Midwest Water Quality Challenges in the Face of a Weather Extremes

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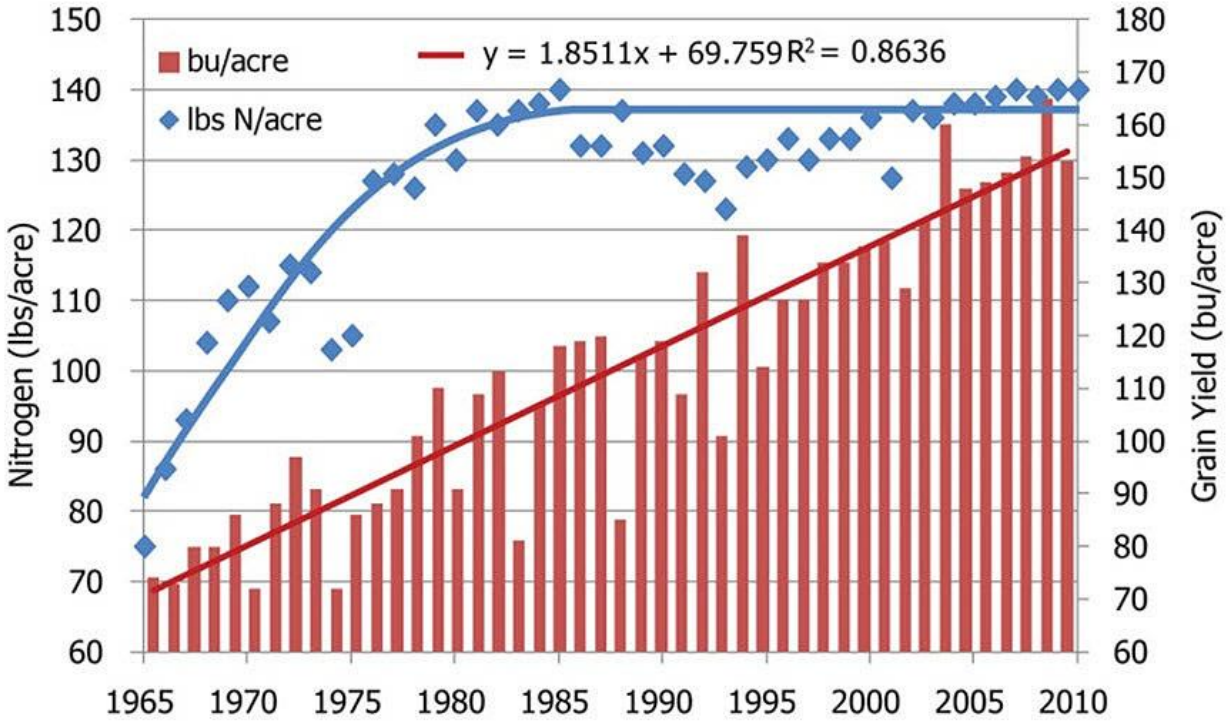
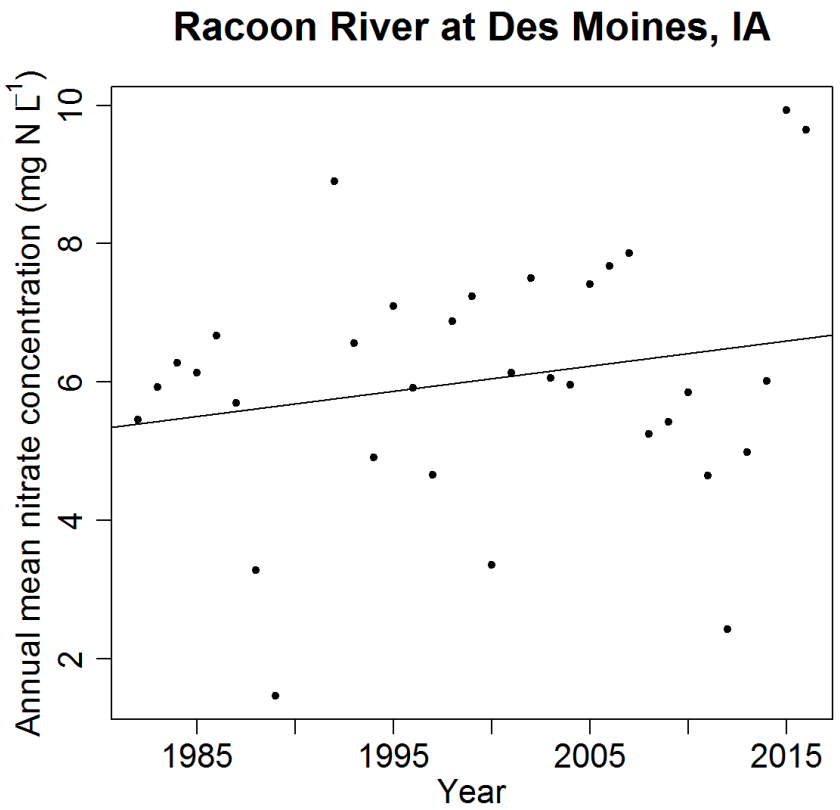
Kansas Biological Survey

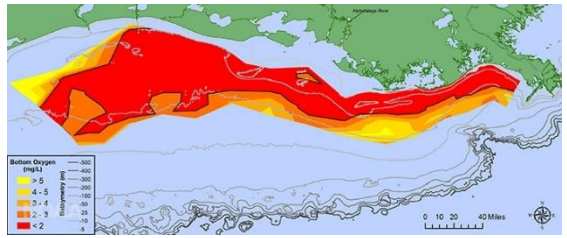
Environmental Studies - KU

Crop nitrogen use efficiency has improved but not water quality. Why?



USDA Ag Statistics





At 8,776 square miles, the 2017 dead zone in the Gulf of Mexico was the largest ever measured. (Courtesy of N. Rabalais, LSU/LUMCON)

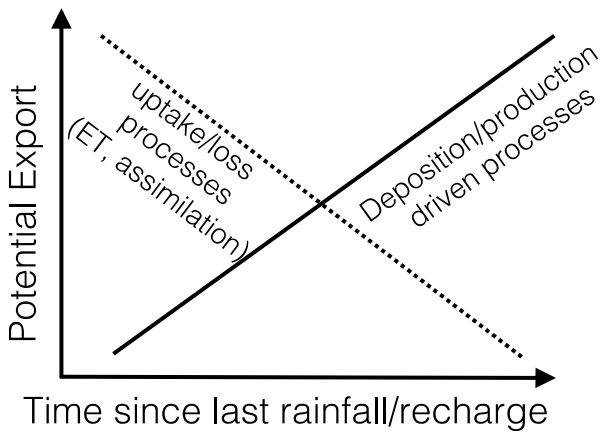
SOURCE X **CONNECTIVITY** = **LOADING**

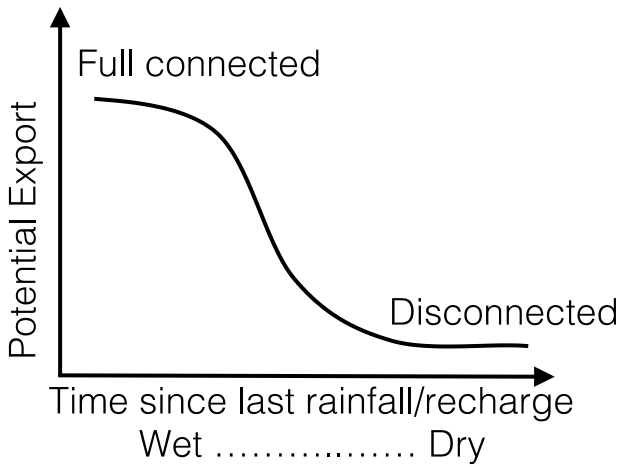
How much transportable material (water, nutrients, pollutants) is available in the watershed?

