total of all tributaries	20291	**75.9%**
IL R. at Valley City	26743	**100.0%**



Modified from Demissie et al (2016)
https://www.isws.illinois.edu/pubdoc/RI/ISWSRI-122extsummary.pdf

		Drainage Area		2009-17 avg discharge		2009-17 avg NO3-N Load	
Upper or Lower Tributary	**Monitoring Location**	**(sq. mi.)**	**% of IL River at Valley City**	**(cfs)**	**% of IL River at Valley City**	**(Mg N/yr)**	**% of IL River at Valley City**
Upper	Des Plaines R. at Joliet	1502	7.9%	3834	12.8%	15676	15.0%
Upper	Kankakee R. at Wilmington	5150	18.8%	5892	19.7%	21487	20.5%
Upper	Mazon R. at Coal City	455	1.7%	493	1.7%	3494	3.3%
Upper	Fox R. at Dayton	2642	9.6%	2767	9.3%	7359	7.0%
Upper	Vermilion R. at Leonore	1251	4.6%	1148	3.8%	8412	8.0%
Upper	Big Bureau Creek	196	0.7%	190	0.6%	1723	1.6%
Lower	Mackinaw R. at Green Valley	1073	3.9%	1003	3.4%	6185	5.9%
Lower	Spoon R. at Seville	1636	6.0%	1647	5.5%	8320	7.9%
Lower	Sangamon R. at Oakton	5093	18.6%	4540	15.2%	20011	19.1%
Lower	La Moine River R. at Ripley	1293	4.7%	1262	4.2%	3819	3.6%
	total of monitored tributaries	**20291**	**75.9%**	**22776**	**76.3%**	**96,486**	**92.2%**
	IL R. at Valley City	**26743**	**100%**	**29,865**	**100%**	**104,657**	**100%**

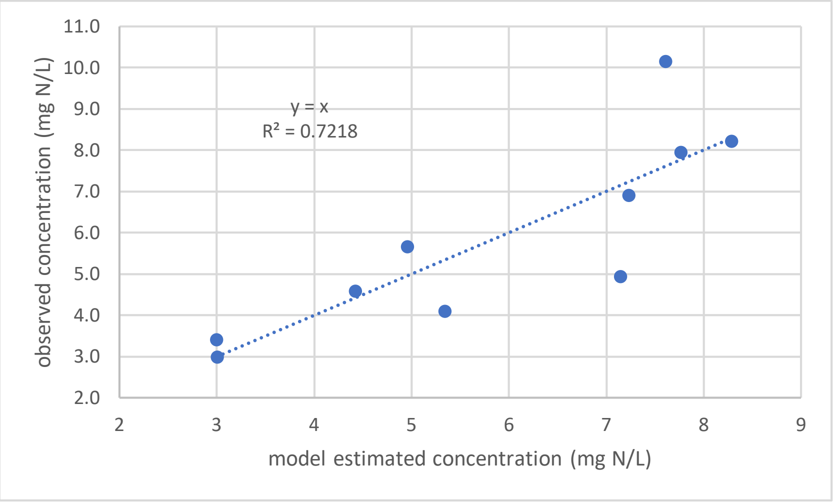
Land Cover USGS GAP/LANDFIRE Terrestrial Ecosystems data from 2011

Watershed	Row Crop	Developed
Des Plaines R. at Joliet	10%	75%
Kankakee R. at Wilmington	75%	8%
Mazon R. at Coal City	88%	7%
Fox R. at Dayton	48%	26%
Vermilion R. at Leonore	90%	7%
Big Bureau Creek	87%	7%
Mackinaw R. at Green Valley	84%	8%
Spoon R. at Seville	75%	6%
Sangamon R. at Oakford	82%	10%
La Moine River R. at Ripley	66%	6%
total of all tributaries	70%	16%
IL R. at Valley City	67%	15%
non-tributary areas	58%	14%

GIS Analysis provided by Aaron Hoyle-Katz, NCSA UIUC

Flow-weighted concentration regression with land cover

Variable	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	-11.8051	4.637113	-2.54578	0.038339
Row Crop	20.72128	5.23177	3.960664	0.005457
Developed	18.8401	6.015492	3.13193	0.016565



Estimated Nitrate-N Concentration for the Non-tributary areas = 2.98 mg N/L

Estimated nitrate-N budget and denitrification between tributary monitoring locations and Valley City 2009-17

- Tributary Load = 212 Million lb N/yr
- Additional flow generated between Valley City (29,865 cfs) and Tributary monitoring locations (22,776 cfs) = 7,088 cfs
- Estimated additional NO3-N load if drainage from non-tributary area has average concentration of 2.98 mg N/L = 40 Million lb N/yr
- Tributary Load+ Non-Tributary Load =212+40 =252 Million lb N/yr
- Load at Valley City = 230 Million lb N/yr
- Estimated denitrification = 252 - 230 = 22 Million lb N/yr
- Approximately 10% of the tributary loads
- 5.5% of the ~400 million lb N/yr statewide load

Comment on Response to "Comment on 'Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico'"

Gregory McIsaac
Department of Natural Resources and Environmental Sciences
University of Illinois at Urbana Champaign
&
Agricultural Watershed Institute
Decatur, IL

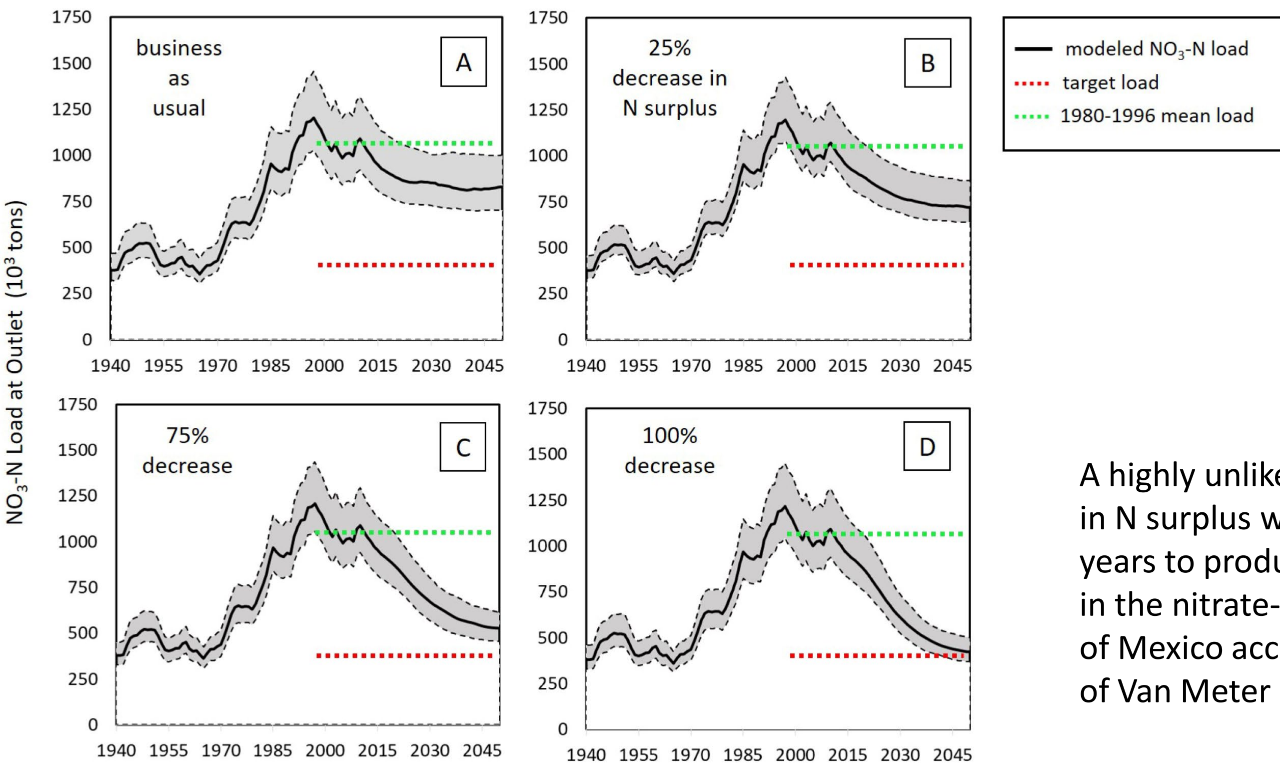
Science AAAS

Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico

Cite as: K. J. Van Meter *et al.*, *Science* 10.1126/science.aar4462 (2018).

