Geographic and Annual Variations in Riverine Nitrate and Total Phosphorus Loads in Illinois

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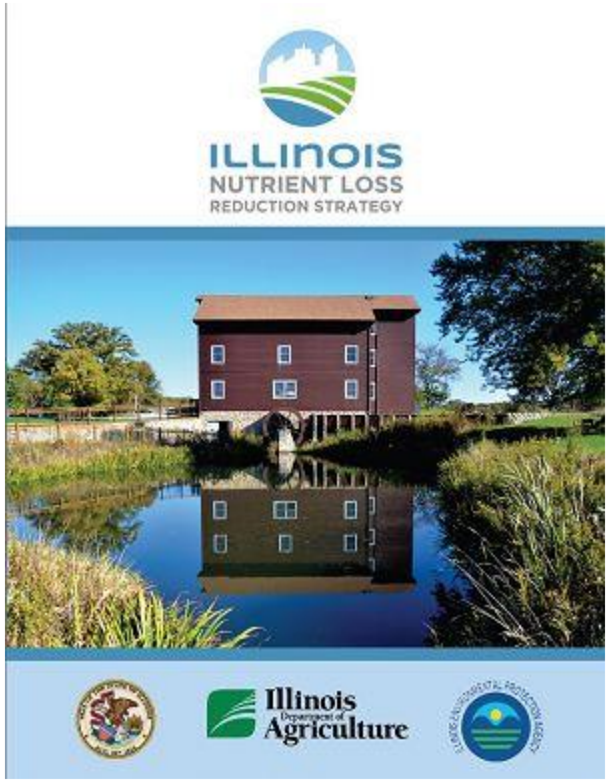
IL Nutrient Loss Reduction Strategy

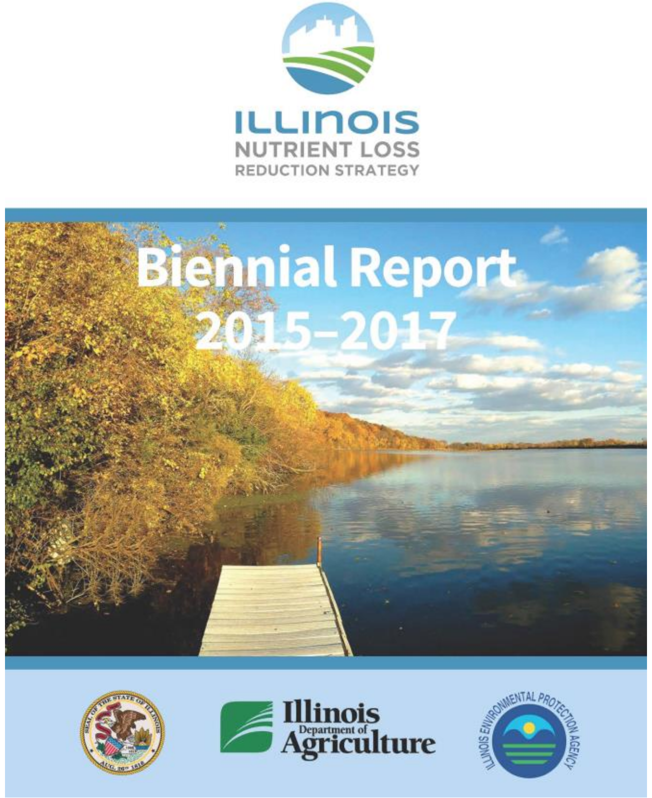
Multi-agency collaboration

Long term goal: reduce nitrate and total phosphorus loads by 45%

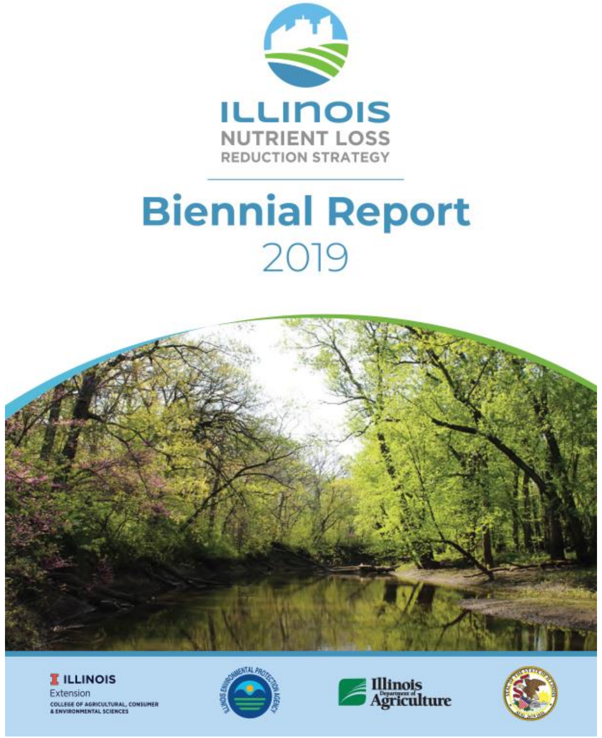
2025 goals: reduce nitrate by 15% and total phosphorus loads by 25%



2015



2017

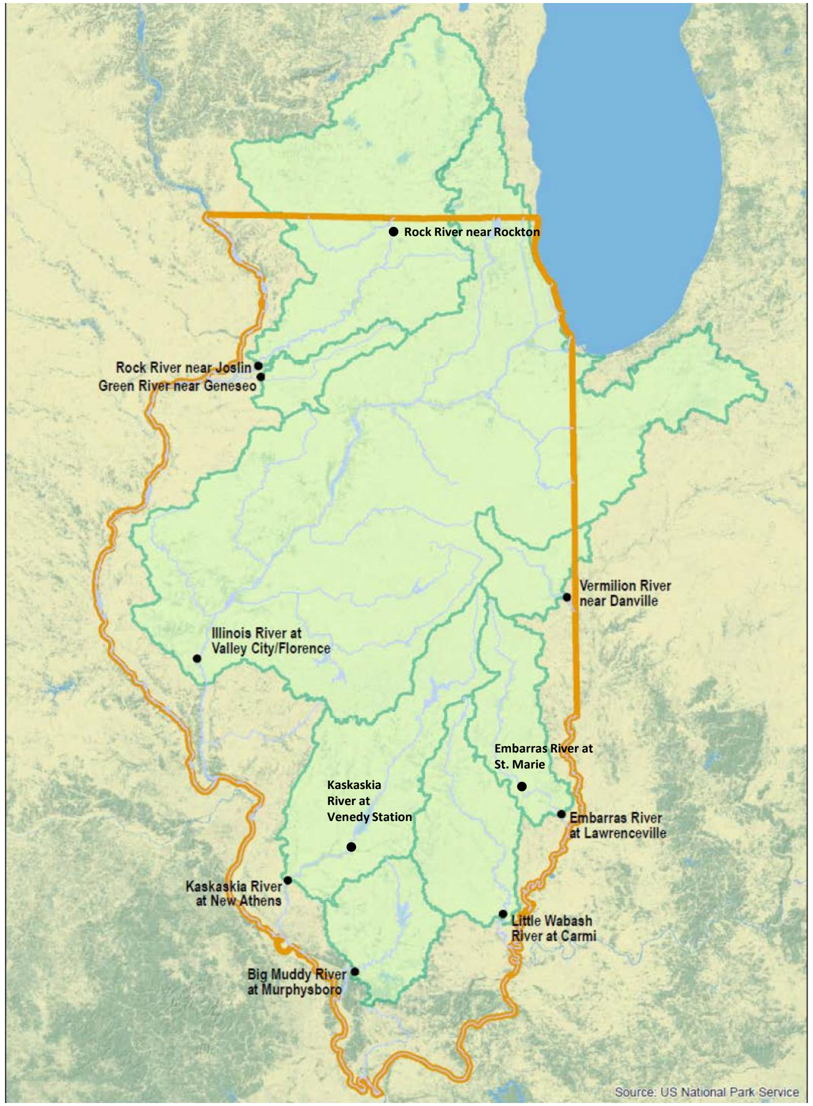


2019

https://www2.illinois.gov/epa/topics/water-quality/watershed-management/excess-nutrients/Pages/nutrient-loss-reduction-strategy.aspx

My role: Quantifying Nitrate and TP loads statewide and for HUC 8s

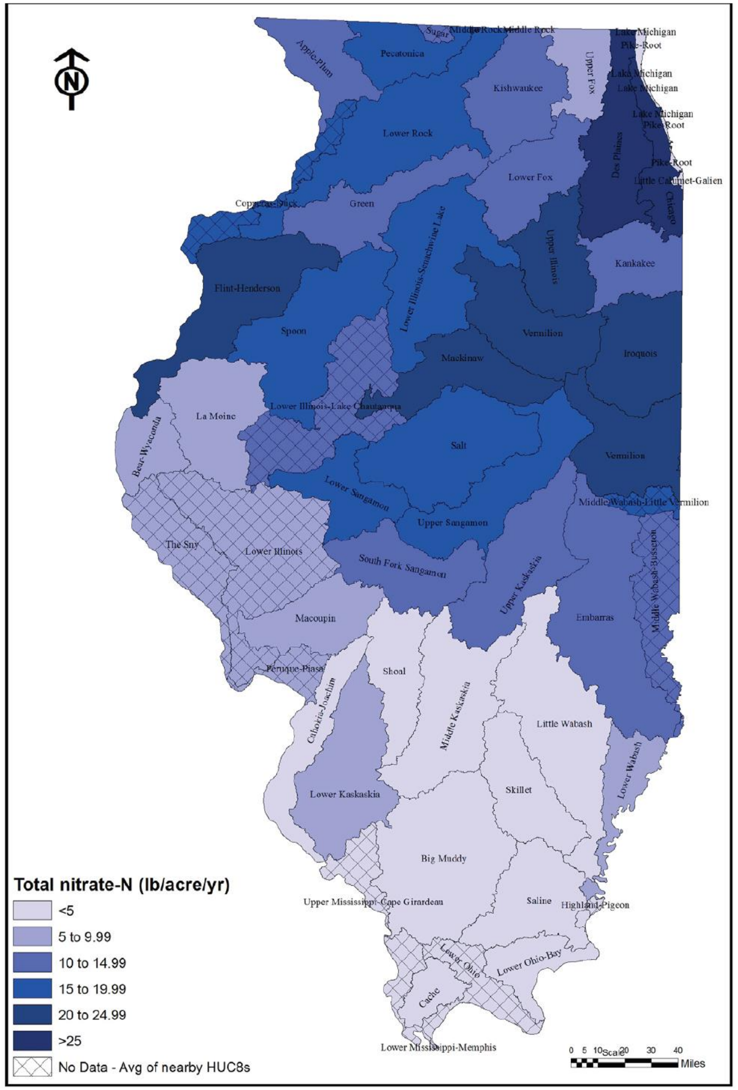
Statewide loads based on 8 major river systems



~40 HUC 8s with sufficient flow and concentration data for load estimation

Point source discharges also reported by HUC 8

HUC 8 Nitrate-N yields 1997-2011 (NLRS 2015)



River Load Calculation Methods

Load (lb/yr) = water flow (volume/time) x concentration (mass/volume)

Yield (lb/ac-yr) = Load/drainage area

USGS provides daily water flow

IEPA and USGS provide sample concentrations approximately monthly

Daily Load = daily water flow x estimated daily concentration

Daily concentrations estimation methods

Nitrate: Linear Interpolation over time between measured samples

Phosphorus: Weighted Regressions on Time, Discharge and Seasonality (WRTDS)

Statewide Results: Riverine Flow and Loads

New update

	1980-96 baseline	2013-17	% change from 1980-96	2014-18	% change from 1980-96
Water Yield (in/yr)	13.0	14.7	+13%	14.1	+9%
Nitrate-N Load (Million lb N/yr)	397	425	+7%	378	-5%
Total P Load (Million lb P/yr)	34	43	+26%		

Statewide Point Source Discharges

	2011	2017*	% change
Total N (Million lb N/yr) # of facilities incl.	87.3 392	75.0 898	-14%
Total P (Million lb P/yr) # of facilities incl.	18.0 1660	14.1 1371	-22%