How hydrologically connected is the watershed to its receiving water body?

Recent event history

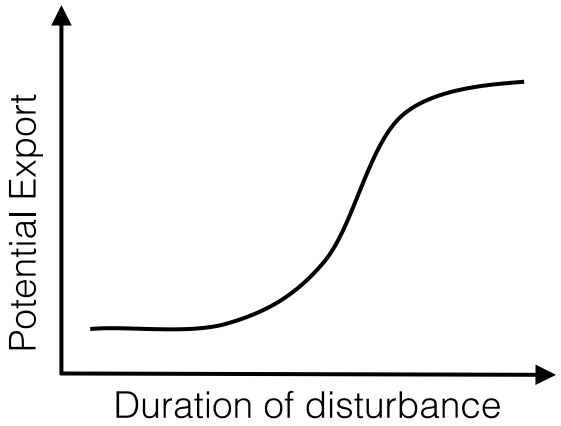
rainfall, snowmelt recharge, temperature, radiation, season

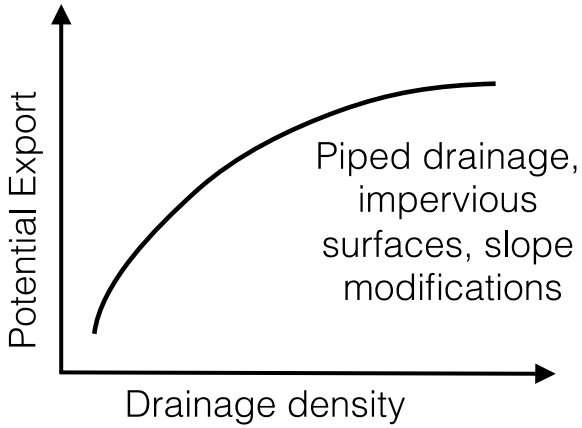




Long term legacy

succession stage, land use history, disturbance regimes, climate regime

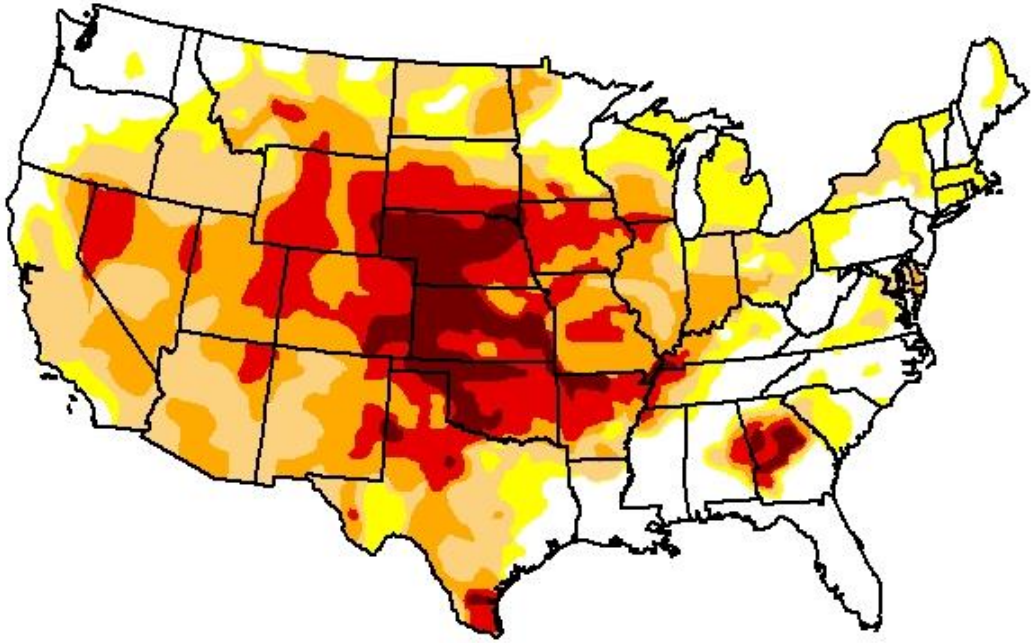




McMillan, Loecke, et al. *in review*

U.S. Drought Monitor

CONUS



September 4, 2012

(Released Thursday, Sep. 6, 2012)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	22.54	77.46	63.39	42.48	21.45	6.14
Last Week *8/28/2012*	22.31	77.69	62.89	42.34	23.18	6.04
3 Months Ago *6/5/2012*	36.01	63.99	38.60	18.92	4.60	0.60
Start of Calendar Year *1/3/2012*	50.41	49.59	31.90	18.83	10.18	3.32
Start of Water Year *9/27/2011*	56.45	43.55	29.13	23.44	17.80	11.37
One Year Ago *9/6/2011*	56.53	43.47	30.00	23.37	18.05	11.20

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

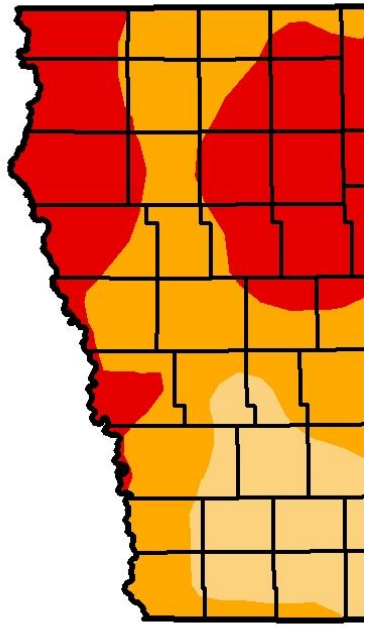
Author(s):
Brian Fuchs
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