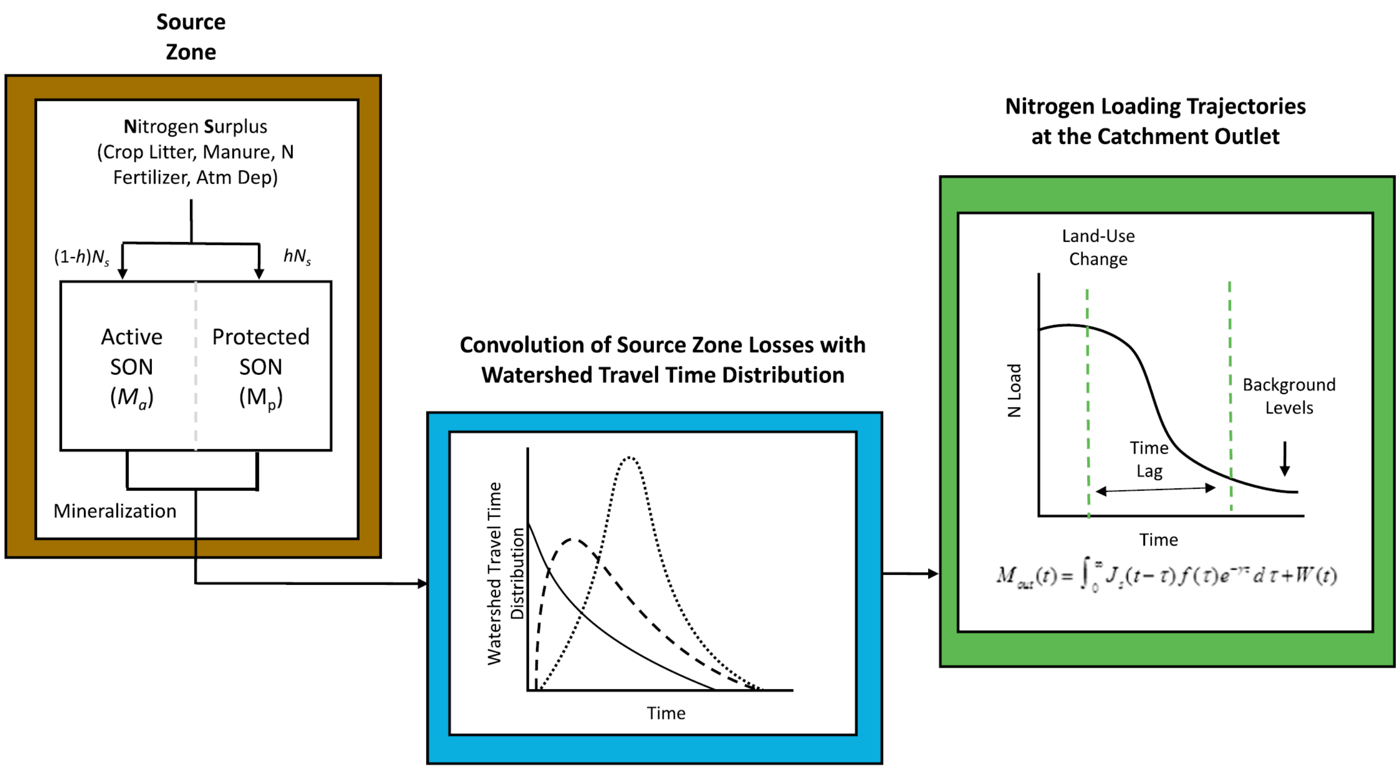
K. J. Van Meter,[1,2] P. Van Cappellen,[1,2,3] N. B. Basu[1,3,4]*

[1]Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, ON, Canada N2L 3G1. [2]Ecohydrology Research Group, University of Waterloo, Waterloo, ... , University of Waterloo,



A highly unlikely 100% reduction in N surplus would take about 30 years to produce a **<u>60%</u>** reduction in the nitrate-N loads to the Gulf of Mexico according to the model of Van Meter et al.

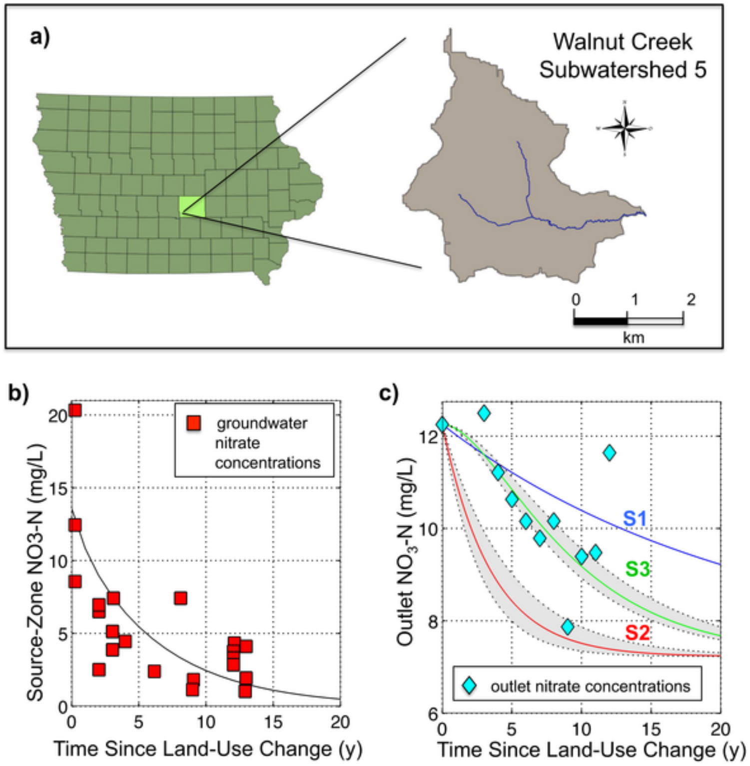
Conceptual framework for the model of Van Meter et al.



Two centuries of nitrogen dynamics: Legacy sources and sinks in the Mississippi and Susquehanna River Basins

Global Biogeochemical Cycles, Volume: 31, Issue: 1, Pages: 2-23, First published: 01 December 2016, DOI: (10.1002/2016GB005498)

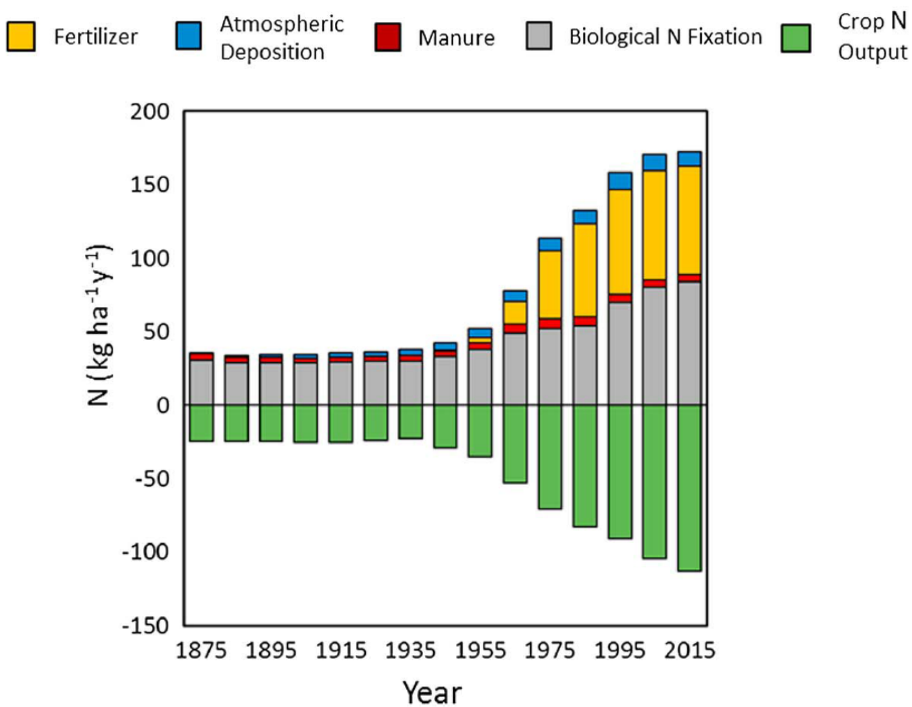
Fig 3. Site Information and Results for the Walnut Creek Case Study.