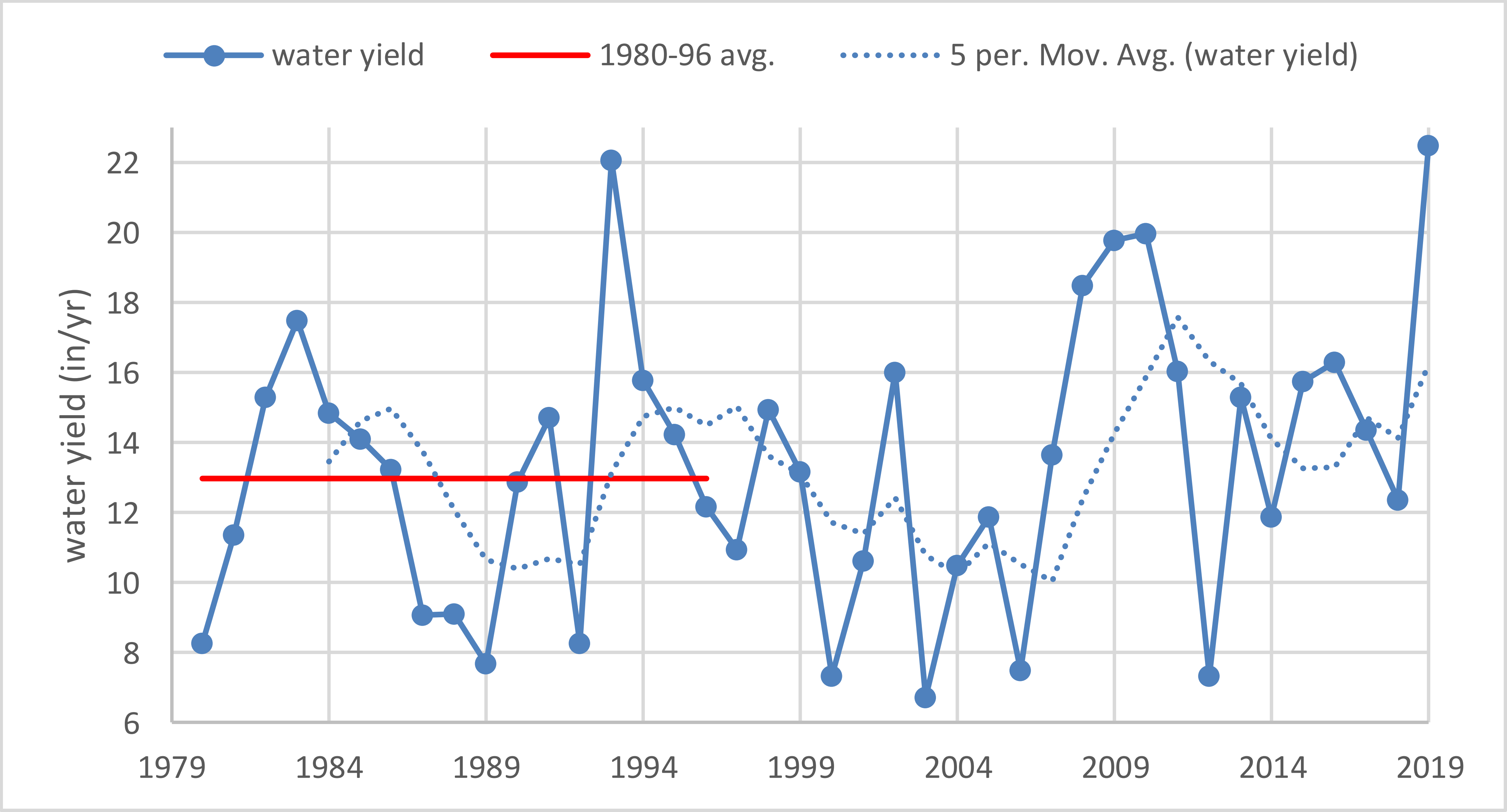
*2011 discharge data was used for facilities included in the NLRS estimate, for which 2017 data was unavailable

Cooling water discharge not included in 2017

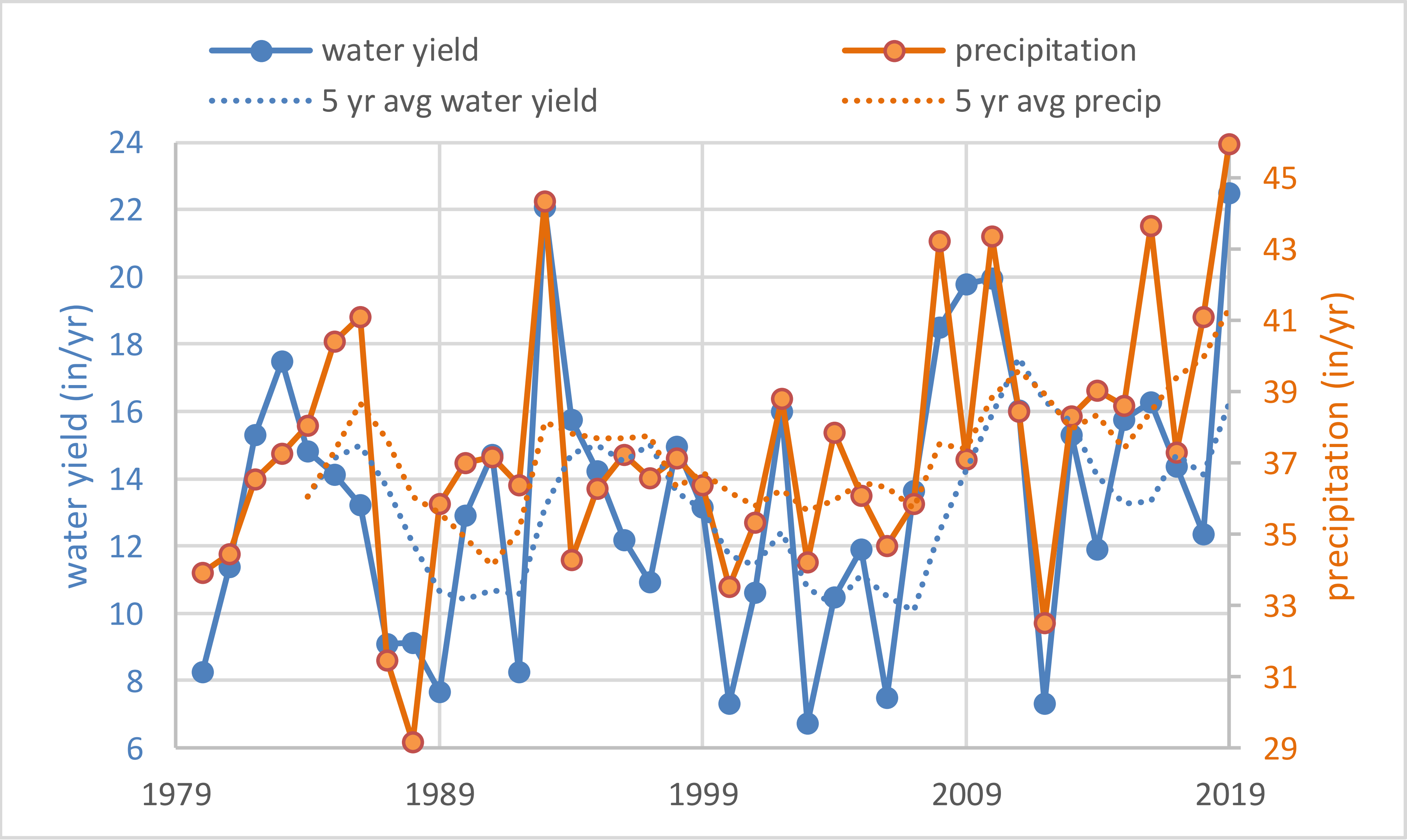
Note that we do not have point source discharge data during the 1980-96 baseline period. Riverine load increases in the previous slide were relative to the baseline period and are not directly comparable to these decreases. Statewide riverine NO3-N loads in 2017 were 5% lower than in 2011 and 2017 TP loads were 6% lower than in 2011.