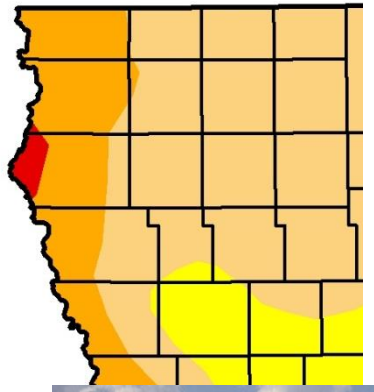
Drought effects on river nitrate flux

2012 = Drought → 2013 = Cold, Wet Spring

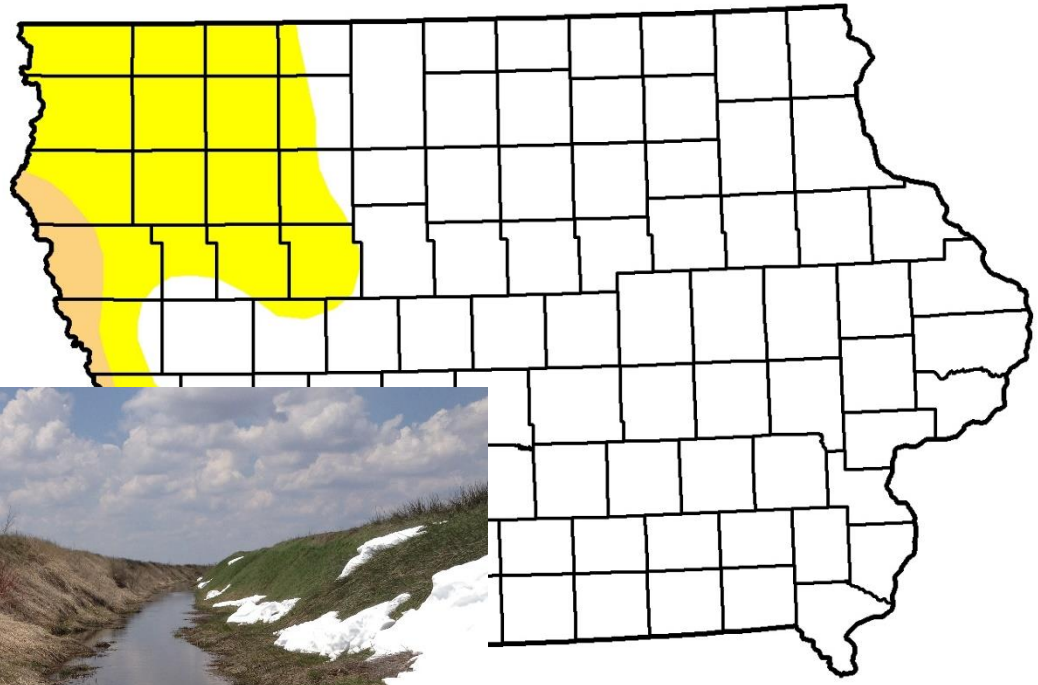
March 19, 2013

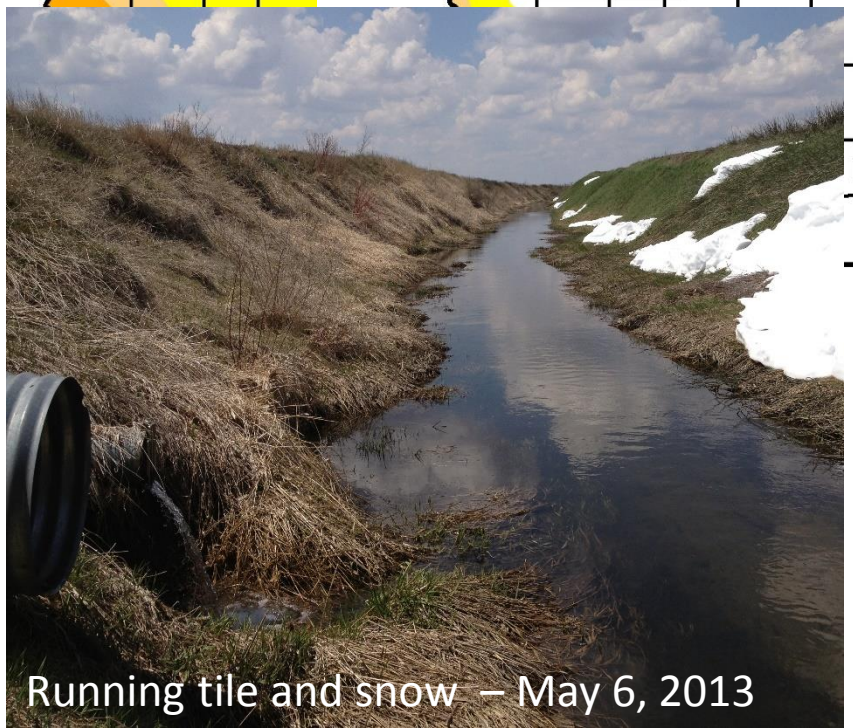


April 23, 2013



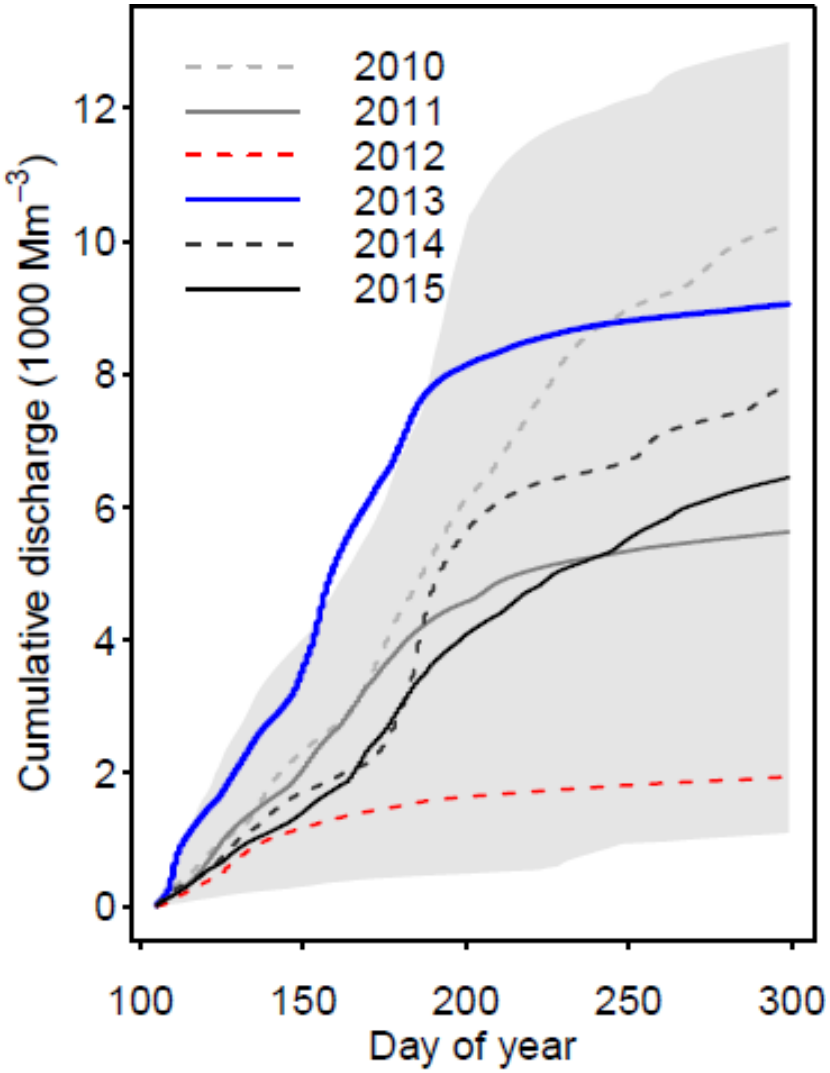
May 28, 2013

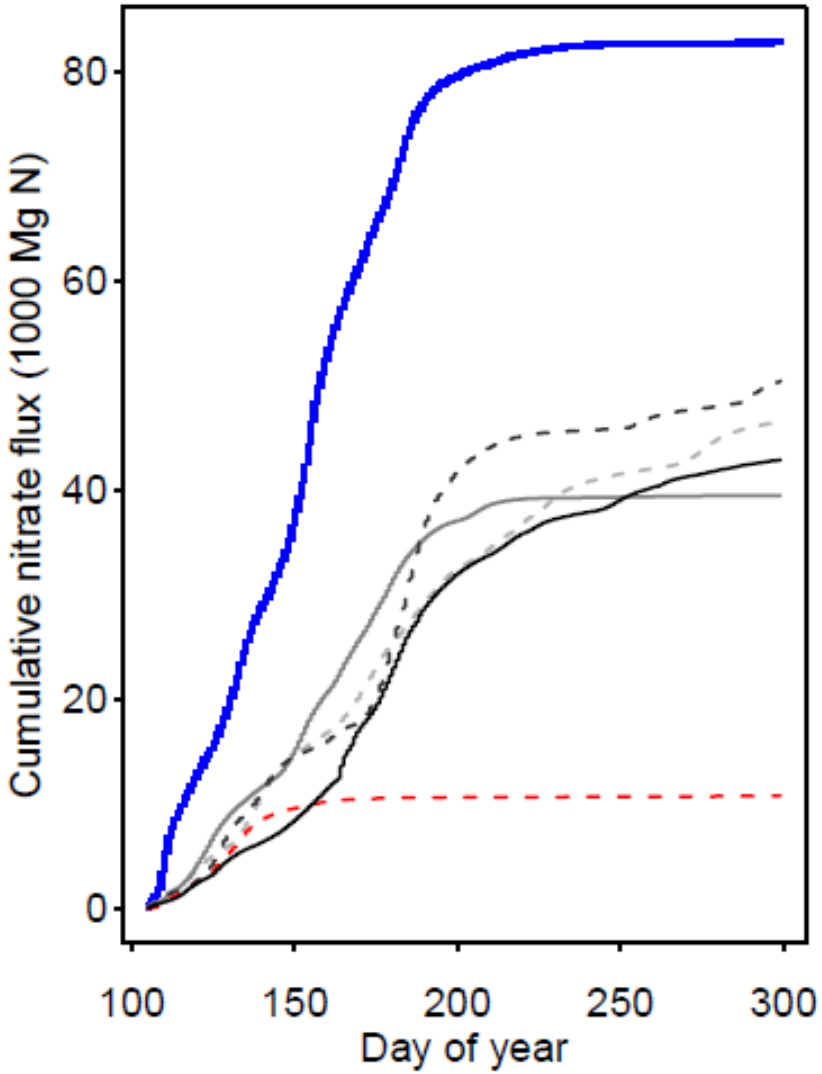




Running tile and snow – May 6, 2013

Drought followed by flood increased riverine nitrate concentration and flux