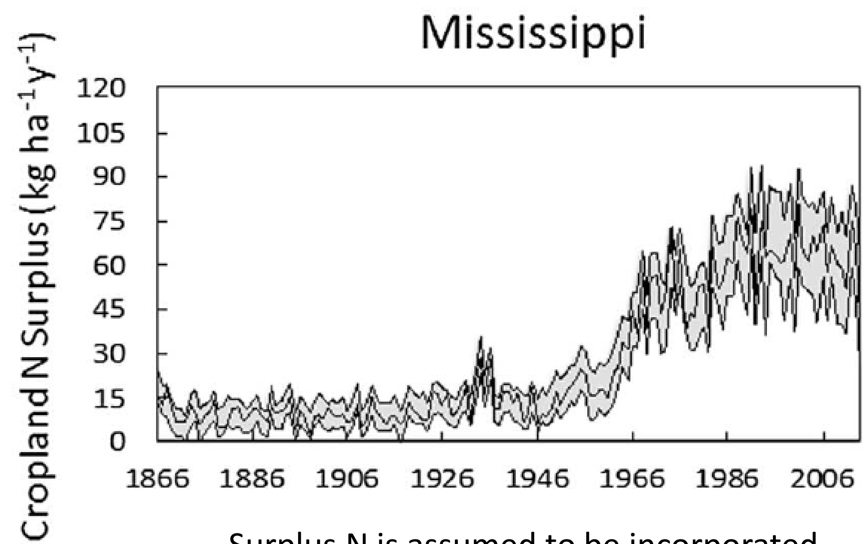


Van Meter KJ, Basu NB (2015) Catchment Legacies and Time Lags: A Parsimonious Watershed Model to Predict the Effects of Legacy Storage on Nitrogen Export. PLOS ONE 10(5): e0125971. https://doi.org/10.1371/journal.pone.0125971
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0125971

PLOS | ONE

Cropland N Surplus = Fertilizer N + Atm. N Dep. + Manure N + Biological N Fixation – Crop N Harvest





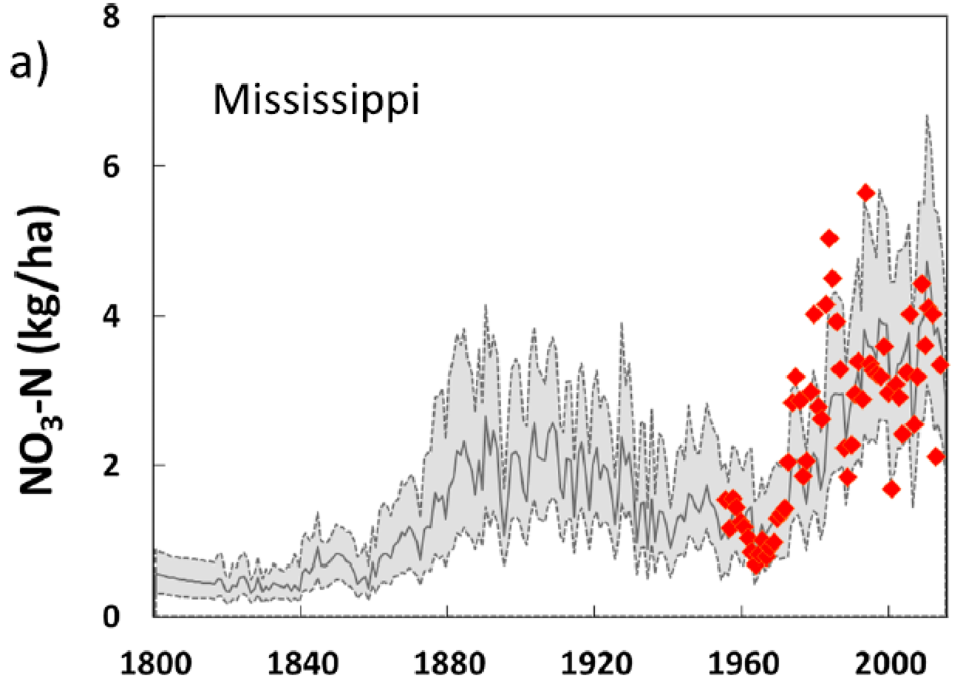
Surplus N is assumed to be incorporated into soil organic matter and this produces one portion of the legacy or lag time (but it is well known that fertilizer N can be lost without cycling through organic matter)

These N surplus values are larger than previously published estimates.

Two centuries of nitrogen dynamics: Legacy sources and sinks in the Mississippi and Susquehanna River Basins

Global Biogeochemical Cycles, Volume: 31, Issue: 1, Pages: 2-23, First published: 01 December 2016, DOI: (10.1002/2016GB005498)

Van Meter et al. Model (gray) vs observed (red) Nitrate-N yield for the Mississippi River Basin



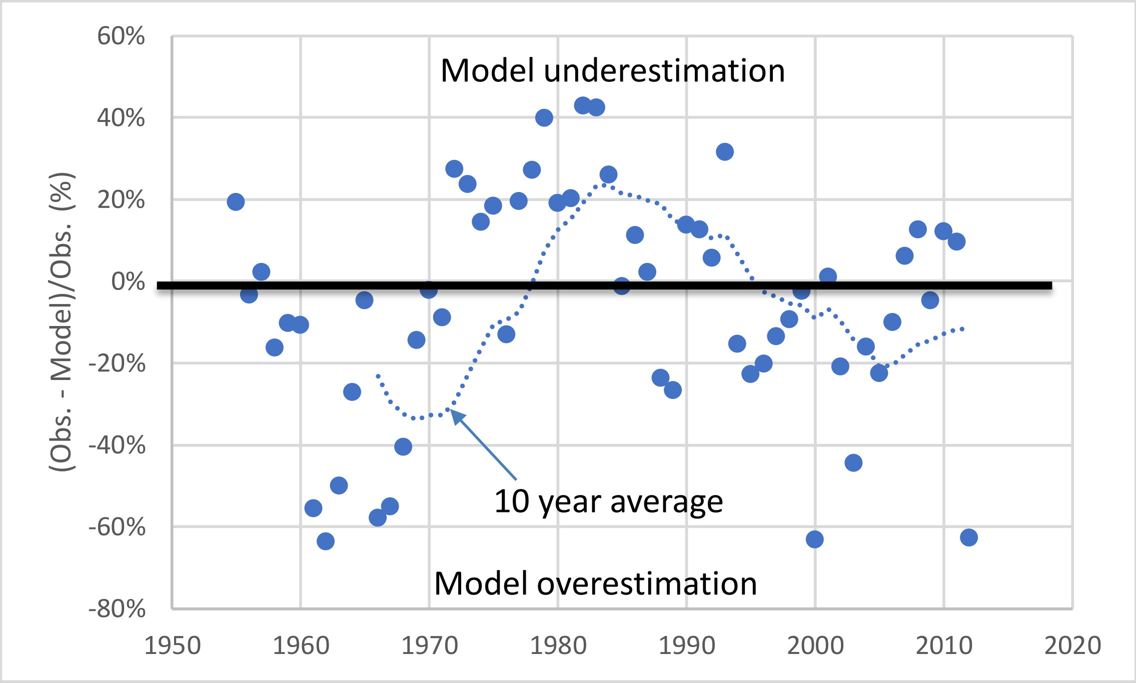
Model calibrated to 1979-2013 accounts for 67% of variation in observed nitrate yield 1955-2014.

Model (gray) systematically underestimates observed (red) yields in 1970s and 1980s.