Statewide annual water yield

annual, 5 year moving average, and 1980-96 average

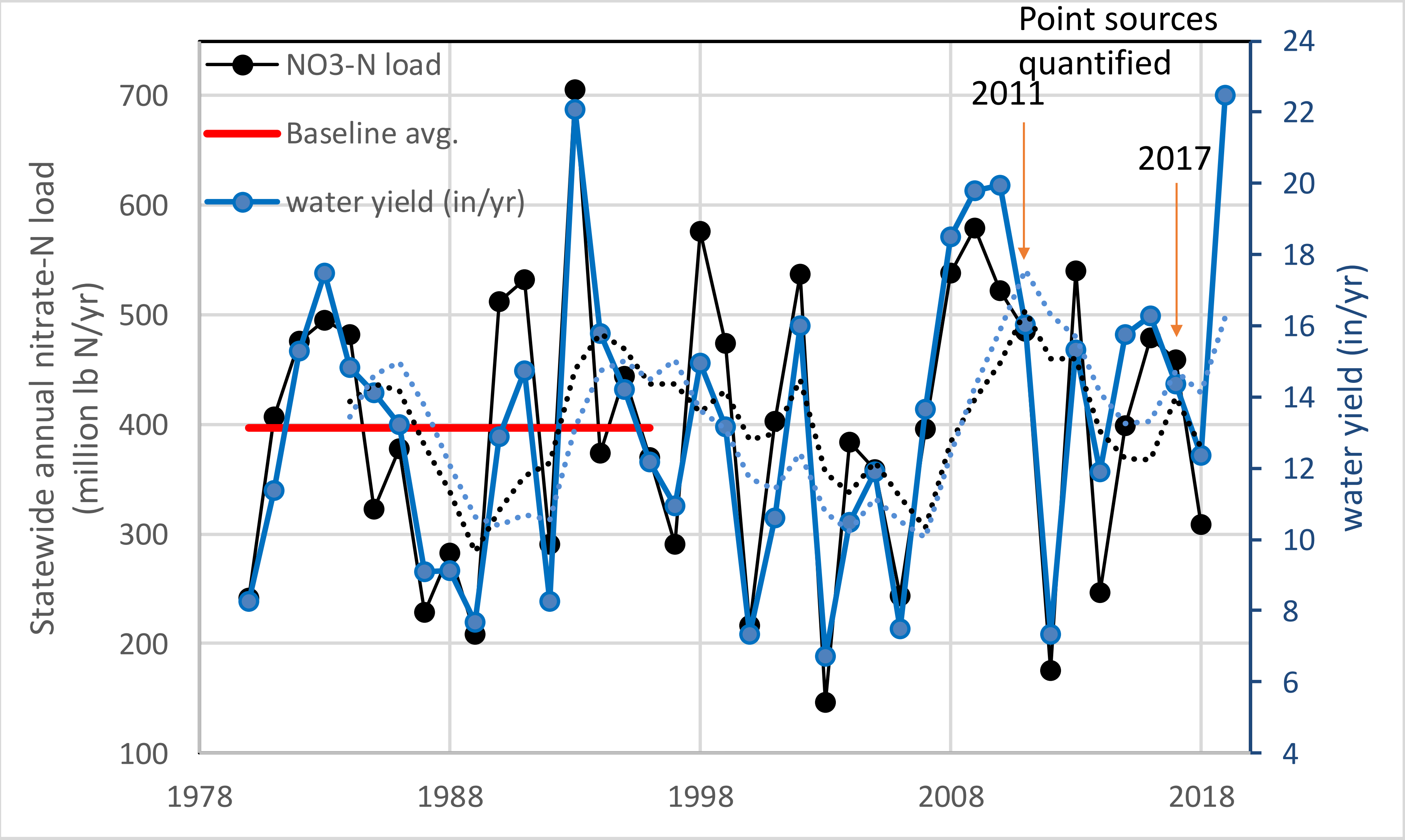


Statewide average precipitation and water yield 1980-2019

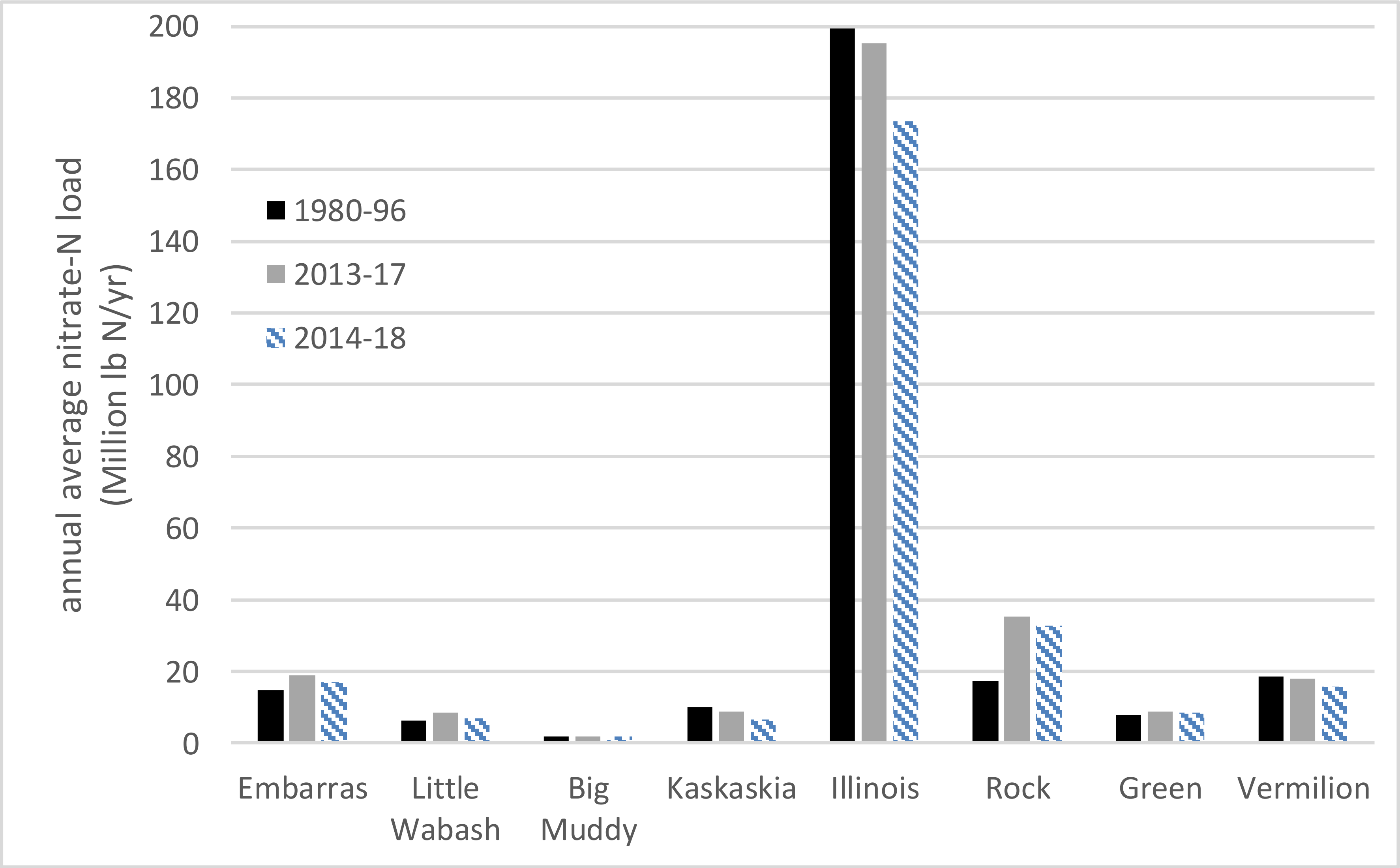


water year basis (Oct 1 to Sept 30)

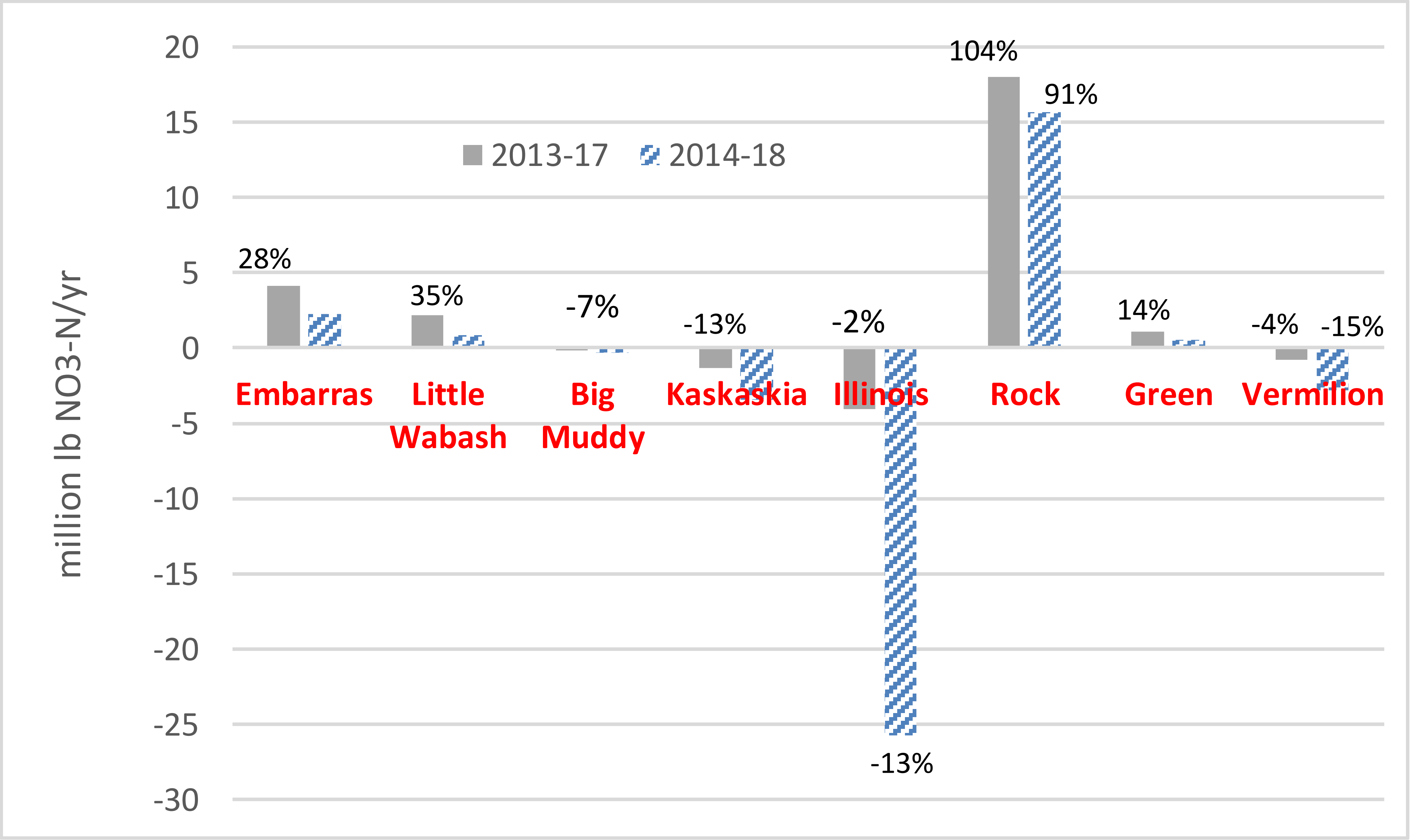
Statewide estimates of annual nitrate loads (black), water yield (blue), 1980-96 baseline average (solid red line), and five year moving average values (dashed lines)



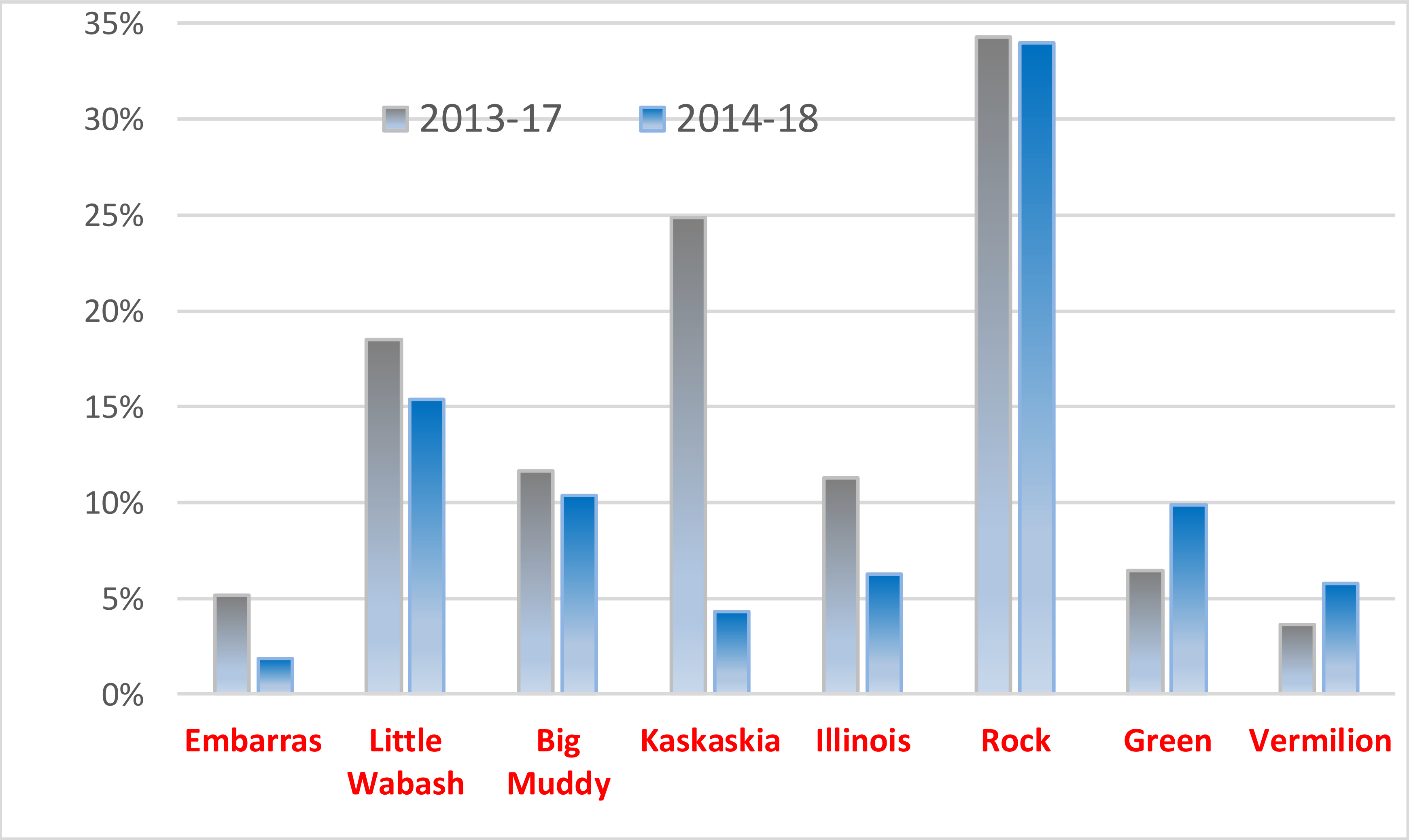
Nitrate-N Load Estimates for Major Rivers in Illinois 1980-96, 2013-17 and 2014-19



<u>Changes</u> in Riverine Nitrate-N Loads from 1980-96 to 2013-17 and 2014-18 for major rivers in Illinois