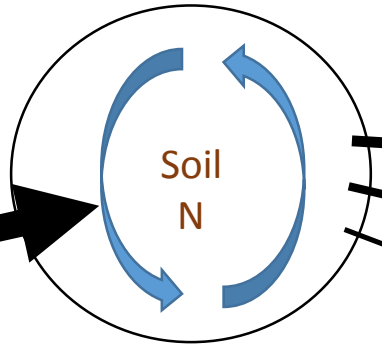
Loecke et al. 2017

Average and Drought N Cycles

Average:

<u>Inputs</u>

N fertilizer



<u>Outputs</u>

Crops

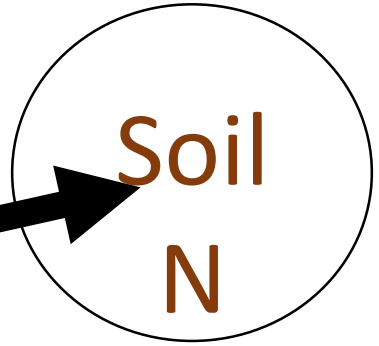
Hydrologic loss

Gaseous loss

<u>2012 Drought:</u>

<u>Inputs</u>

N fertilizer



<u>Outputs</u>

Crops

Hydrologic loss

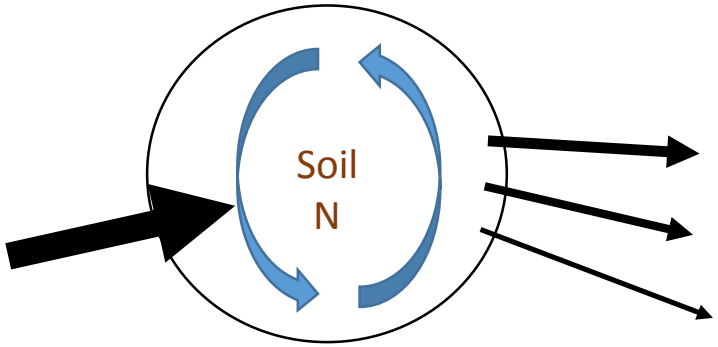
Gaseous loss

Spring 2013 - N cycle

Average:

Inputs

N fertilizer



Outputs

Crops

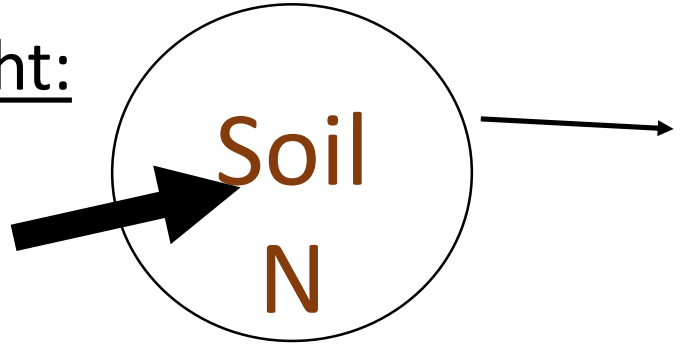
Hydrologic loss

Gaseous loss

2012 Drought:

Inputs

N fertilizer



Outputs

Crops

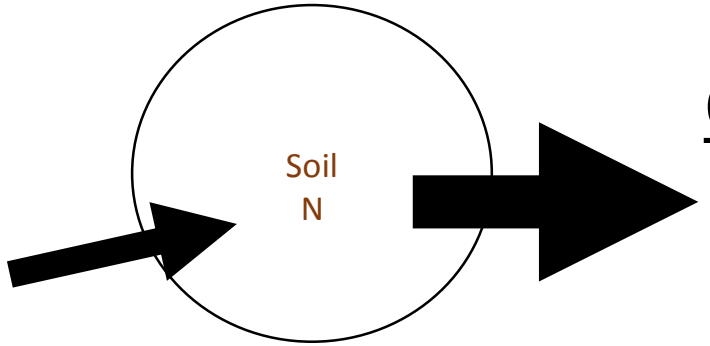
Hydrologic loss

Gaseous loss

2013 Flush:

Inputs

N fertilizer



Outputs

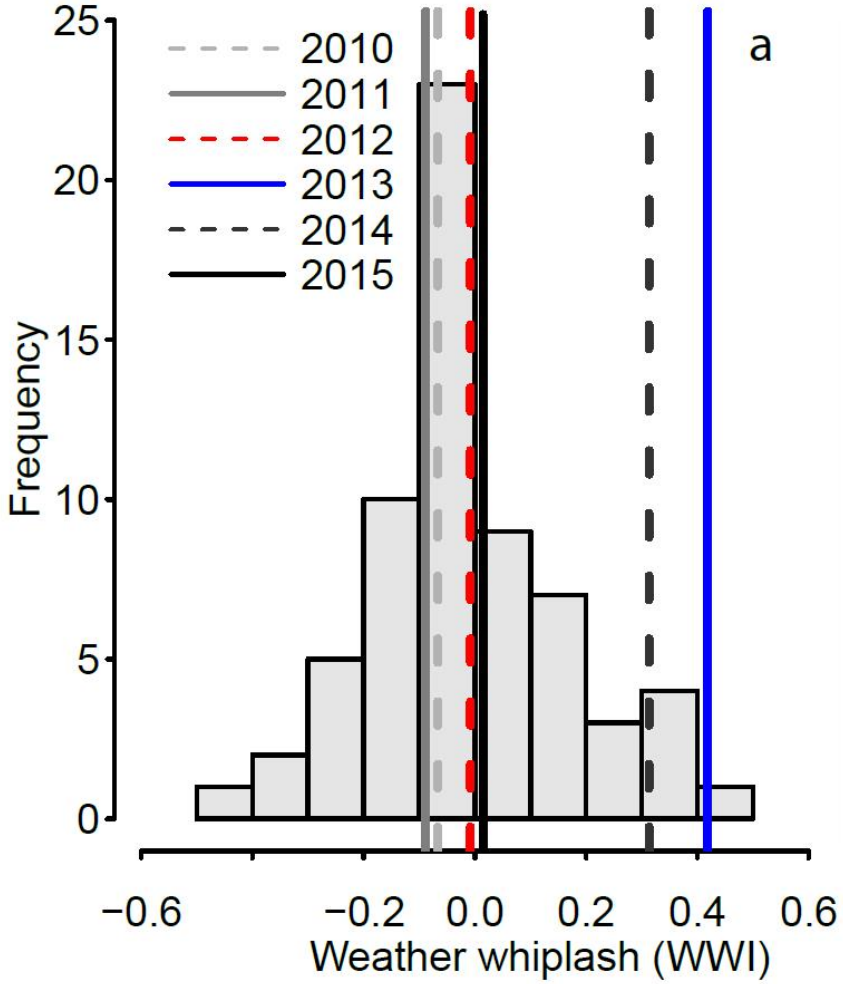
Hydrologic loss

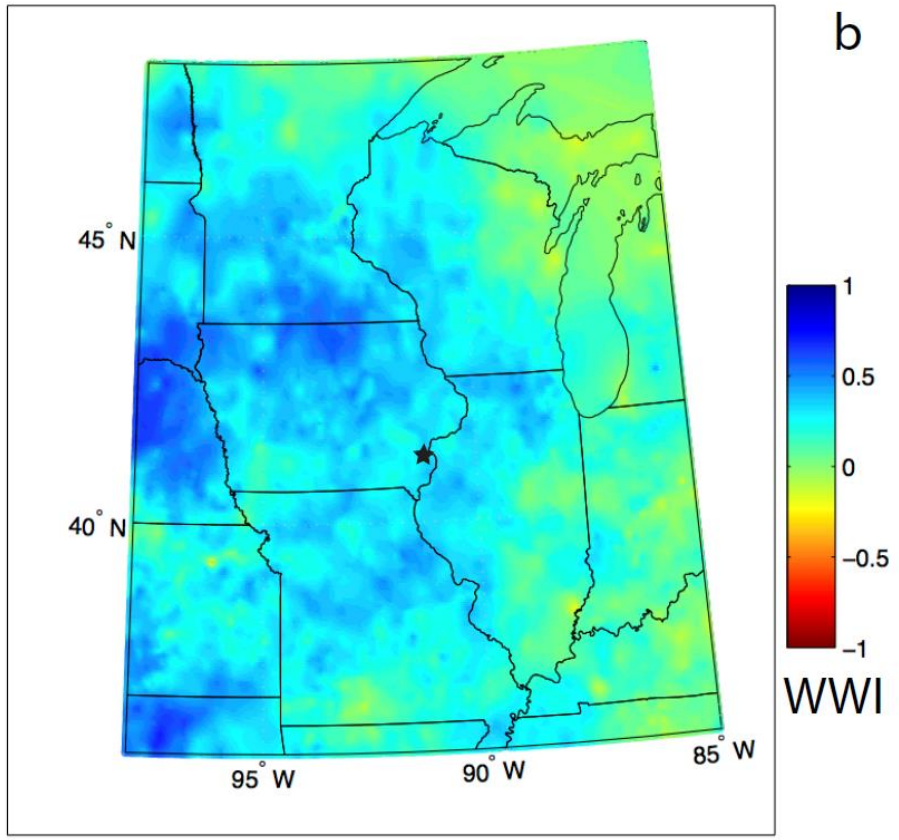
Weather whiplash index

Whiplash Index =

$$\frac{\Sigma \text{ Spring precip. } i+1 - \Sigma \text{ Fall precip. } i}{\Sigma \text{ Spring precip. } i+1 + \Sigma \text{ Fall precip. } i}$$

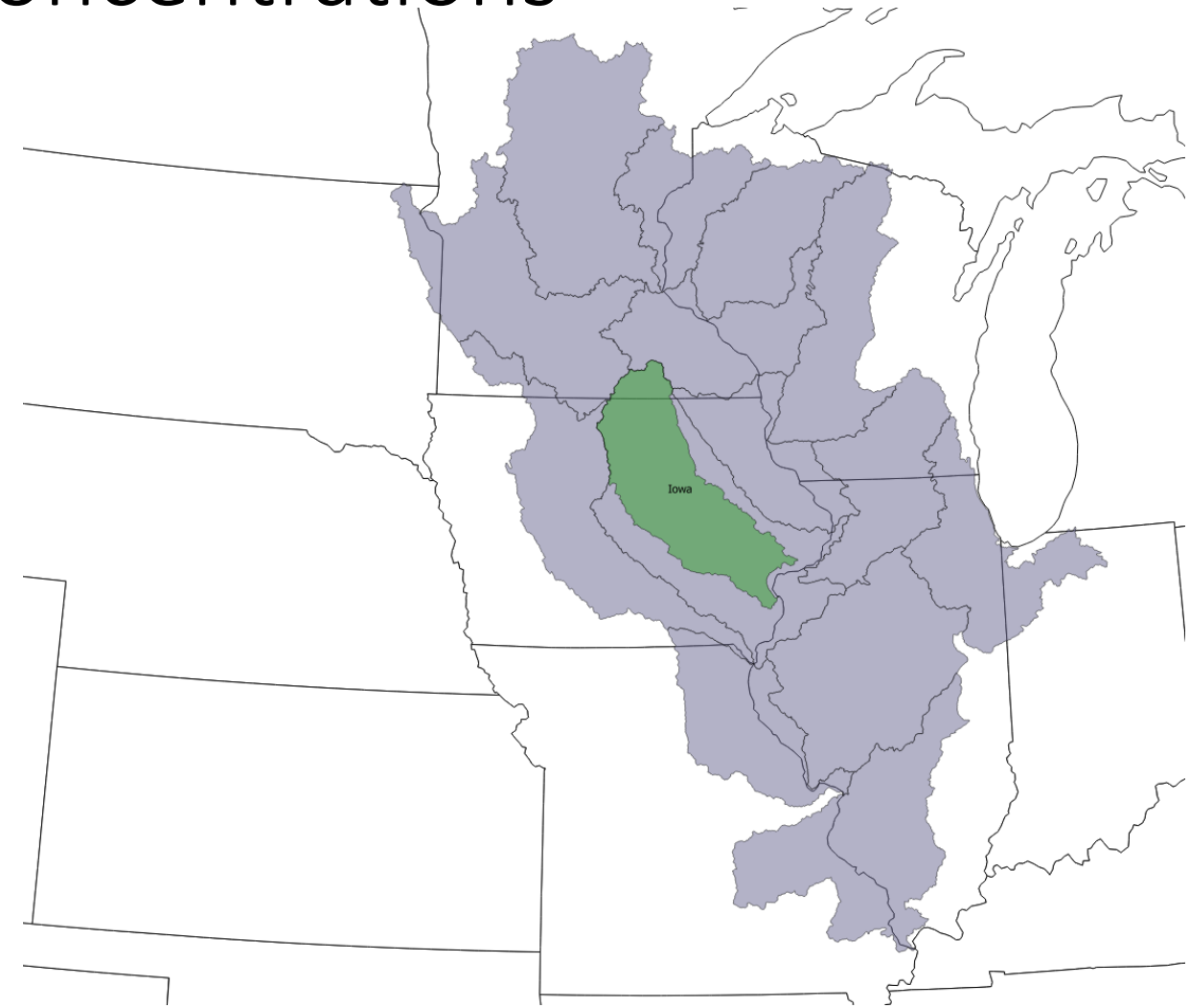
$$\frac{\text{Spring 2013} - \text{Fall 2012}}{\text{Spring 2013} + \text{Fall 2012}}$$