Two centuries of nitrogen dynamics: Legacy sources and sinks in the Mississippi and Susquehanna River Basins

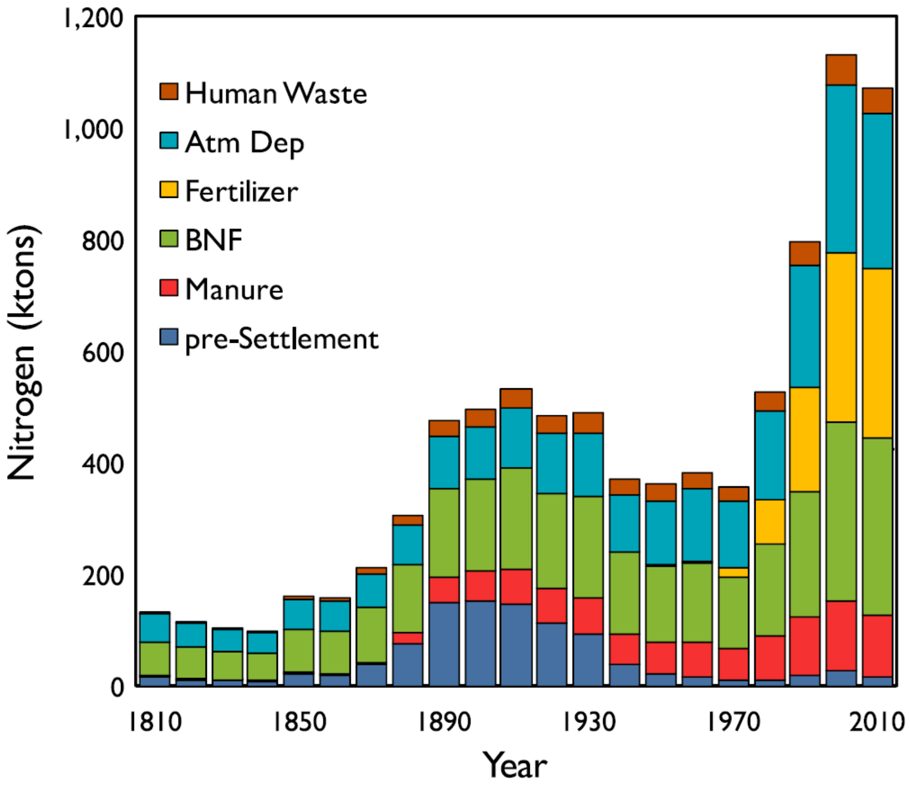
Global Biogeochemical Cycles, Volume: 31, Issue: 1, Pages: 2-23, First published: 01 December 2016, DOI: (10.1002/2016GB005498)

Van Meter et al. Model deviation from Observed Nitrate-N Load from Mississippi River Basin as a percent of the observed values

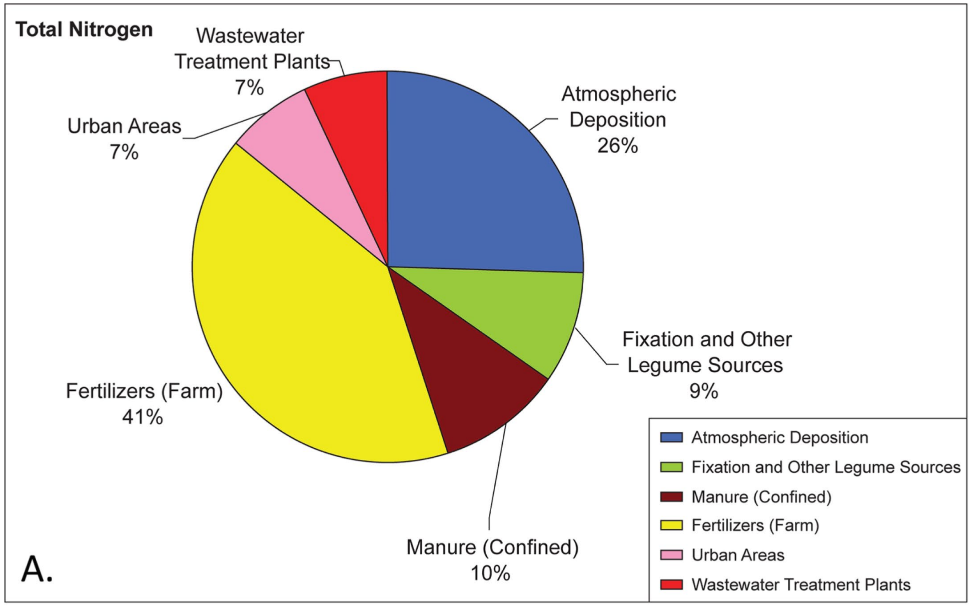


Model and observed load data from Van Meter et al. 2018

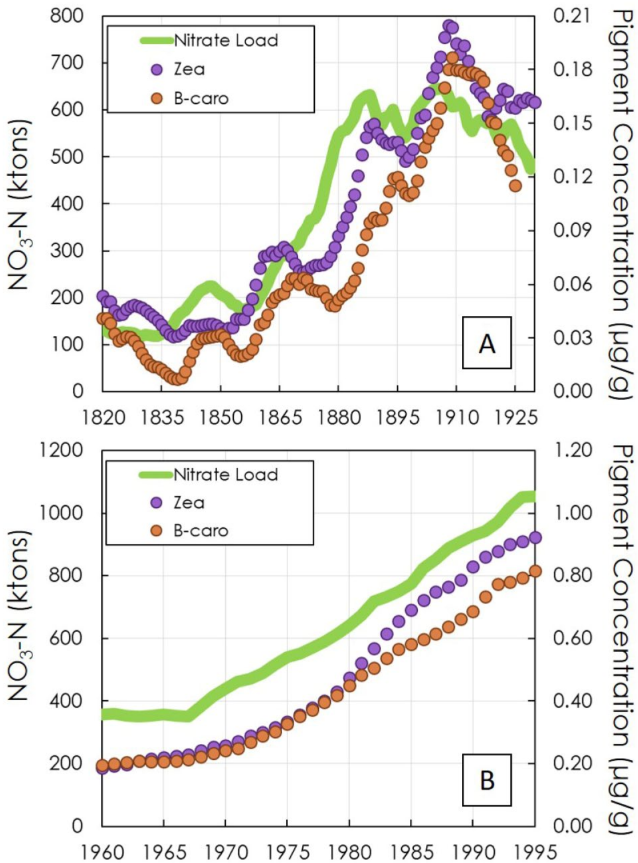
Sources of nitrogen at the MRB outlet
Van Meter et al. (2016).



2002 SPARROW model (Robertson and Saad (JEQ 2014)



Similar proportions except for fertilizer and biological N fixation (BNF)

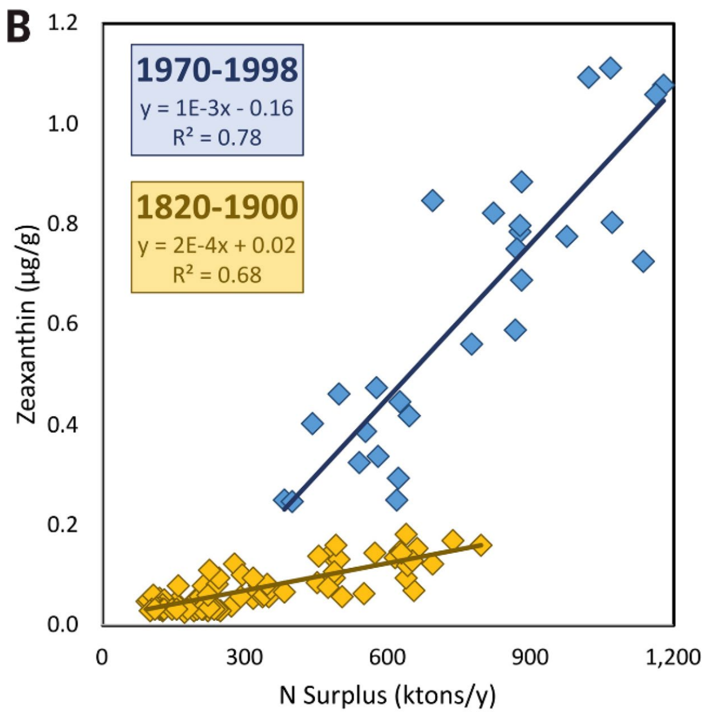


Van Meter etl al. (2018) Science

Van Meter et al. model estimated nitrate-N load (green line) appears correlated with a proxy measure of historical nutrient loading nd hypoxia in the Gulf of Mexico: chloropigments in a single sediment core in the Gulf of Mexico taken from an area that was not highly impacted by hypoxia 1985-2001.

Relationship between model estimated nitrate-N load and chloropigment shifts by a factor of ~4 between top graph (1820-1925) bottom graph (1960-95)

Pigment data from Rabalais et al. (2004) was used without consultation, and is highly smoothed. Relationship to observed annual nitrate-N load 1969-97 R^2 =0.68.



Van Meter et al.(2019)
(horizontal axis maybe should be estimated Mississippi River N Load, not N Surplus)

Van Meter et al (2019): "The change in slope… reflects the well-known post-1970s change in the relationship between MRB N loads and Gulf hypoxia driven by increased primary productivity and increases in sediment carbon content, as noted by Turner *et al*. [*2006]*."

Turner et al. (2006) "TN:TP ratio … **suggests** N, not P, has become more important as a factor limiting phytoplankton growth in the last 20 years." (emphasis added)

Turner et al. (2006) did not examine sediment pigments and did not suggest a doubling and more in productivity for each unit of N as indicated by the change in slope. The accumulation of carbon in sediments was presumed to increase the benthic respiration load and contribute to an increase in area of hypoxia for each unit of N delivered to the Gulf.