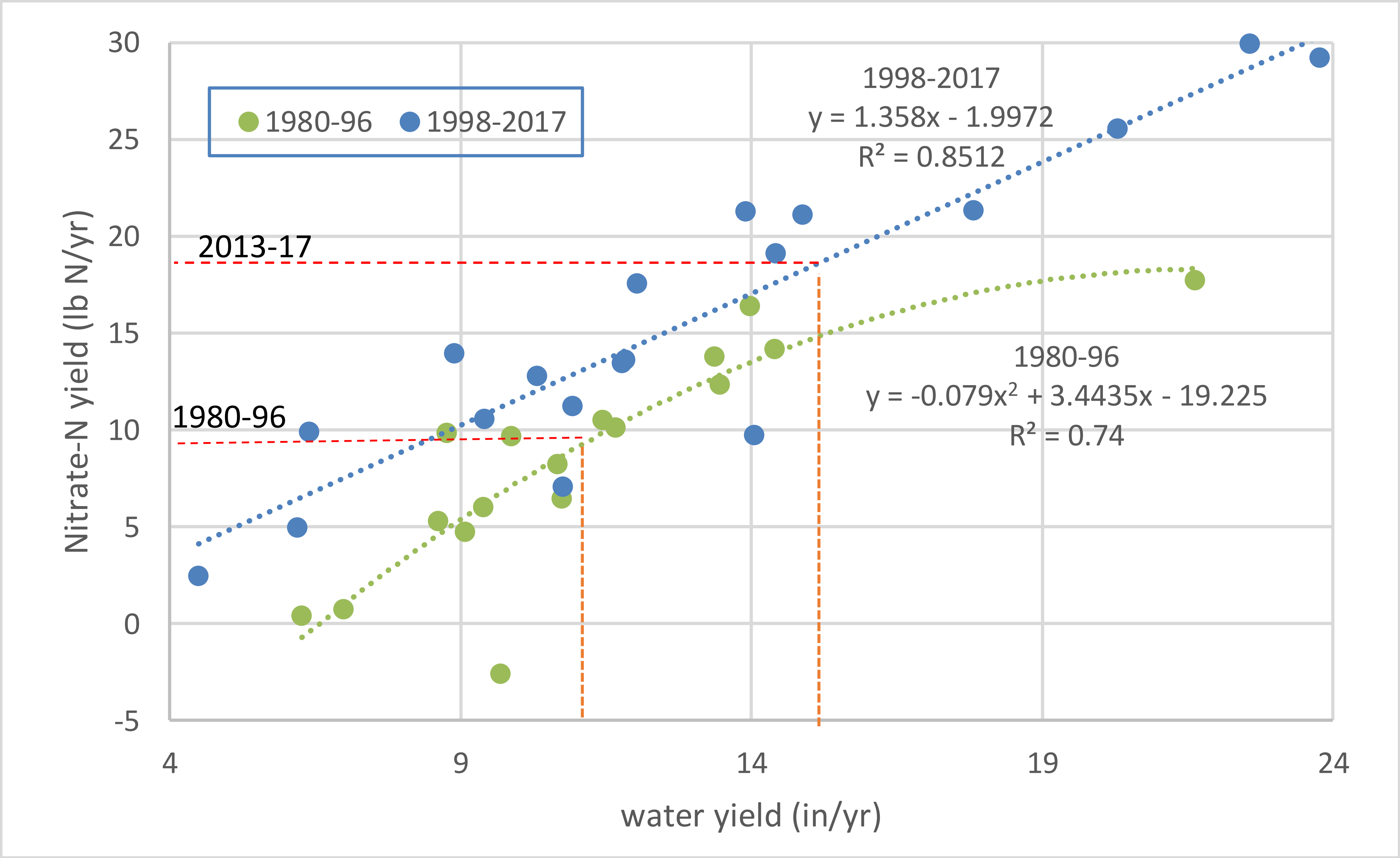


% Changes in water flow from 1980-96 for major rivers in Illinois

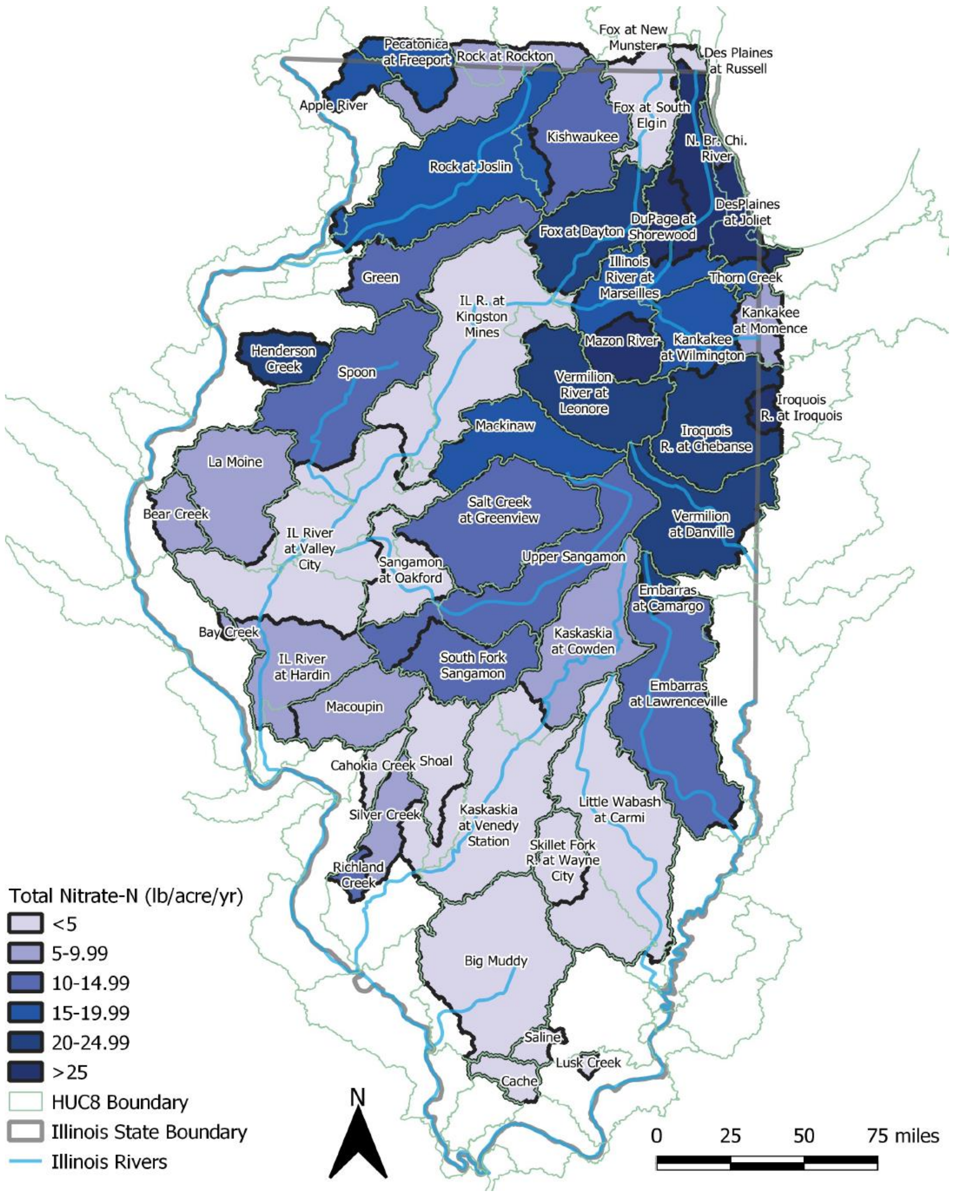


Rock River between Rockton and Joslin

Annual Nitrate-N yield as a function of water yield for 1980-96 and 1998-2017



Nitrate-N yield (2012-17) at monitoring locations



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HUC-8 Challenges

Drainage areas of the monitoring locations do not match HUC boundaries.

Extrapolating from monitored area to HUC area introduces uncertainty and probability of inaccurate estimates

For 16 HUCs, monitored drainage area is between 85% and 115% of HUC area.

For another 9 HUCs, monitored drainage area is between 65% and 135% of HUC area.

For 15 HUCs, monitored drainage area differs from HUC area by more than 35%.

For 9 HUCS there is no monitoring data

2 HUCs draining to Lake Michigan are ignored

Estimated Average Annual Nitrate-N Yields by HUC (lb N/ac-yr)

1997-2011, NLRS

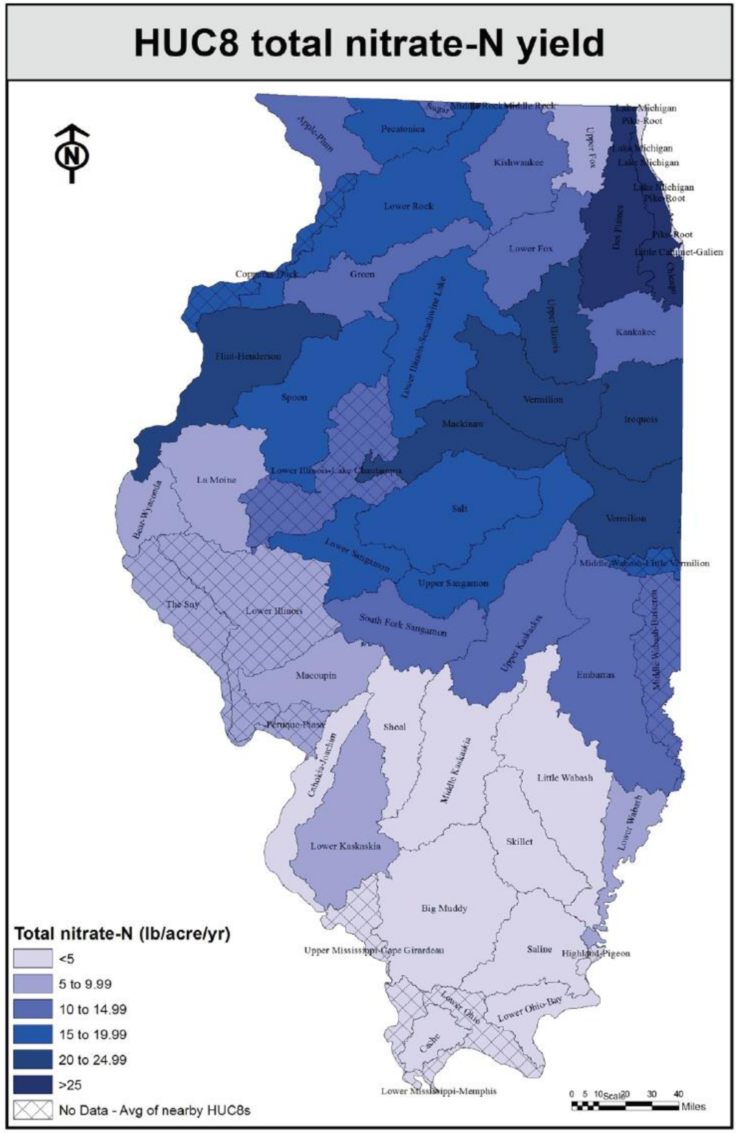
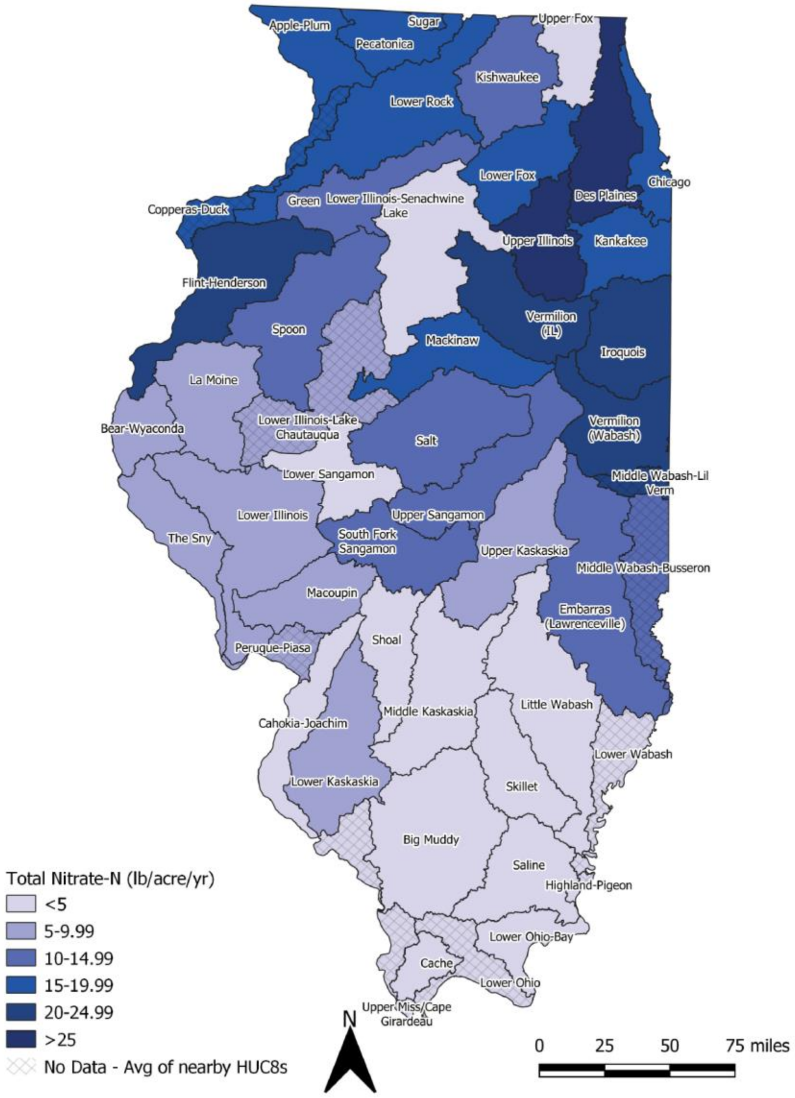


Figure 3.12. Total nitrate-nitrogen yields by HUC8 in Illinois.