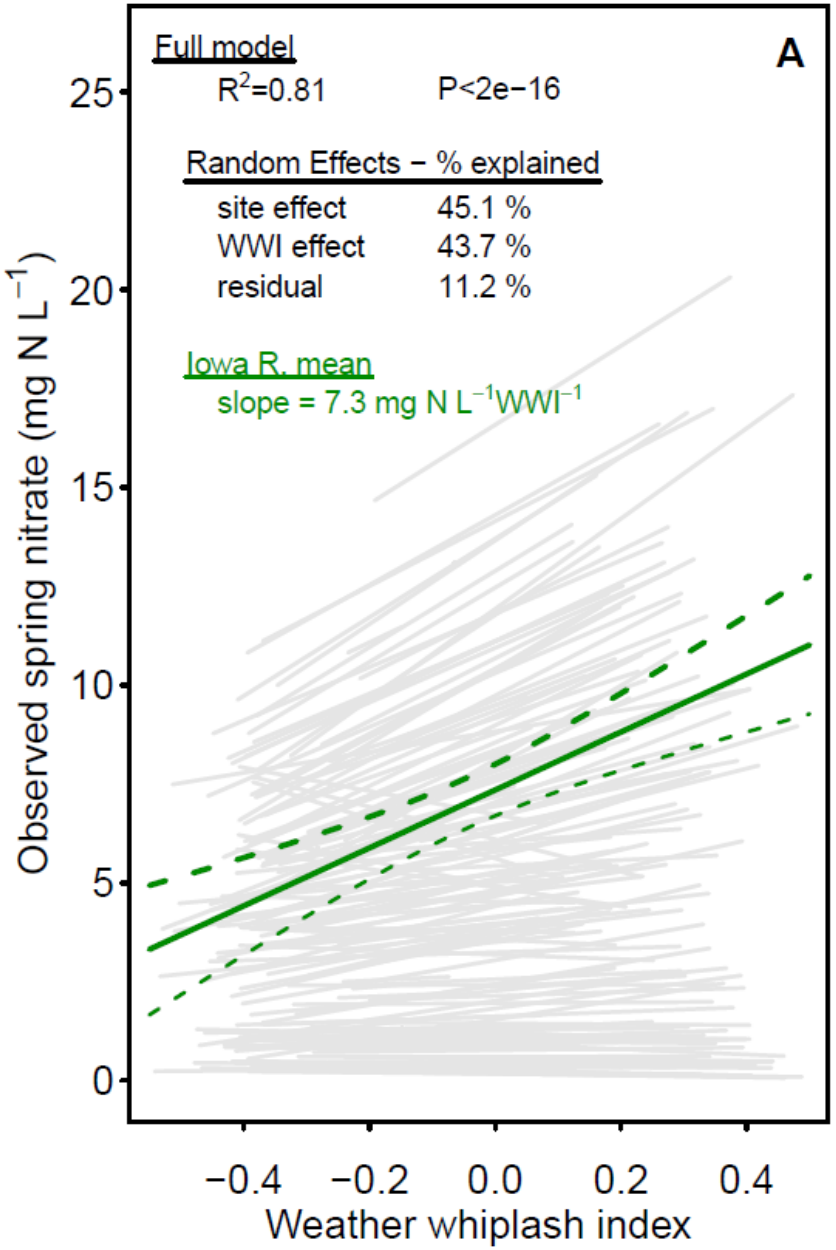




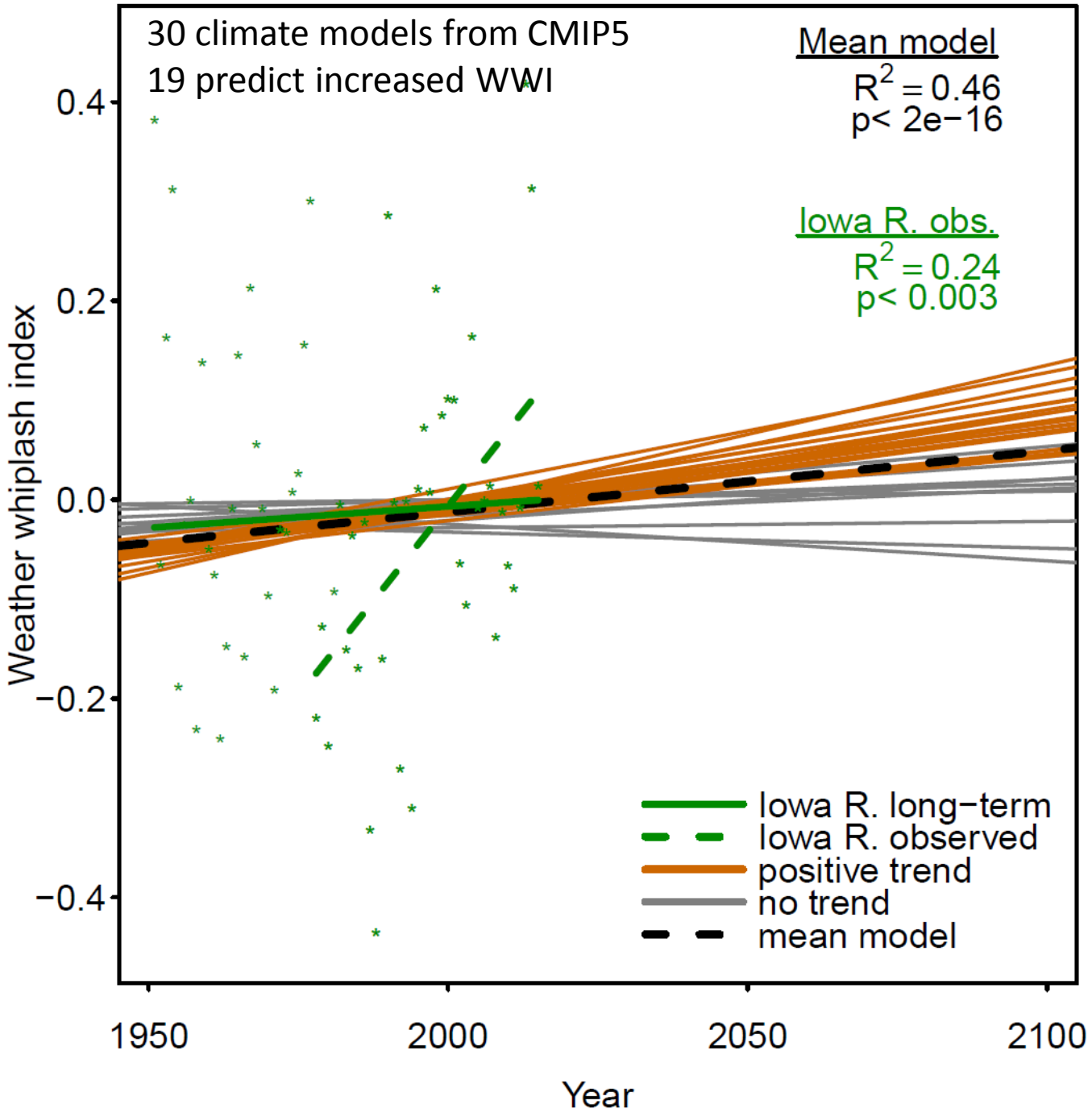
Loecke et al. 2017

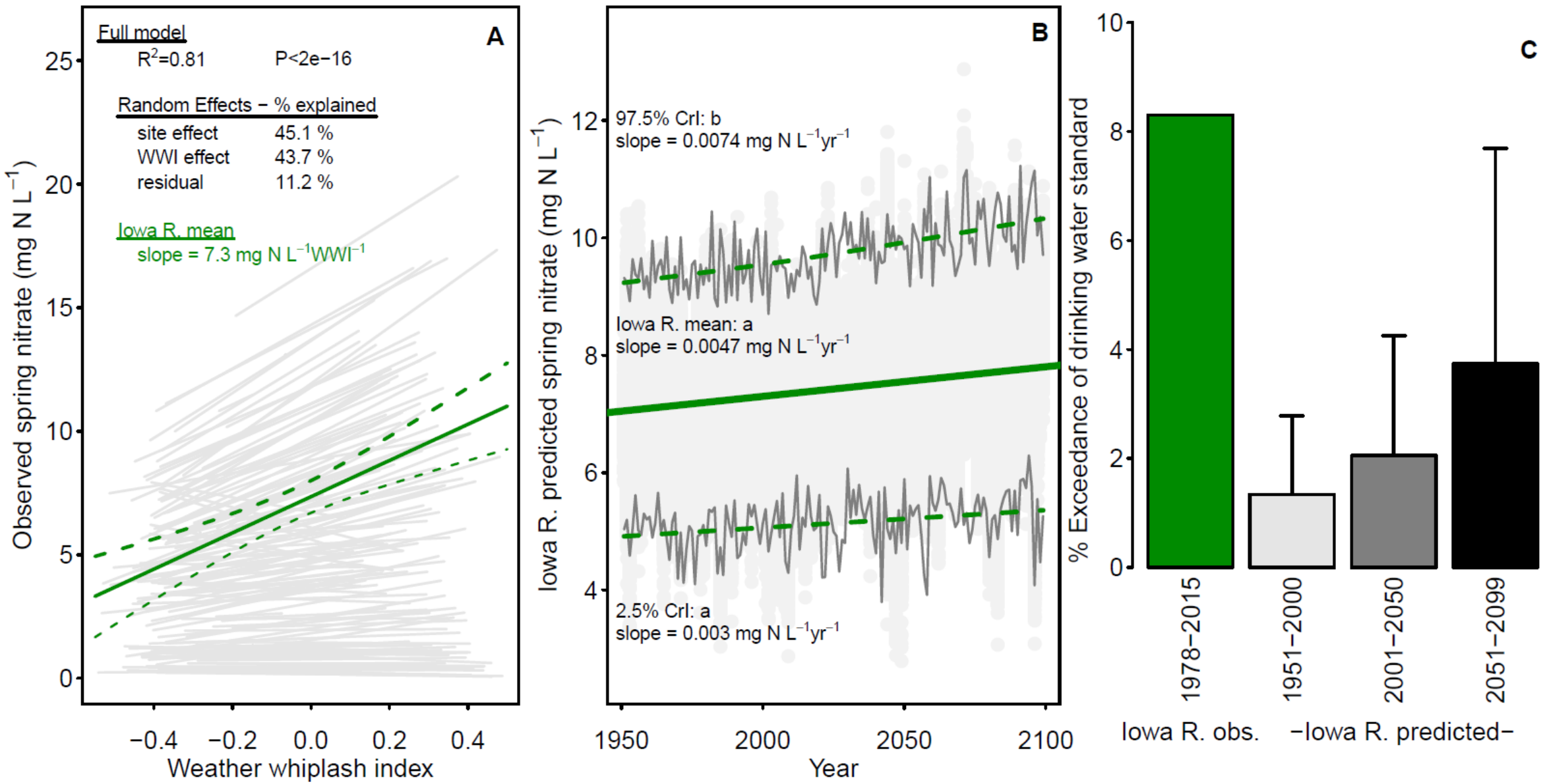
Summer droughts and wet springs leads to highest spring nitrate concentrations