A more likely explanation for the change in slope is that Van Meter et al.(2018) over estimated N loading to the Gulf of Mexico 1820-1920

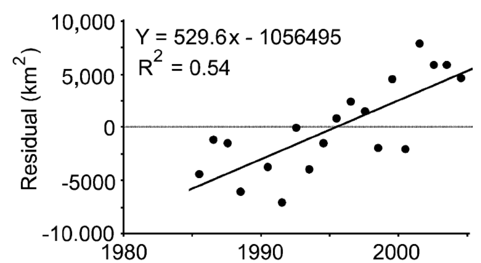
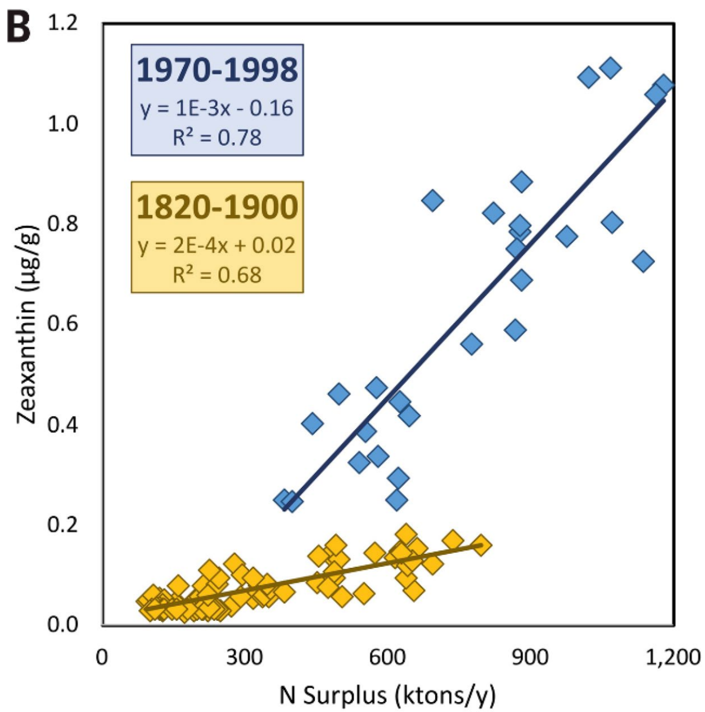
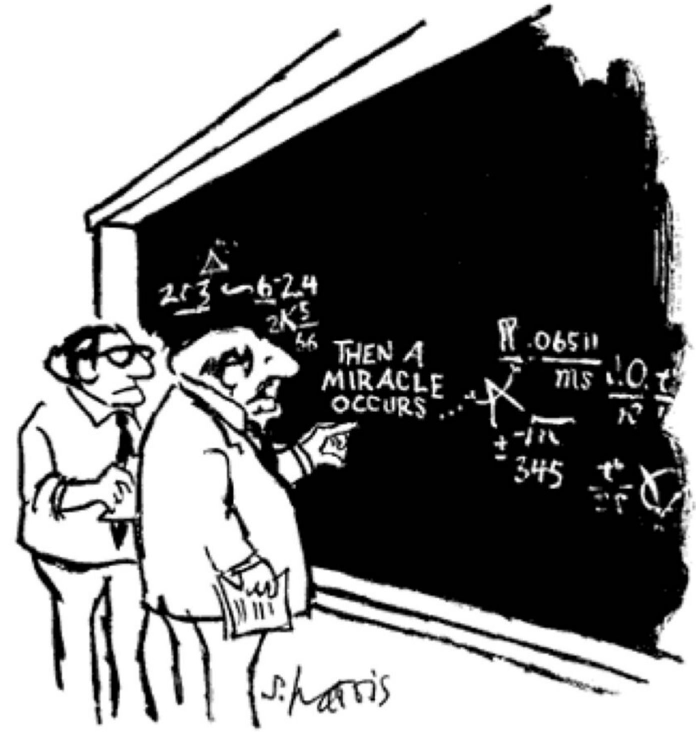


Fig. 6. The residual from a linear regression of hypoxic zone size each summer (km^2) versus NO_{3+2} loading (mt) 2 months before the hypoxia survey (from 1985 to 2004) is plotted against the year of the summer survey. A linear regression of the two variables is shown.



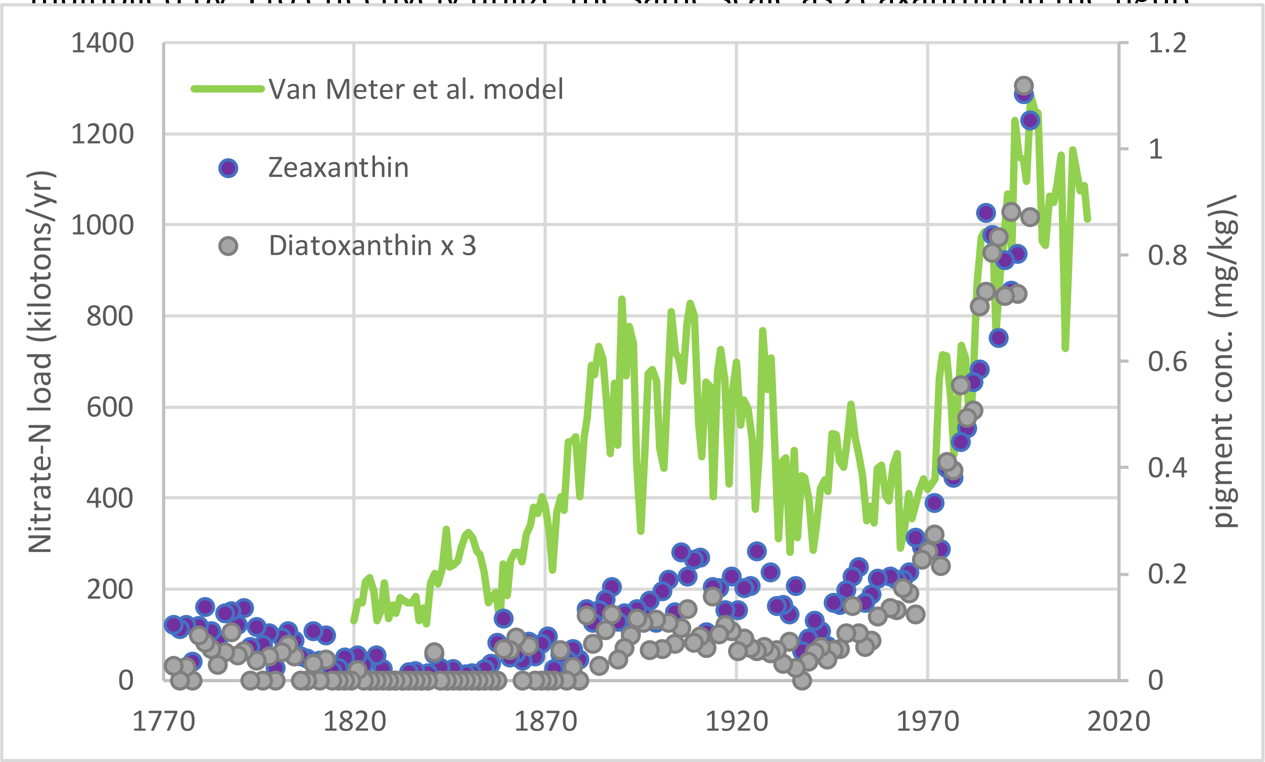
Van Meter et al.(2019)
(horizontal axis maybe should be estimated Mississippi River N Load, not N Surplus)



"I think you should be more explicit here in step two."