2012-17 update



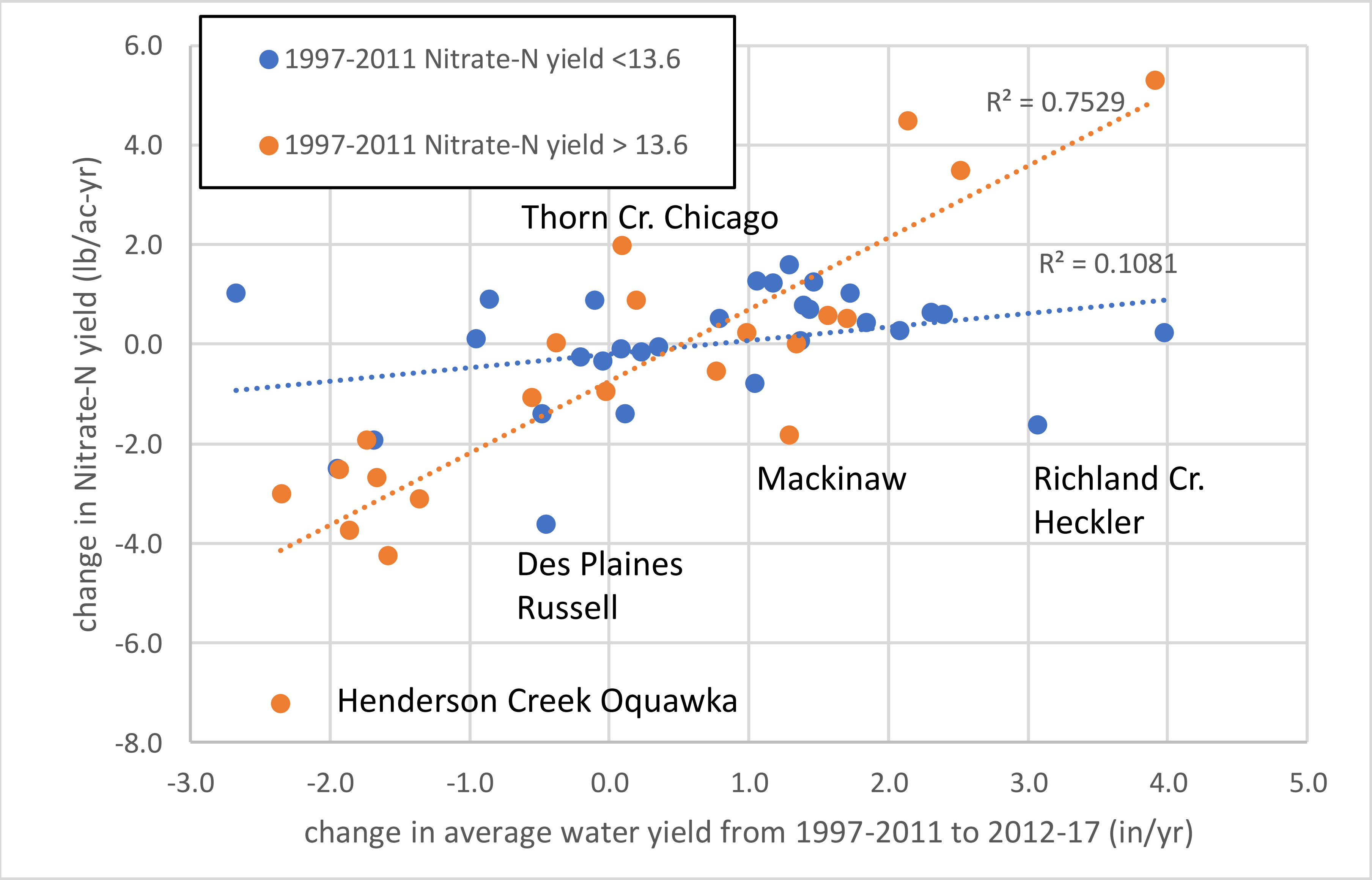
Aaron Hoyle-Katz, NCSA

Changes in HUC 8 estimation methods for the Lower Sangamon and Lower Illinois-Senachewine Lake

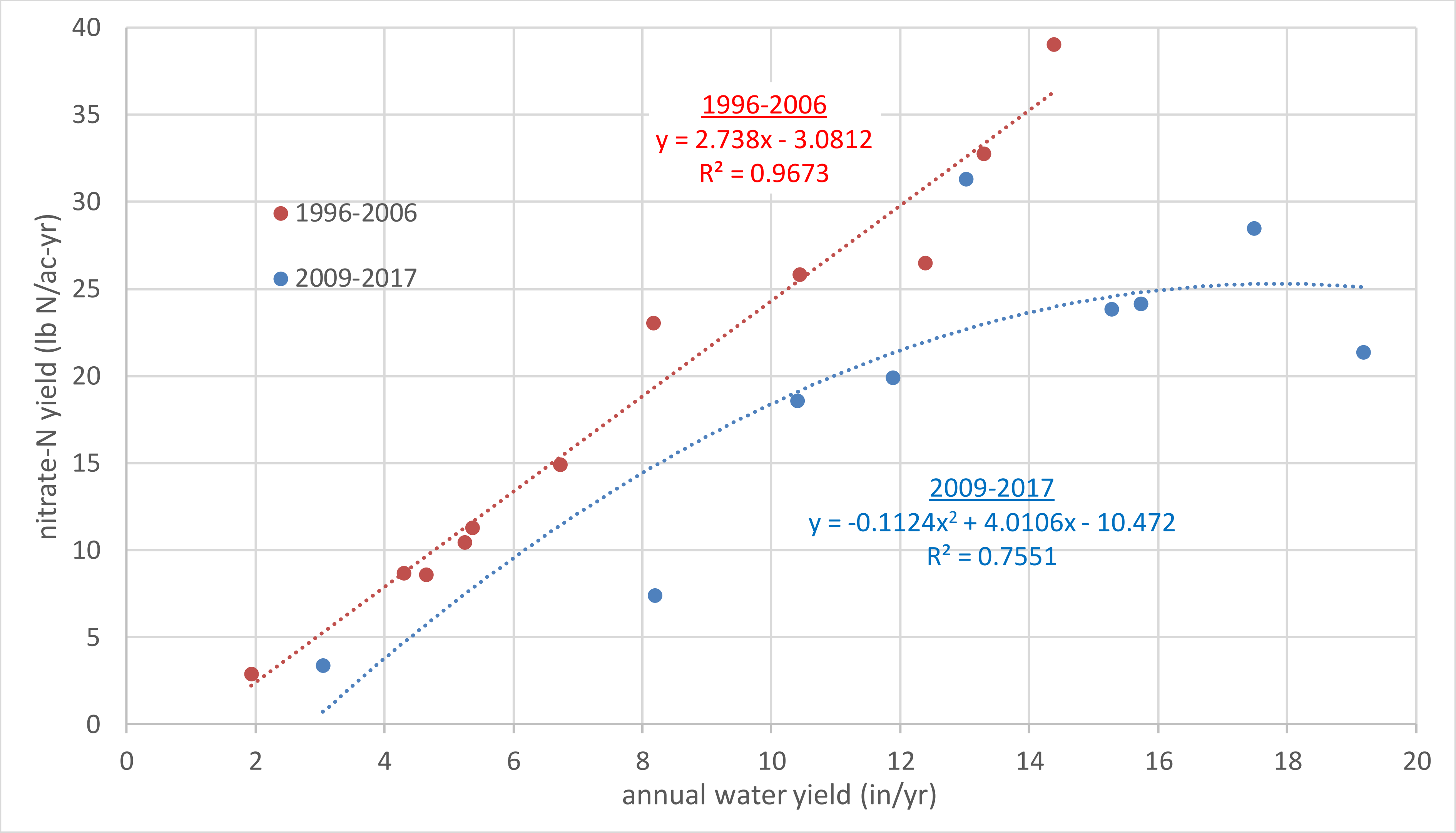
- <u>For NLRS (2015), small tributaries were used as proxies</u>
  - Lower Sangamon: Spring Creek (12% of HUC area)
  - LI-SL: Big Bureau Creek (10% of HUC area)

- <u>For 2012-17 Update</u>
  - Upstream loads were subtracted from downstream load
  - Negative load estimates occurred in some years possibly due to denitrification
  - Comparison of upstream and downstream concentrations is consistent with denitrification losses

Changes in average annual Nitrate-N Yield vs Change in Water Yield from 1997-2011 to 2012-17



Mackinaw River at Green Valley (05568000) and South Pekin (DK-12)
Annual nitrate yield vs annual water yield 1996-2006 vs 2009-2017 water years

