# Do Landscape Water Storage Features Mediate Nutrient Loads in the Upper Mississippi River Basin?

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Great Plains and Midwest Harmful Algal Blooms Workshop, February 4-5, 2020

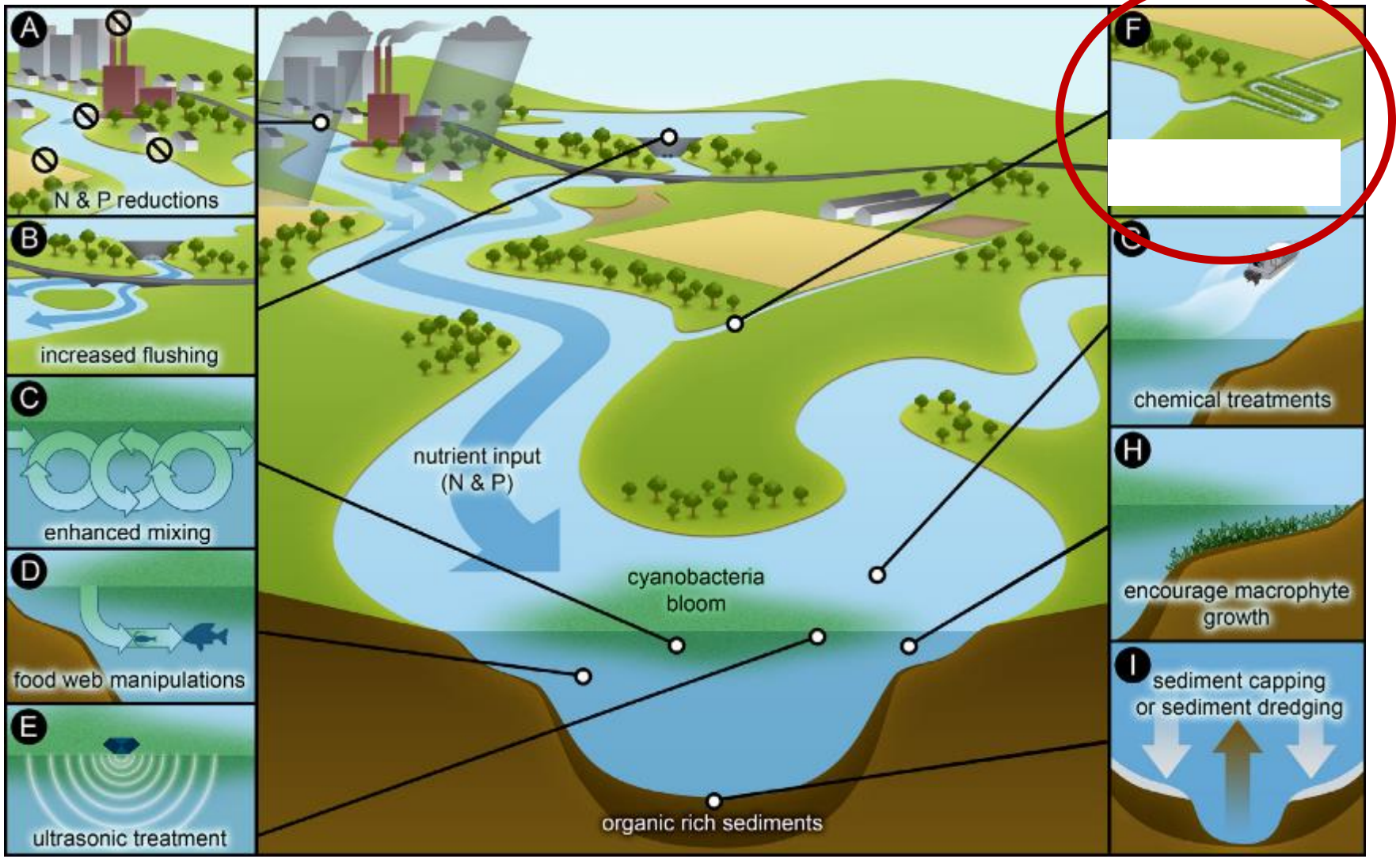
# Nutrient issues persist in the UMRB

Source: T Marsee, Michigan Sea Grant

Excess nutrients (nitrogen, phosphorus) → eutrophication and harmful algal blooms along the freshwater to marine continuum

Source: 2011 Algal Bloom Lake Erie Credit: MERIS/NASA; processed by NOAA/NOS/NCCOS