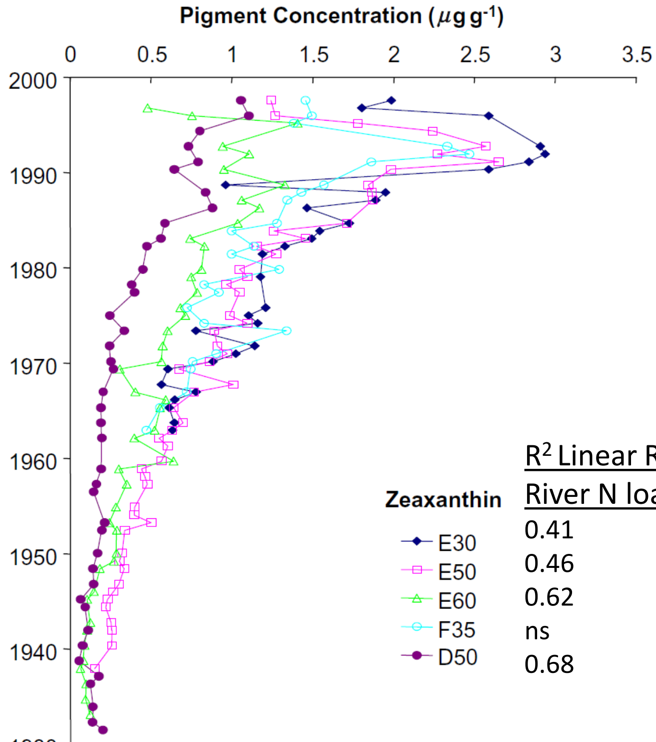
[Sidney Harris](http://www.sciencecartoonsplus.com/index.php)
http://www.sciencecartoonsplus.com/index.php

Van Meter et al. (2018) model Nitrate-N Load to the Gulf of Mexico (green) and pigment concentrations from core D50 (purple and gray). The relationship between pigments and modeled N load changes because the model load and pigment concentrations diverge. Diatoxanthin is a better proxy for nitrate-N load than Zeaxanthin as indicated by R^2 values in Rabalais et al. (2004). Diatoxanthin concentrations were multiplied by 3 to effectively utilize the same scale as Zeaxanthin in the figure.

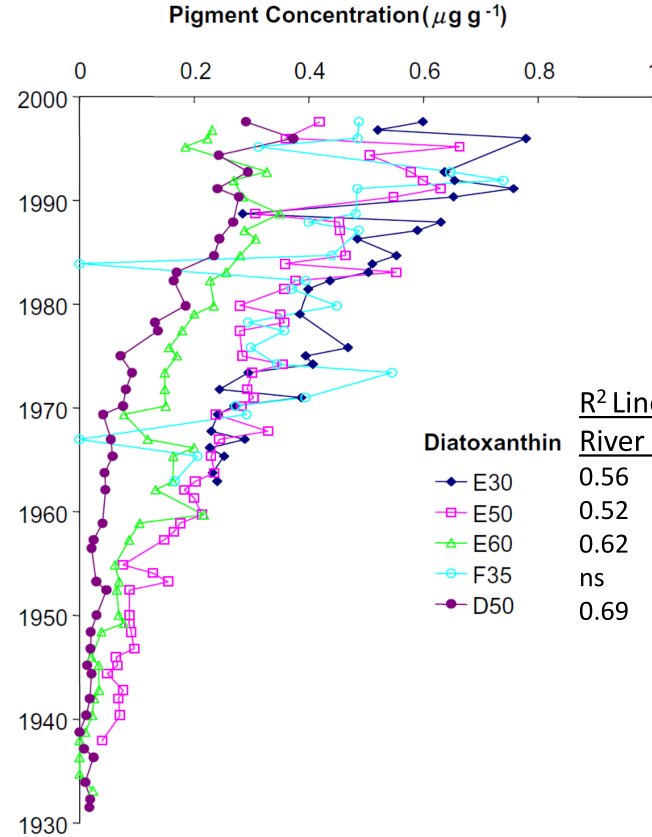


N loss from soil organic matter was large in the 1800s, but tile drainage was fairly limited, and there were large wetland areas that persisted into the early 1900s which could reduce N reaching the Gulf of Mexico.

Pigment concentrations in 5 cores in the Gulf of Mexico plotted by estimated age of deposition. Note the variation among cores.



Zeaxanthin	R^2 Linear Relation to River N load 1969-97
E30	0.41
E50	0.46
E60	0.62
F35	ns
D50	0.68



Diatoxanthin	R^2 Linear Relation to River N load 1969-97
E30	0.56
E50	0.52
E60	0.62
F35	ns
D50	0.69

From Rabalais et al. (2004)

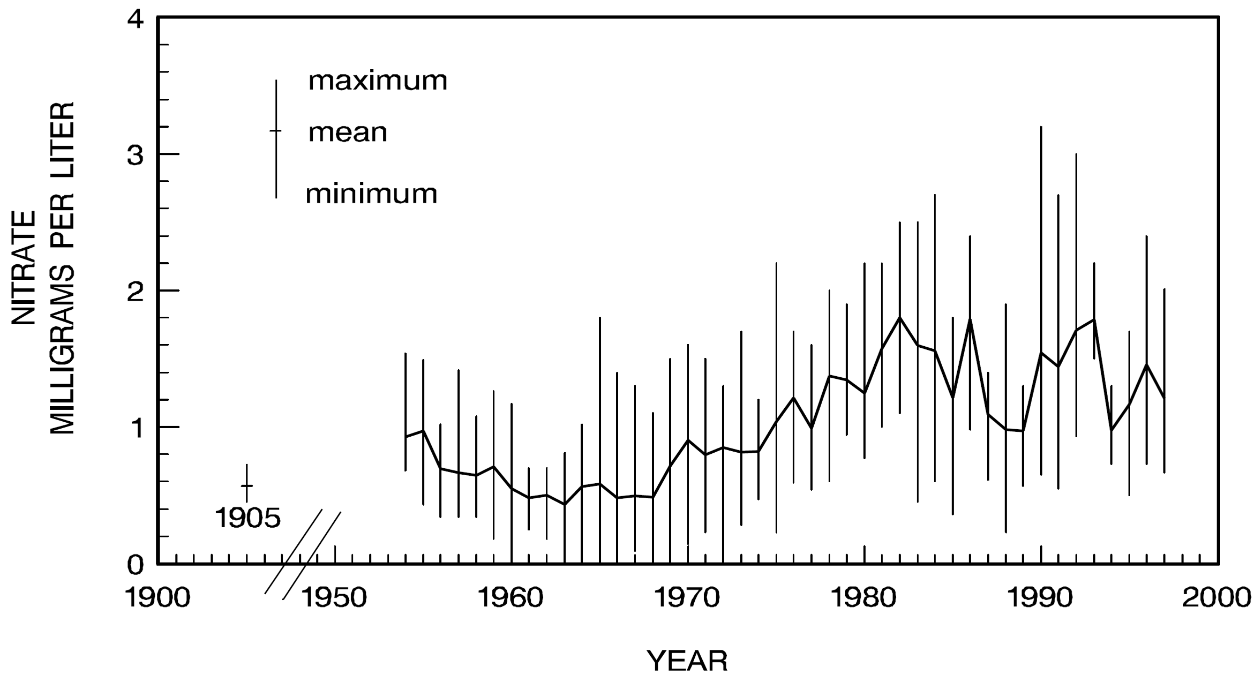
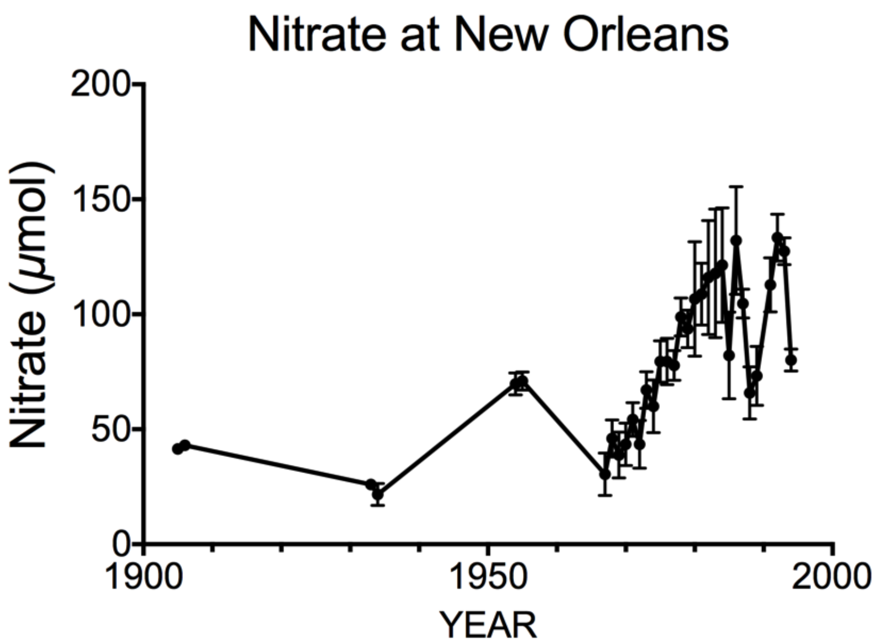