Weather whiplash predicted to increase

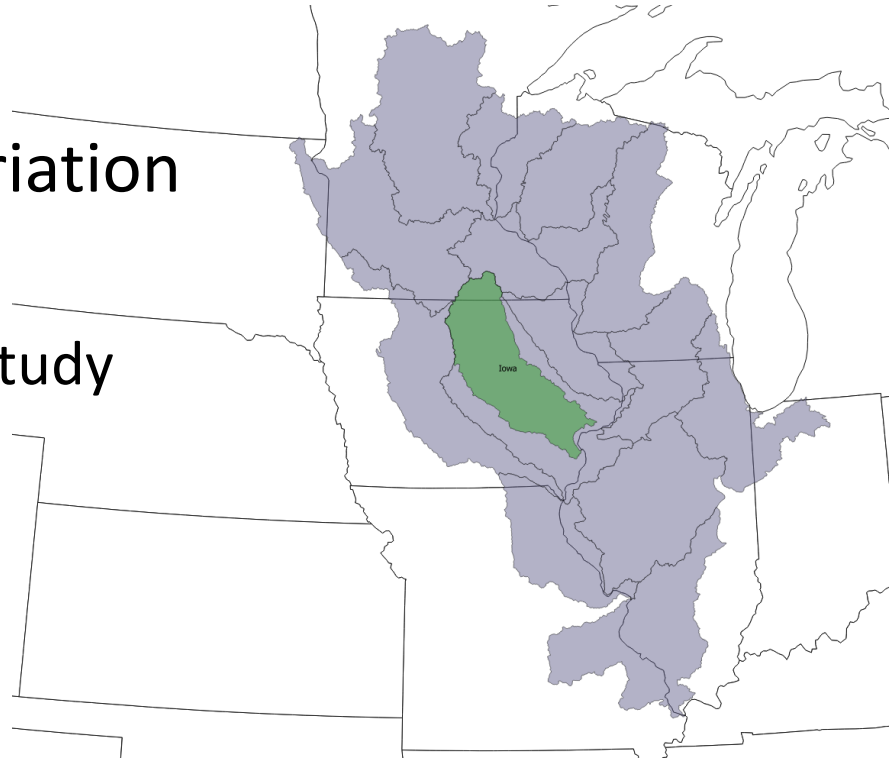




Loecke et al. 2017

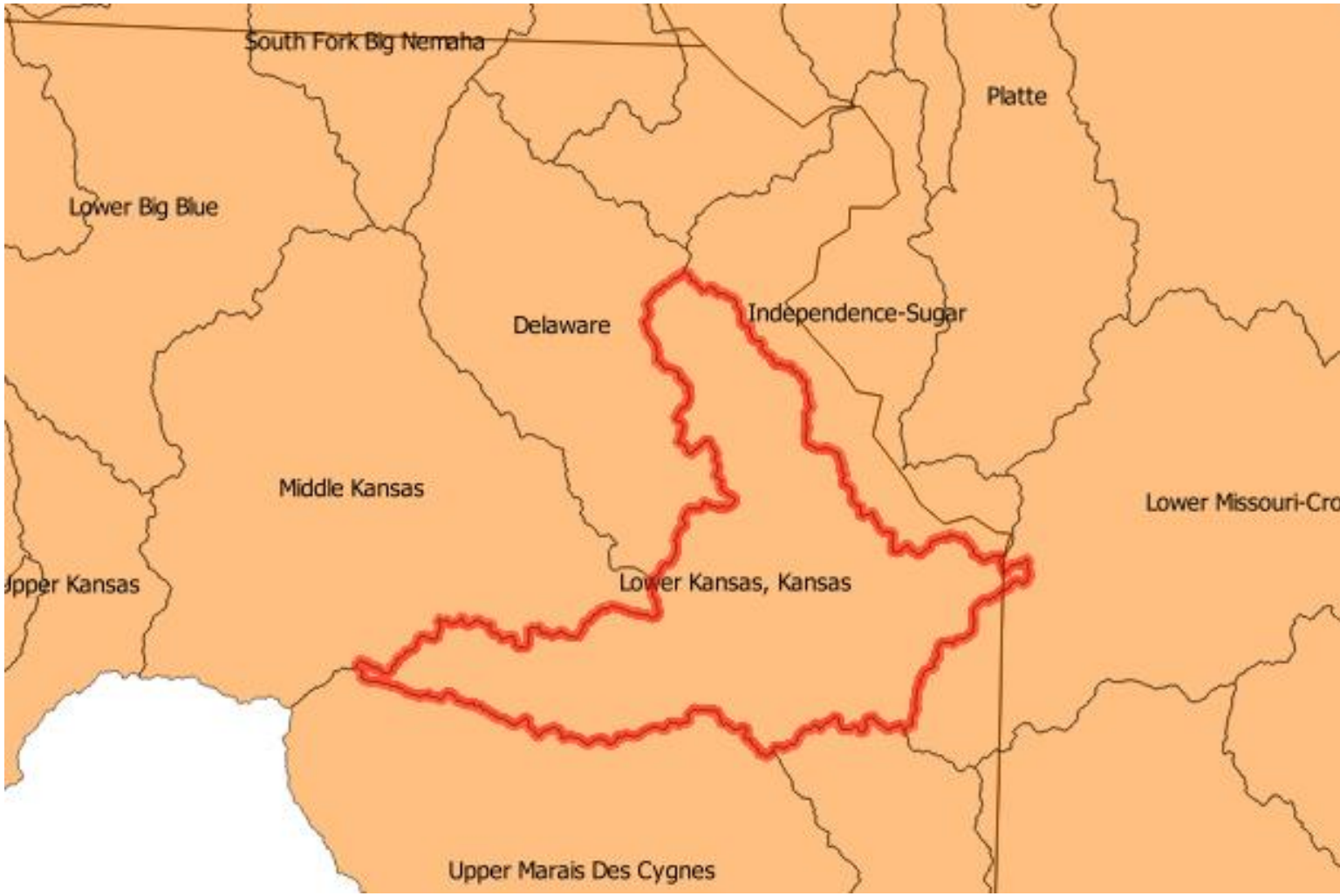
Conclusions – Upper Mississippi River Basin