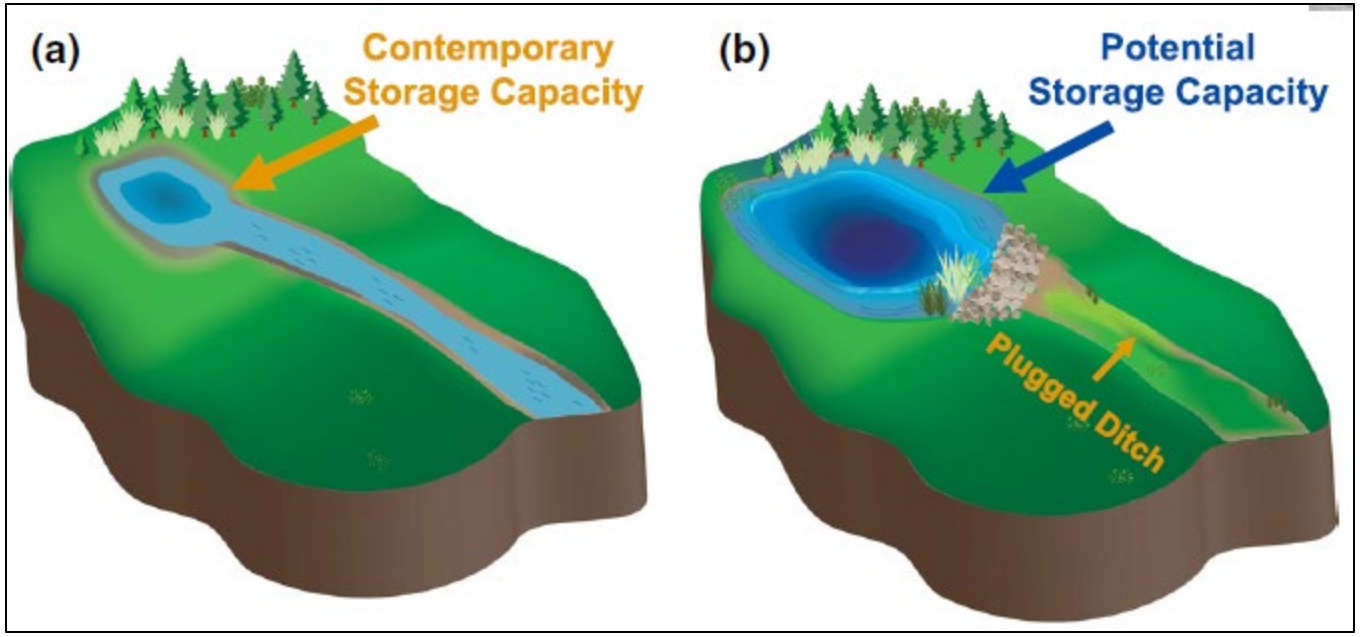
# Landscape surface water storage as a solution