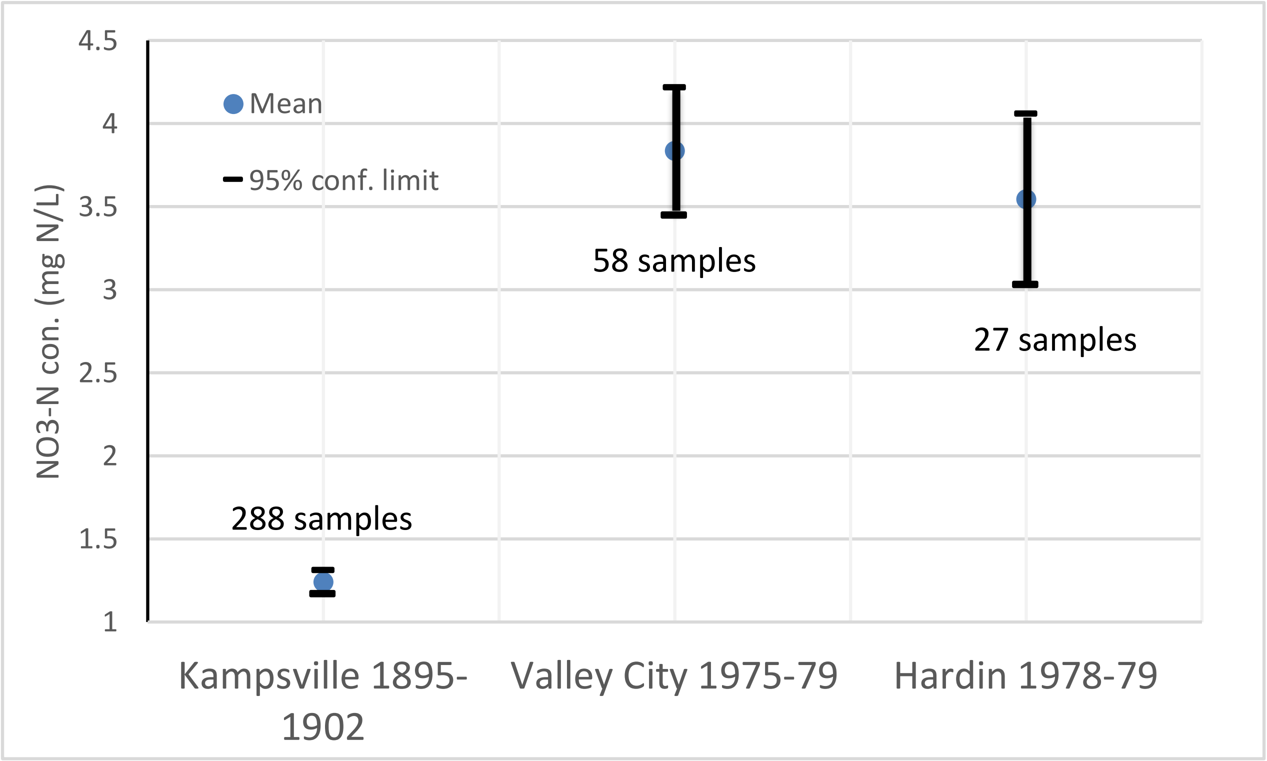
Figure 2. Long-term patterns in nitrate concentrations in the lower Mississippi River at St. Francisville, La.

Goolsby et al. (2000)
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.531.6264&rep=rep1&type=pdf

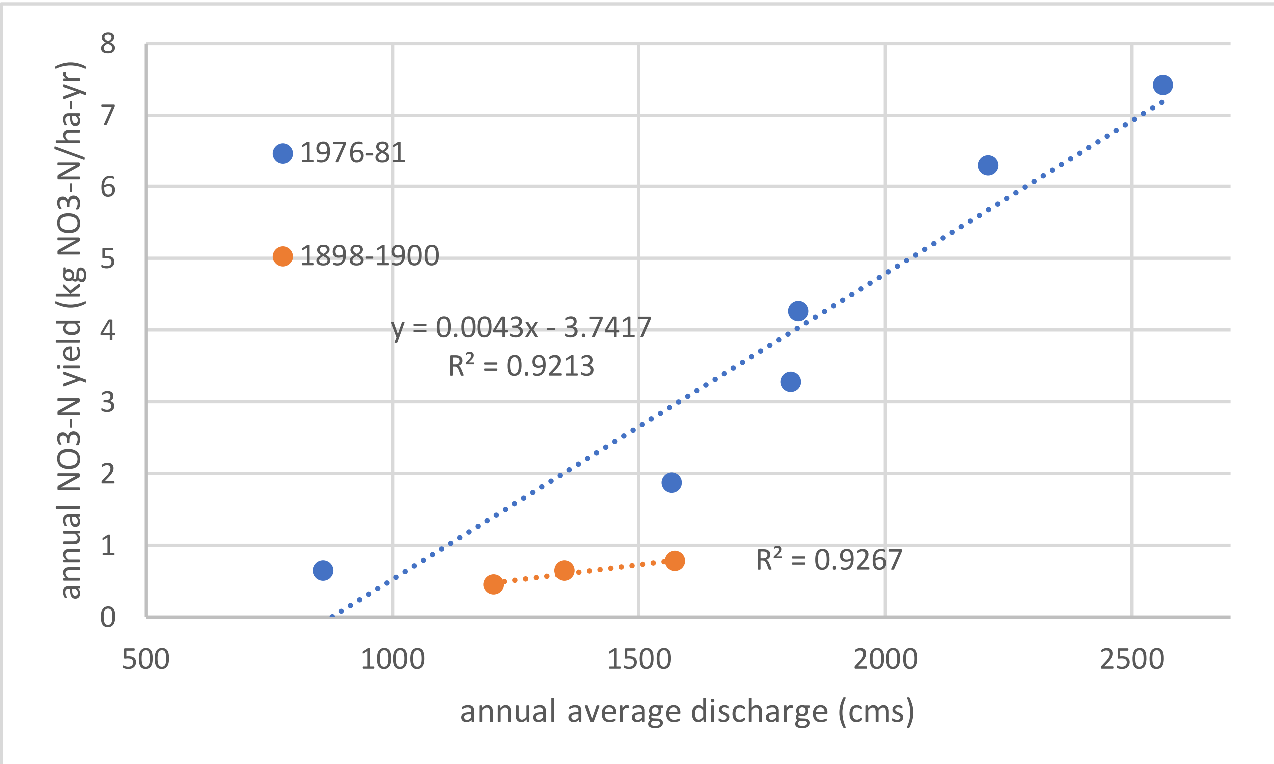


Modified and updated from Turner and Rabalais (1991)

Average Nitrate-N Concentrations in the Lower Illinois River at Kampsville (1895-1902, ISWS), Valley City (1975-79 USGS and IEPA), and Hardin (1978-79, IEPA)



Annual Nitrate N Yield in the Mississippi River at Keokuk Iowa (119,000 mi^2), plotted against annual discharge (water year) 1898-1900 (concentrations at Quincy, IL 135,500 mi^2) and 1975-1981 (concentration at Keokuk)



1897-1900 concentration data collected at Quincy, IL as reported in Palmer (1902). Quincy is about 30 miles downstream from Keokuk, IA. Nitrate-N and Nitrite-N concentrations were added together to be comparable to modern analyses that measure combined concentrations. All other concentration and discharge data were from the USGS. 1975-81 analyses used both filtered and unfiltered nitrate concentrations.