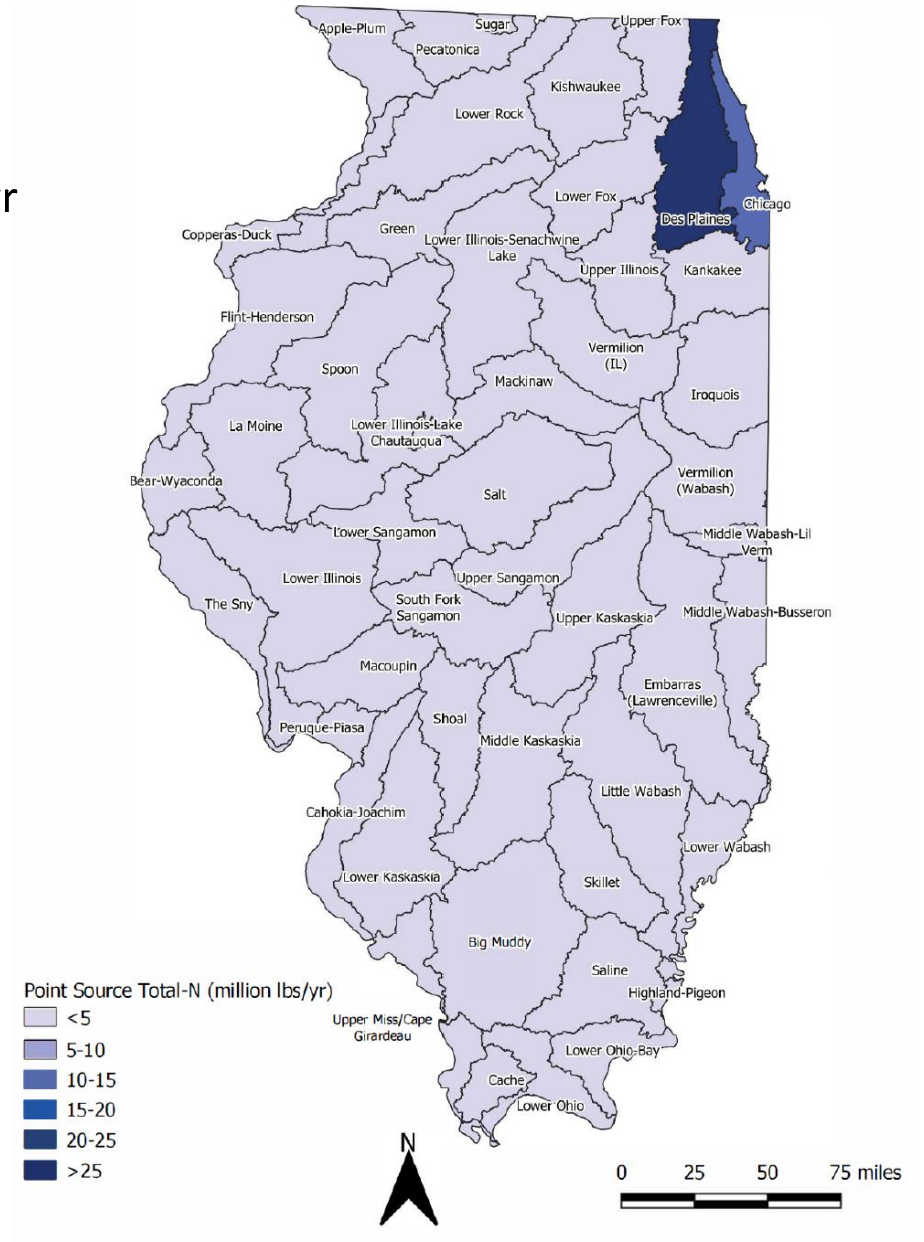


Similar patterns occurred for the Spoon River and Henderson Creek

2017 Estimated Point Source Total N Loads by HUC

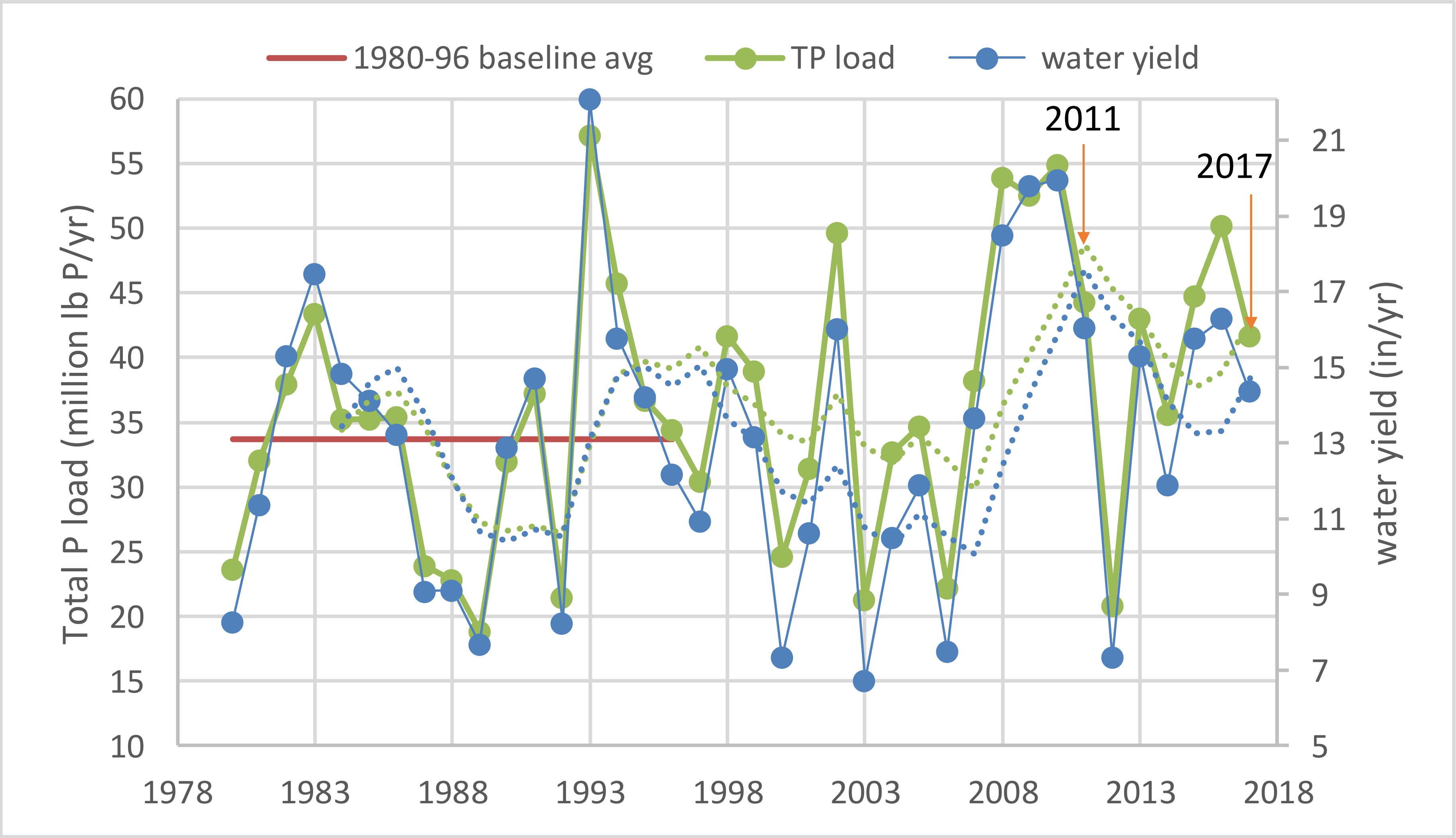
Statewide total point source discharge: 75 million lb N/yr
(~18% of statewide riverine nitrate-N load)

Des Plaines HUC: 32.2 Million lb N/yr
<u>Chicago HUC: 14.4 Million lb N/yr</u>
Total =   46.6 Million lb N/yr
(62% of state total point source N)

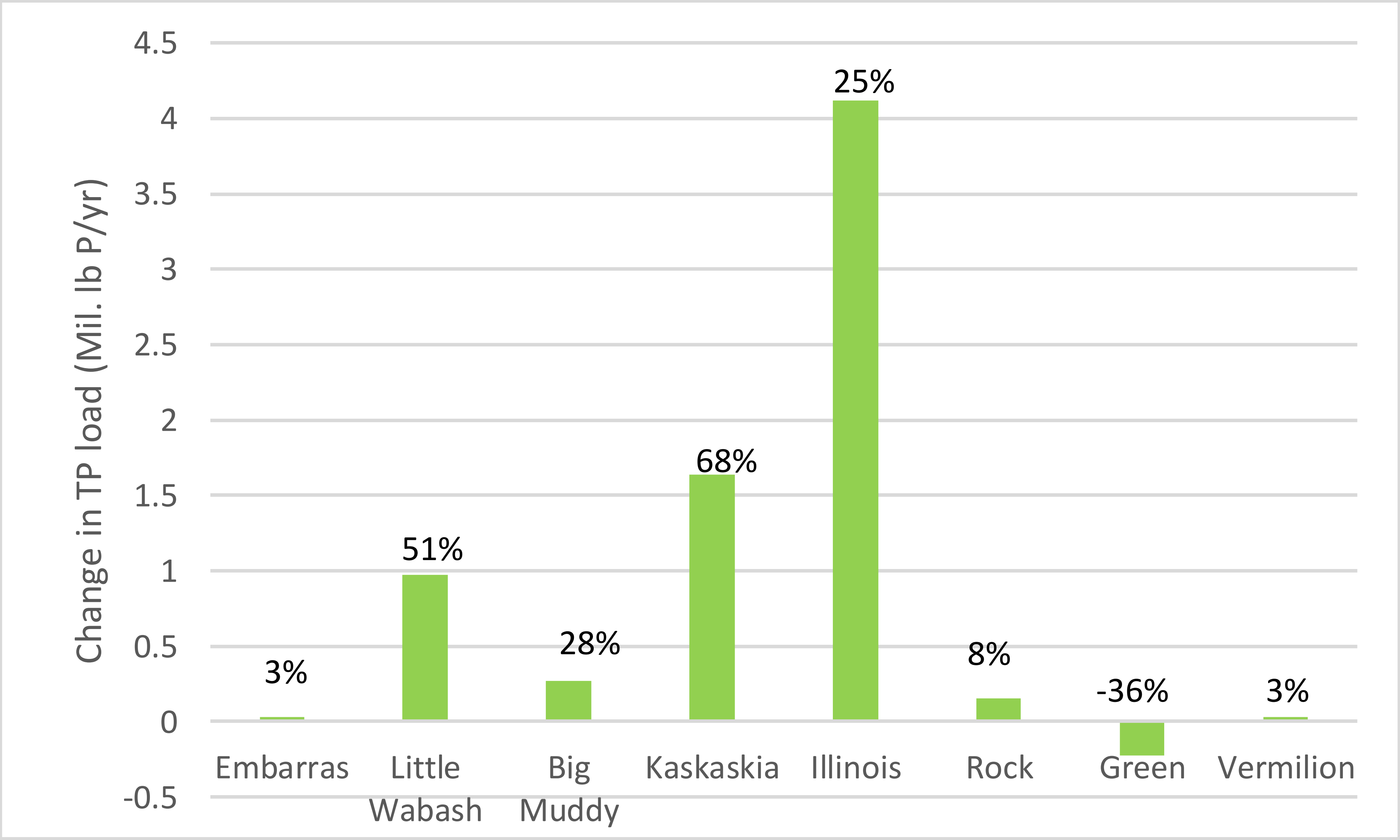


Total Phosphorus (TP) Loads

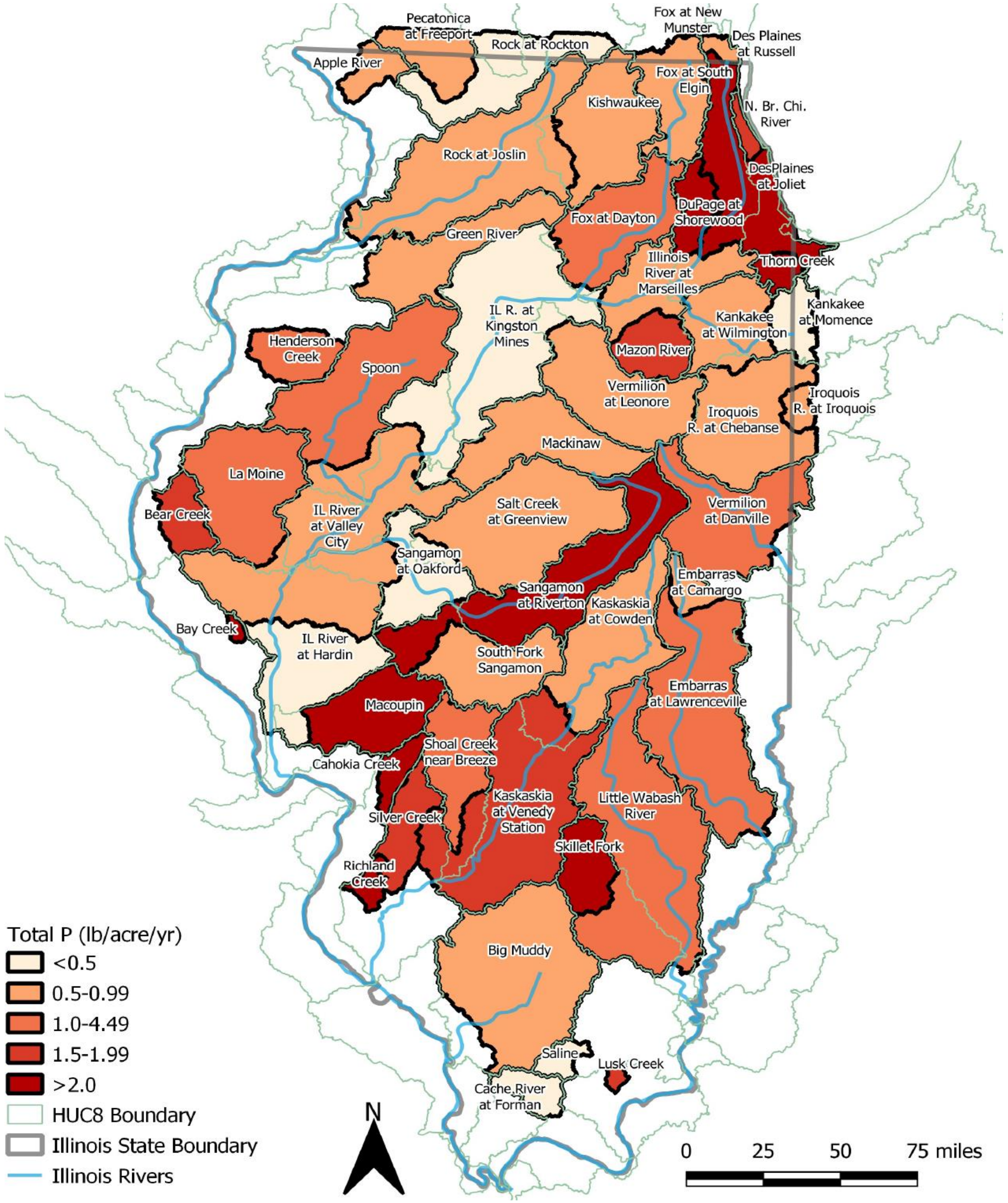
Statewide estimates of annual TP loads (green), water yield (blue),
1980-96 baseline average (solid red line),
five year moving average values (dashed lines)
point-source loads were quantified in 2011 and 2017