Existing or restorable surface water storage features

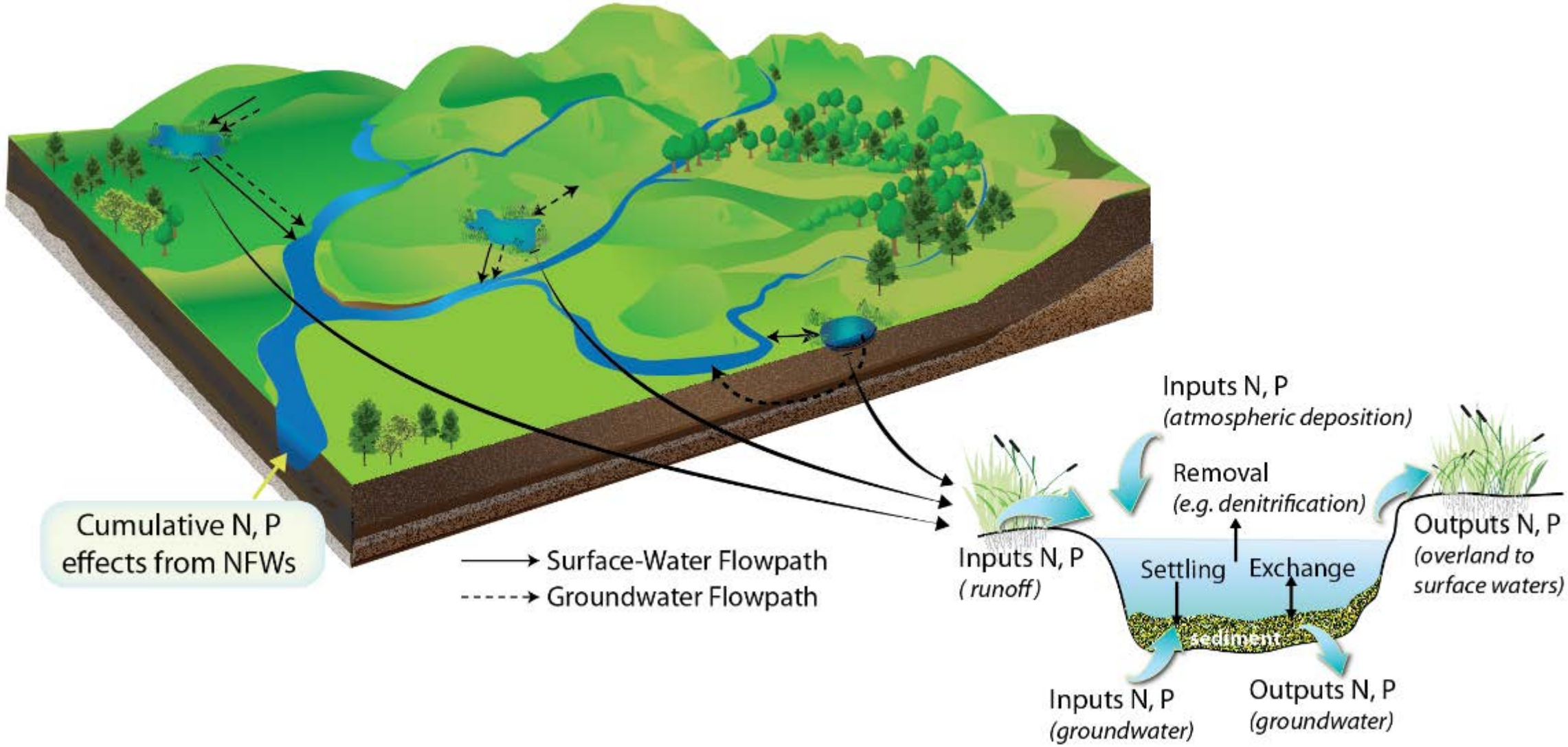
Paerl et al. (2016) *Harmful Algae*

# Non-floodplain wetlands (NFWs): primary surface water storage features




CN Jones *et al*. (2018) *Hydrological Processes*

# Conceptual model: NFWs for mediating nutrients at watershed scales




Golden *et al*. 2019, *Environmental Science & Technology*

# Landscape water storage and watershed nutrient conditions

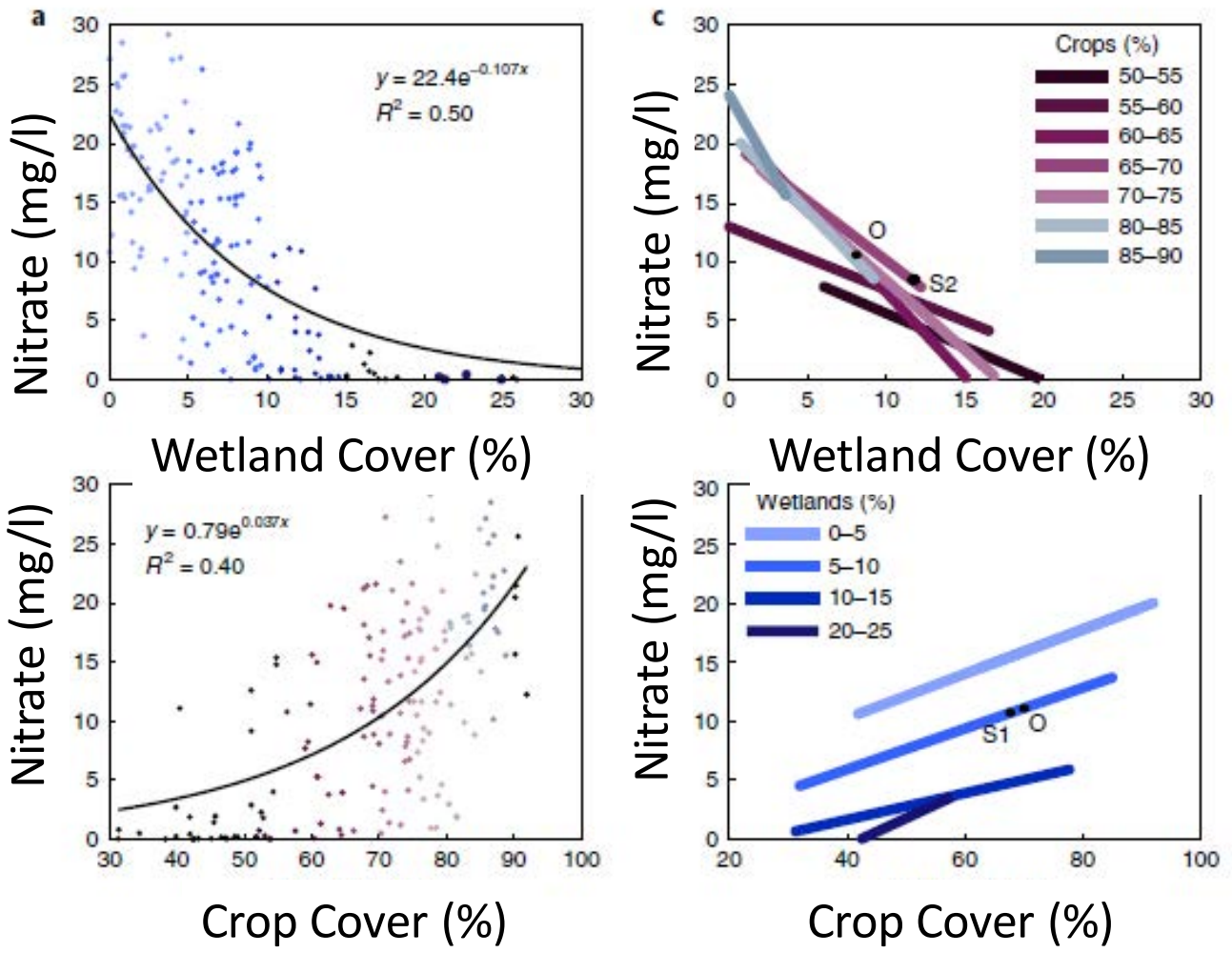
- Limited understanding of how landscape water storage features (wetlands, floodplains) interact with nutrient sources to affect stream nutrient loading, particularly in large river basins