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Submitted Manuscript: Confidential

Title: Comment on "Legacy nitrogen may prevent achievement of water quality goals in the Gulf of Mexico"

Authors: Tristan C. Ballard[1,2*], Anna M. Michalak[1,2], Gregory F. McIsaac[3,4], Nancy N. Rabalais[5], R. Eugene Turner[5]

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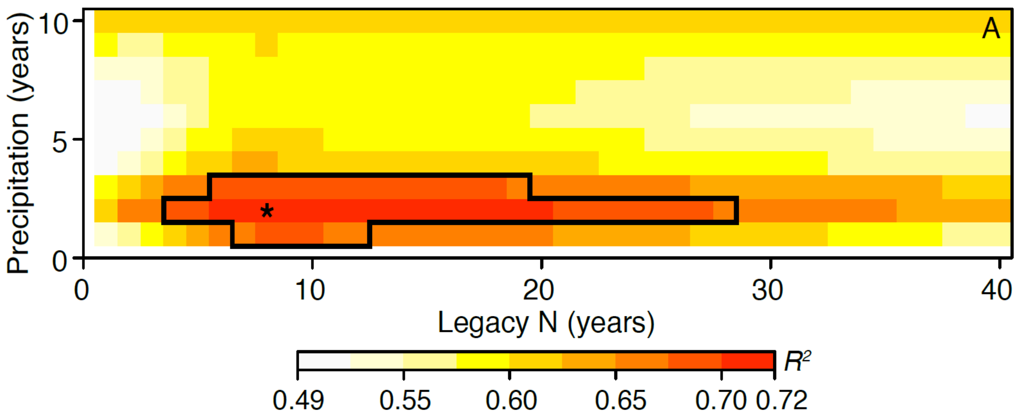
Alternative model from Ballard et al(2019): Nitrate-N Load = C_1*(Precip. Legacy) + C_2*(N Surplus Legacy)

Regression analysis conducted with cumulative Precipitation from 1 to 10 years and cumulative N Surplus from 1 to 40 years to estimate nitrate-N load in the Mississippi River at St. Francisville. 1955-2012

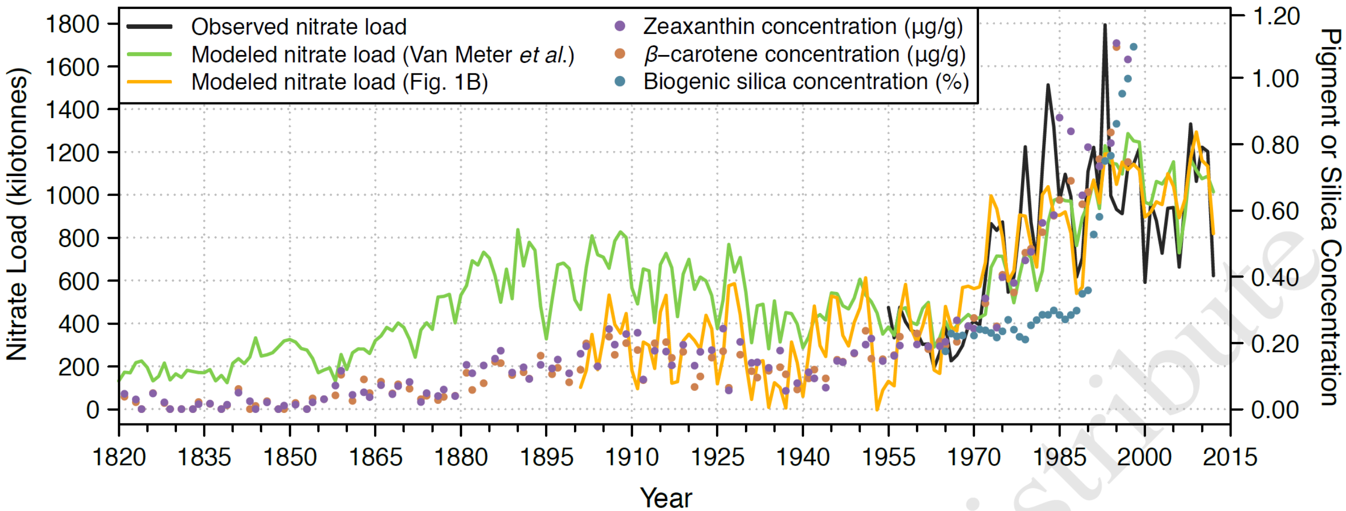
Maximum explanatory power = 72% of variation in nitrate-N load using 2 years cumulative precipitation legacy and 8 years cumulative N Surplus legacy (black star in figure below)

N Surplus Legacies ranging from 4 to 28 years had as much or more explanatory power as the Van Meter et al. model (67%) (combinations within the black line in figure below)



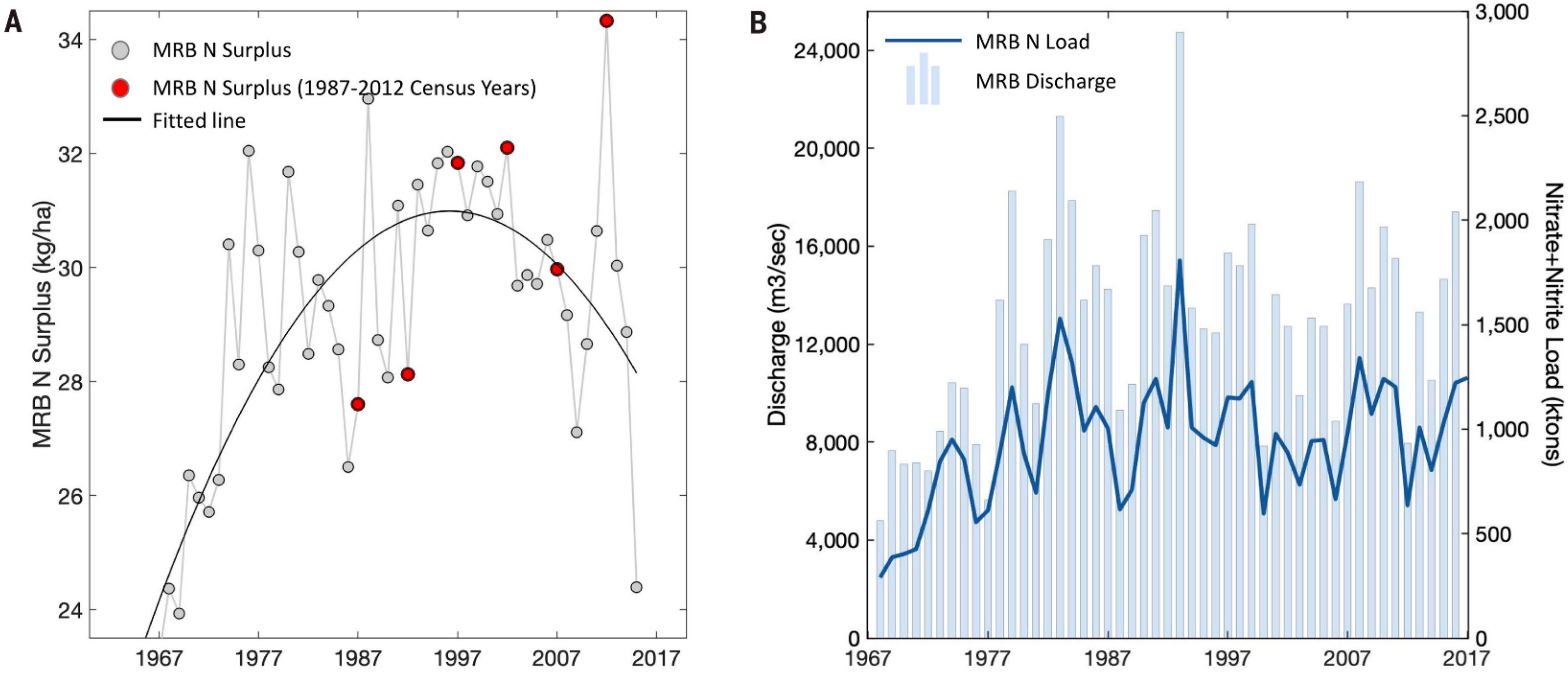
Ballard et al. (2019) Science

Estimated nitrate-N loads (solid lines, based on observations and both models) and concentrations (circles) of chloropigments and biogenic silica in single sediment cores in the Gulf of Mexico plotted by estimated time of deposition



Ballard et al. (2019) Science

Model of Ballard et al (2019) tracks the chloropigment data better than the model of Van Meter et al. (2018); although the choropigment data is an imperfect proxy for nitrate-N load.



Van Meter et al. 2019

Conclusions

- Nitrate load 1955-2014 to the Gulf of Mexico based on measured river flow and concentrations can be modeled with N legacy effects ranging from just four years to 28 years with approximately equal explanatory value to the Van Meter Model
- Recovery times are uncertain. Recovery may indeed take decades, as Van Meter *et al*. suggest, but recovery may also be much faster.
- Chloropigment data from **one** Gulf sediment core presented in Van Meter et al. does not validate their model.
- River nitrate concentration data from 1895-1906 is limited but **NOT** consistent with concentrations and loads similar to the late 1970s as simulated by the Van Meter model.

Lunch Time!

Estimating Statewide Nutrient Loads from USGS Super Gages, Adding Non-Monitored Areas and Subtracting WI and IN Contributions – Paul Terrio

Super Gages Update, and 2021-2025 Operation and Funding Discussion – USGS and IEPA

NMC Member Updates

Exciting or Boring News to Share?

NEWS

"Next Steps" Summary
(NMC March 19, 2019)

- Today's Action Items?
  - A.
  - B.
  - C.
- Topics/Presentations for Next Meeting?
- Other (TBD)