- Water quality has not improved with improved crop N use efficiency
- Increased variability in hydrology leads to water quality impairment
  - Droughts can enrich landscapes with mobile N
  - Floods mobilize enrich N
- Climate models predict increased precipitation variation
- Climate change likely to decrease water quality
  - Ag management response to extreme weather needs study

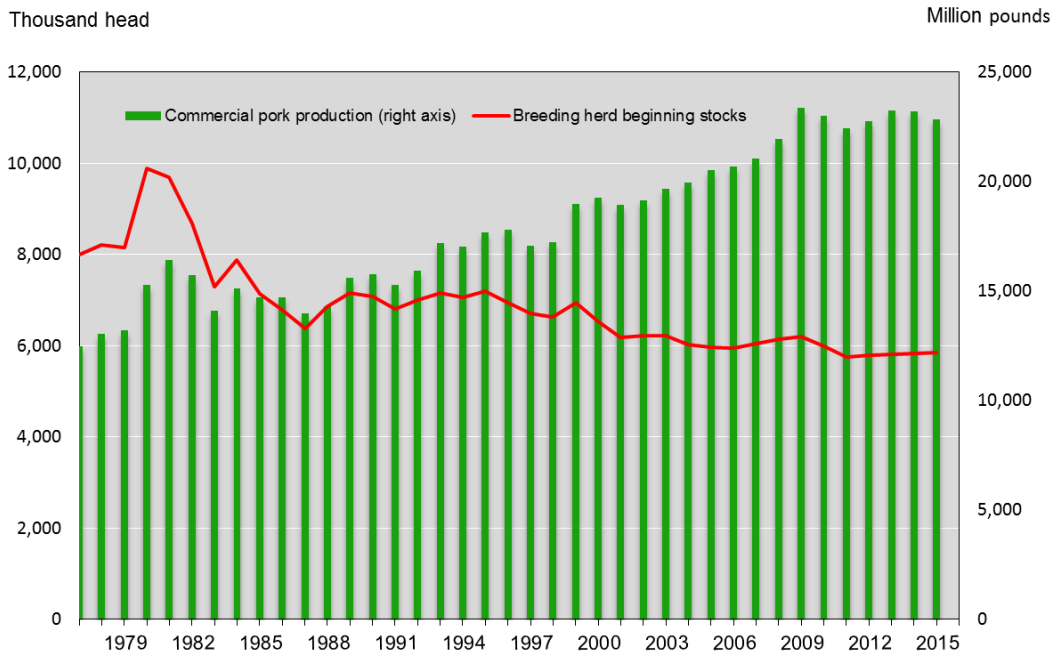


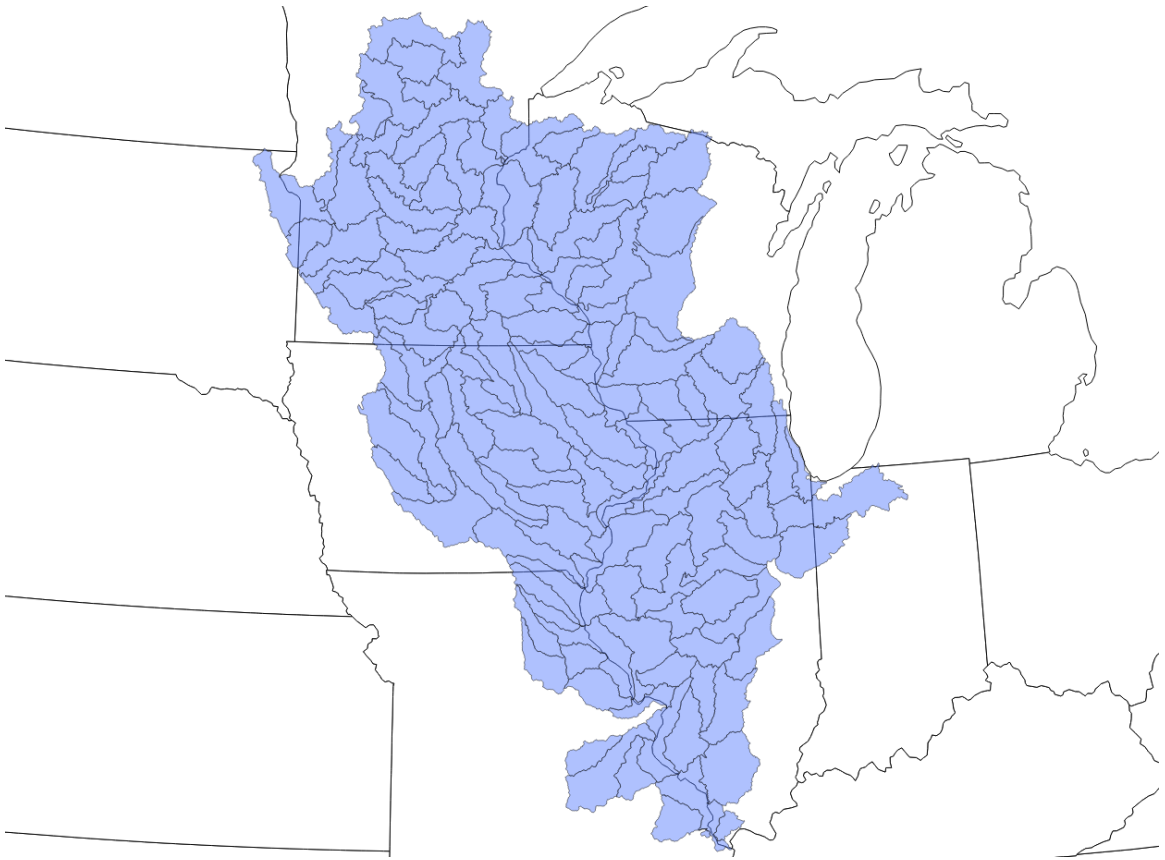
Implications for Kansas

- Climate models predict
  - slight shift in seasonal precipitation
    - Significance is unclear
  - 13 of 30 models increase whiplash
  - 17 models no change
- Slight change in transport less likely important than in UMRB



U.S. commercial pork production versus breeding herd beginning stocks, 1977-2015



Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and World Agricultural Outlook Board, "World Agricultural Supply and Demand Estimates."

Changes in transport (precip and flow)