- **Research Question**: How do wetlands, as landscape water storage features, mediate water quality across a range of land use and environmental gradients?

A first glimpse:

Relationships among riverine nitrate, wetland cover (%), and crop cover (%)

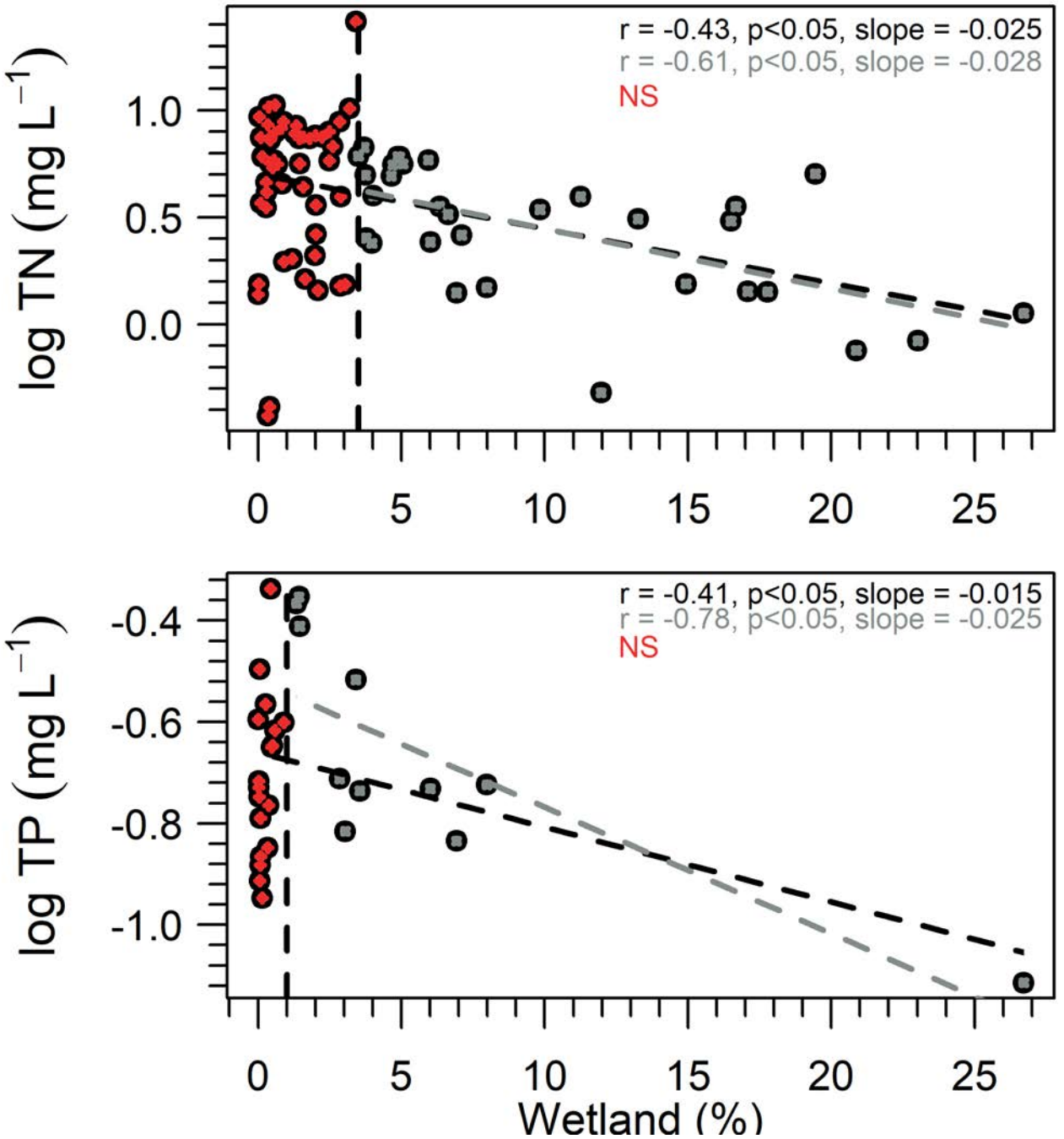
Hansen *et al.* (2018) *Nature Geoscience*