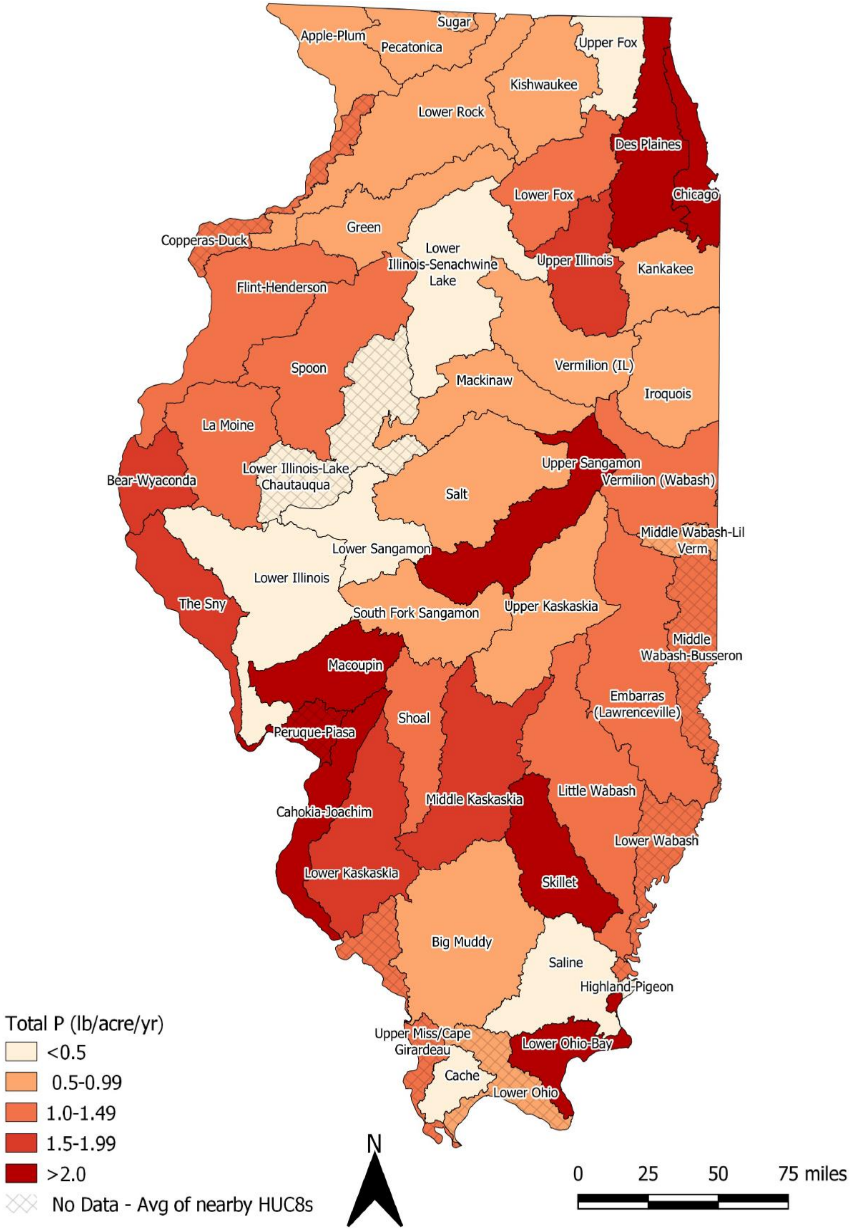
Changes in Riverine TP Loads from 1980-96 to 2013-17 for major rivers draining Illinois



Total P yield by monitored drainage area 2012-17



Total P yield by HUC 8 2012-17



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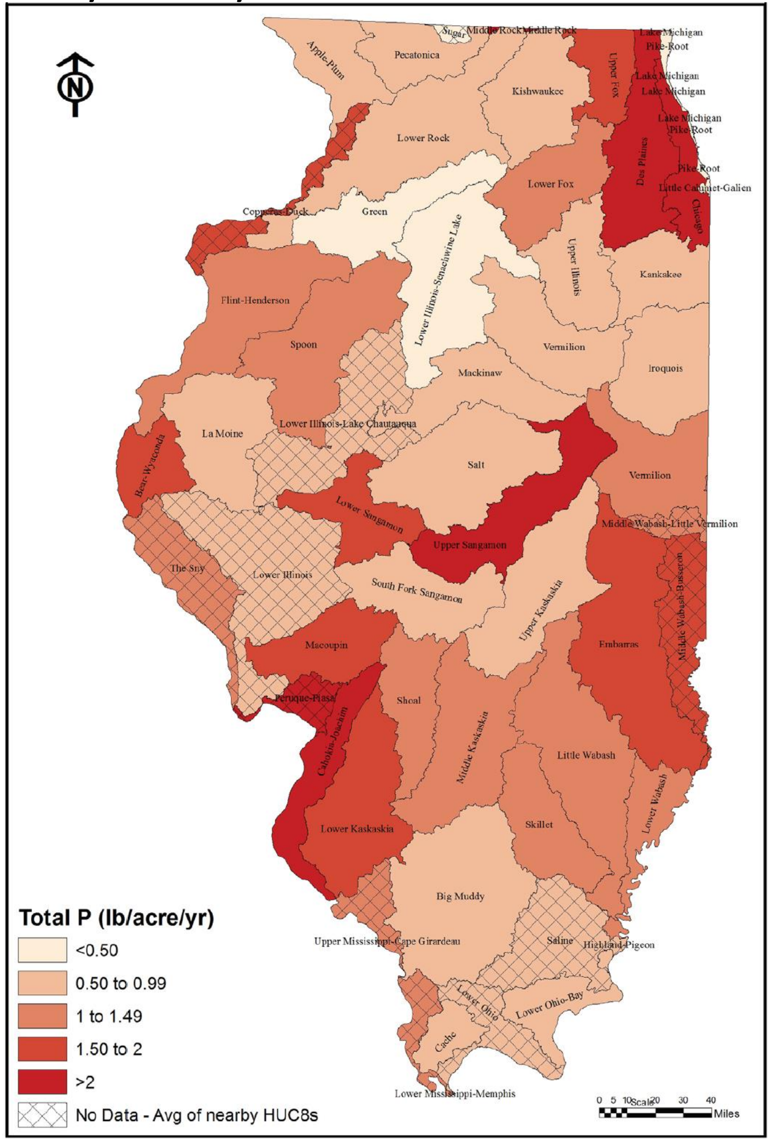
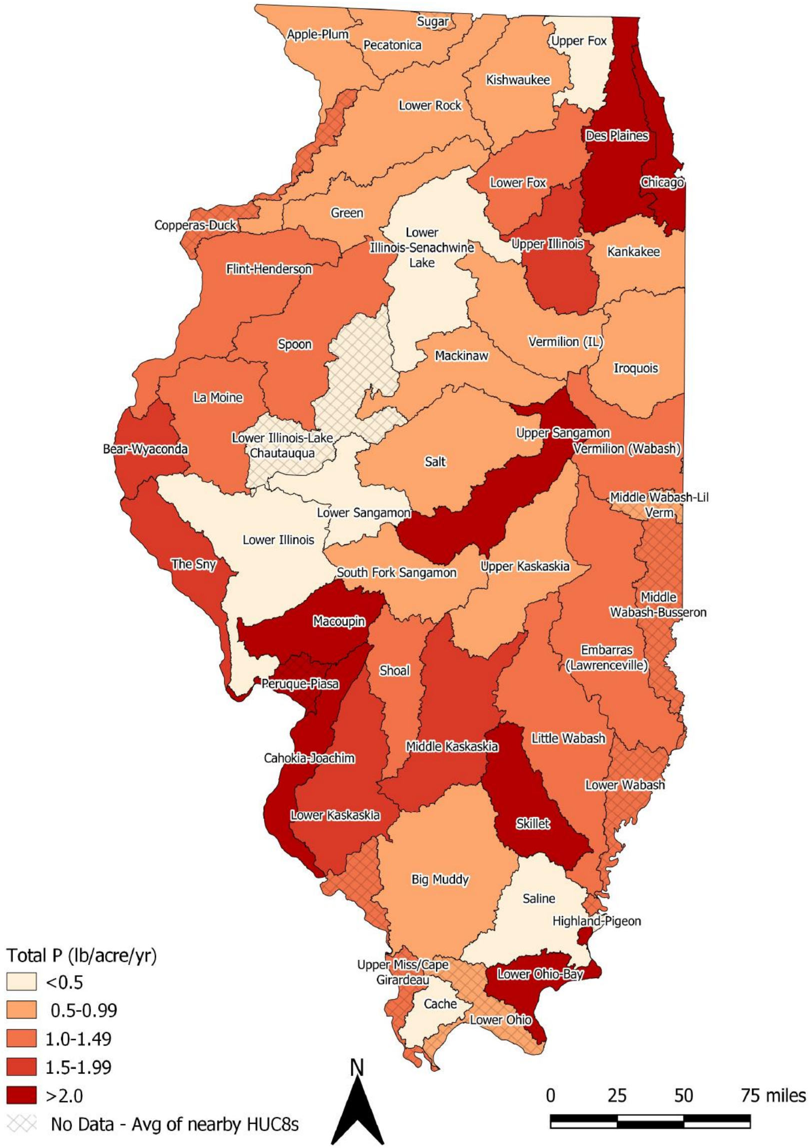
TP yields by HUC 8 1997-2011



IL NLRS (2015)

TP yields by HUC 8 2012-17



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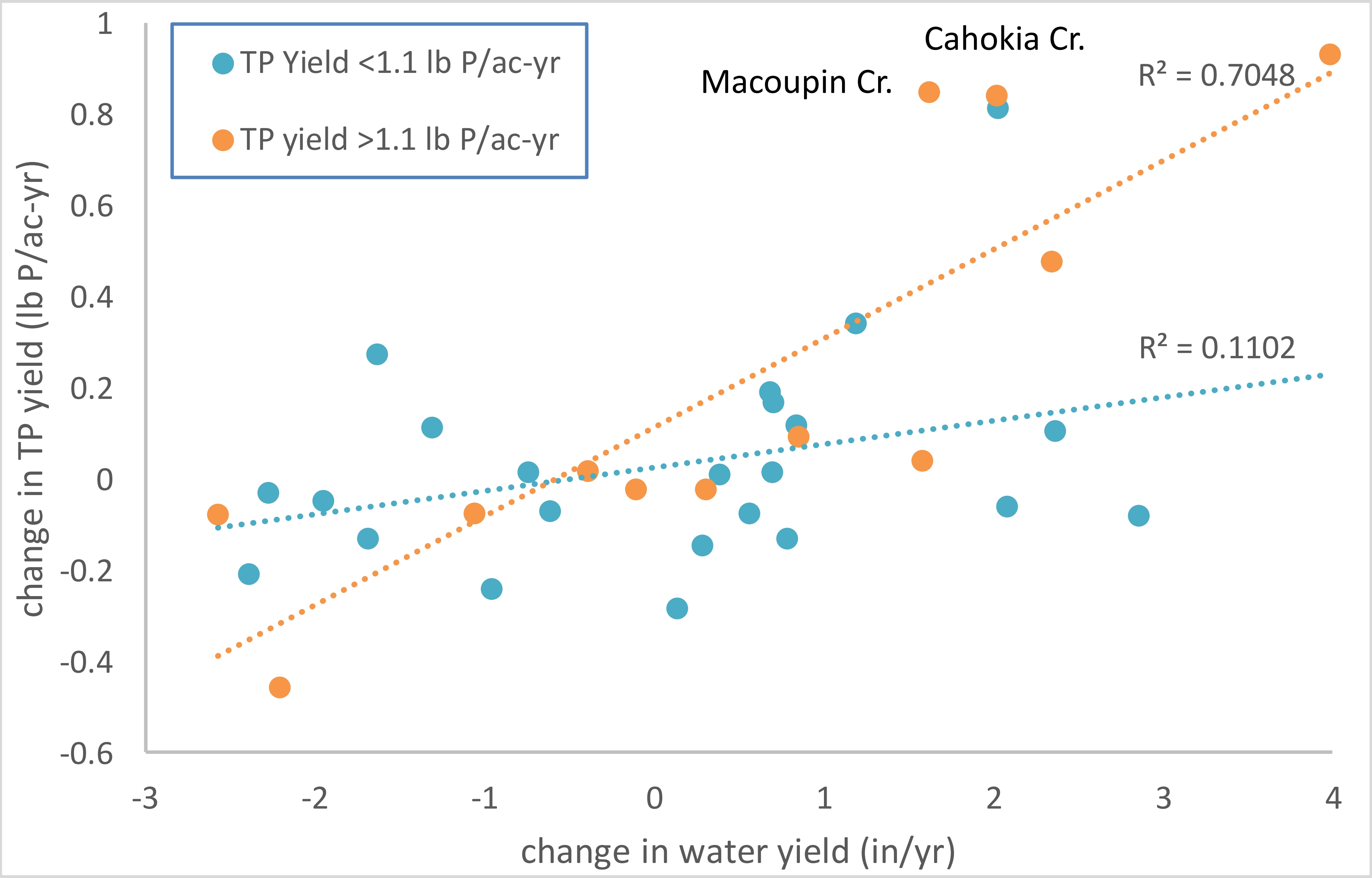
Changes in TP yield from 1997-2011 to 2012-17 plotted against change in water yield from 1997-2011 to 2012-17. Chicago, Des Plaines, Sangamon Basins are excluded due to high point source inputs. The Sny is excluded due to high uncertainty in yield estimate.

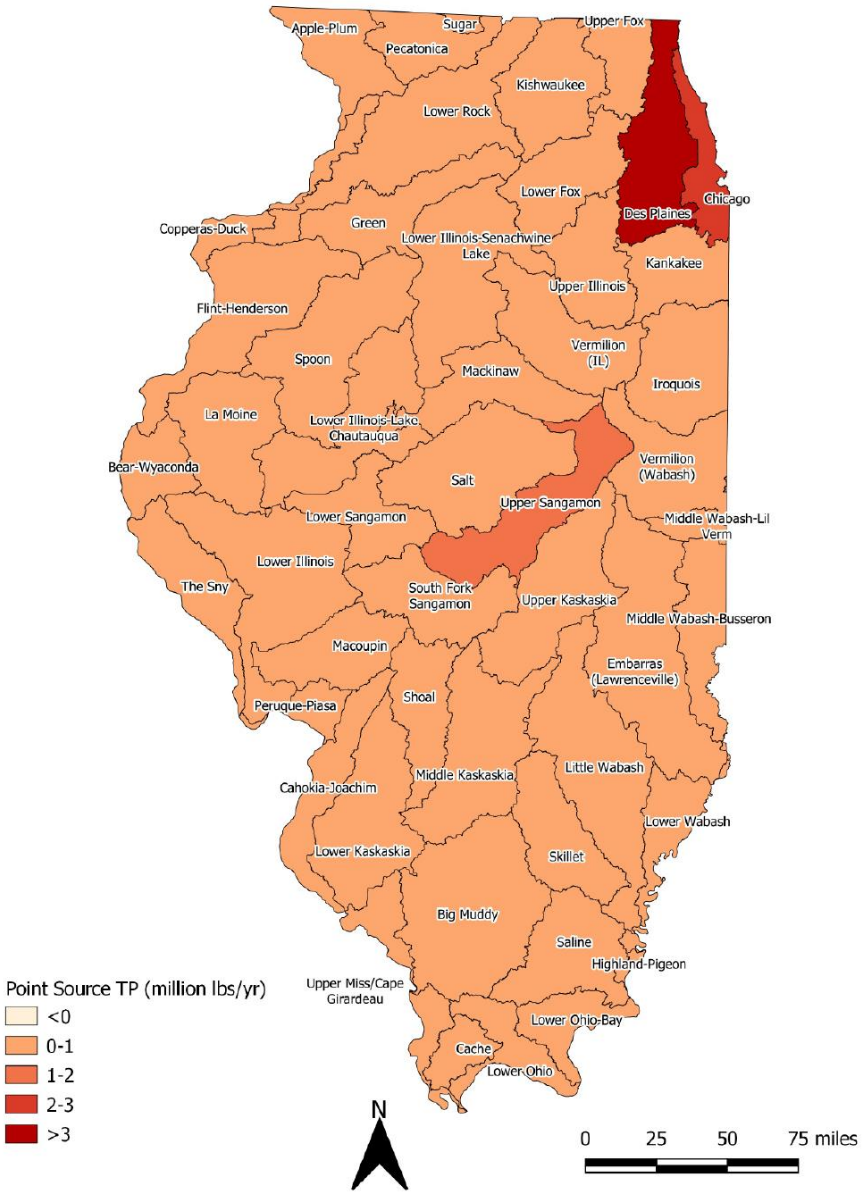


Work in progress

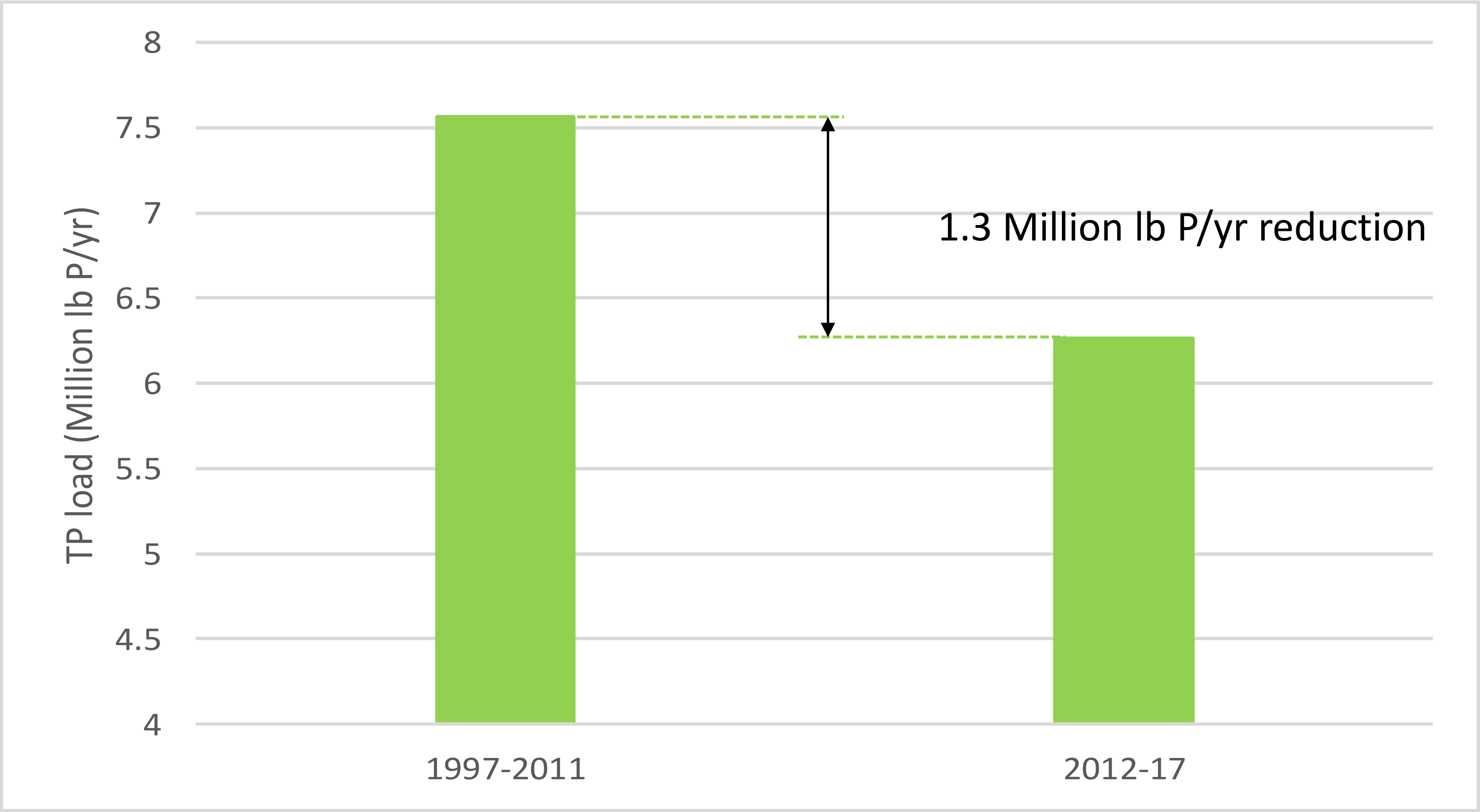
2017 Estimated Point Source Total P Discharge by HUC 8

Statewide 2013-17 TP riverine load: 43 million lb P/yr
Statewide TP point source load 14.1 million lb P/yr (33%)

Top 3 HUCs
Des Plaines HUC: 4.1 million lb P/yr
Chicago HUC: 2.9 million lb P/yr
Upper Sangamon HUC 1.8 million lb P/yr
total 8.8 million lb P/yr
62% of statewide point source P



Riverine TP Load for the **Des Plaines River at Joliet** minus Des Plaines at Russell plus DuPage River at Shorewood
(Approximately Des Plaines plus Chicago HUCs; Point source load reduction of ~2.3 million lb P/yr from 2011 to 2017)



Summary

- Statewide average riverine nitrate-N and TP load estimates 2013-2017 were 7%, and 26% greater than the 1980-96 baseline period.
- The 2014-18 nitrate-N load estimate was 5% less than the baseline period.
- Loads were generally correlated with water flow.
- 2017 Point-source TP and TN discharge estimates declined 22% and 14% relative to 2011 estimates.
- At the HUC 8 scale, nitrate and TP yields 2012-17 were generally similar to 1997-2011 values, with some exceptions:
  - TP load reductions in Chicago and Des Plaines
  - TP increases in the Upper Sangamon, Macoupin Creek and elsewhere
  - Changes in nitrate-N and TP load were correlated with changes in water flow for HUCs with high nitrate and TP yields
  - Nitrate-N reductions per unit of water yield in the Mackinaw, Spoon and Kaskaskia Rivers and Henderson Creek

Further Study and Action Needed

- Investigate and quantify factors causing and influencing changes in nutrient loads in monitored watersheds
- Evaluate uncertainty, lag times and Climate Change impacts
- Retire HUCs; transition to drainage areas above river monitoring sites
- Extensive conservation measures are needed to achieve the nutrient loss reduction goals
- Increased precipitation and river flow will likely increase the need for conservation

Acknowledgements

- Funding from IEPA
- River flow and concentration data from USGS, IEPA, Lowell Gentry (U of IL), Fox River Study Group and Metropolitan Water Reclamation District of Greater Chicago (MWRD)
- Point Source discharge data from USEPA and IEPA (Trevor Sample) and Sanitary District of Decatur
- GIS from Aaron Hoyle-Katz and Jong Sung Lee at the National Center for Supercomputing Applications
- Helpful comments from Trevor Sample, Dennis McKenna, George Czapar, Momcilo Markus, Clark Bullard, Bruce Hannon.

Thank you!

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Full Science Assessment Update

https://www2.illinois.gov/epa/topics/water-quality/watershed-management/excess-nutrients/Documents/NLRS_SCIENCE_ASSESSMENT_UPDATE_2019%20v7_FINAL%20VERSION_web.pdf