A first glimpse:

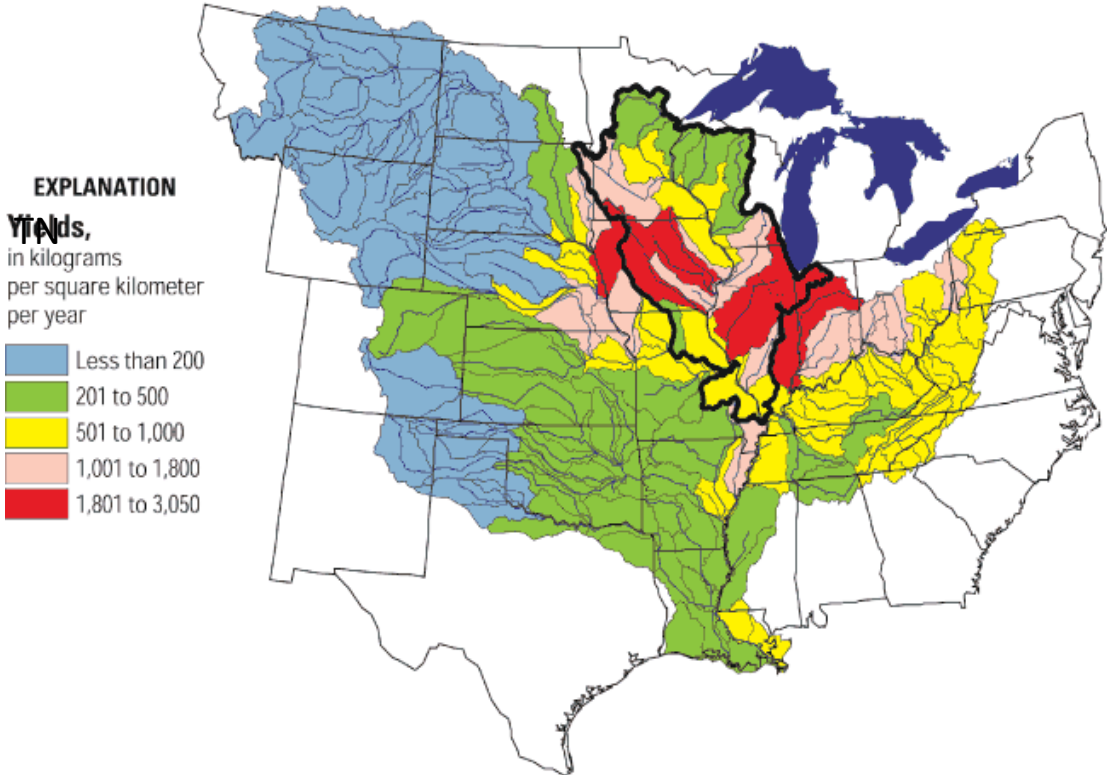
Our data agree!

(A teaser for the forthcoming slides…)



# Upper Mississippi River Basin (UMRB)

Mississippi River Basin (UMRB is outlined in solid black)




USGS Fact Sheet 105–03 (2003)


UMRB contributes more TN and TP to the Gulf of Mexico than other portions of the Mississippi River Basin.

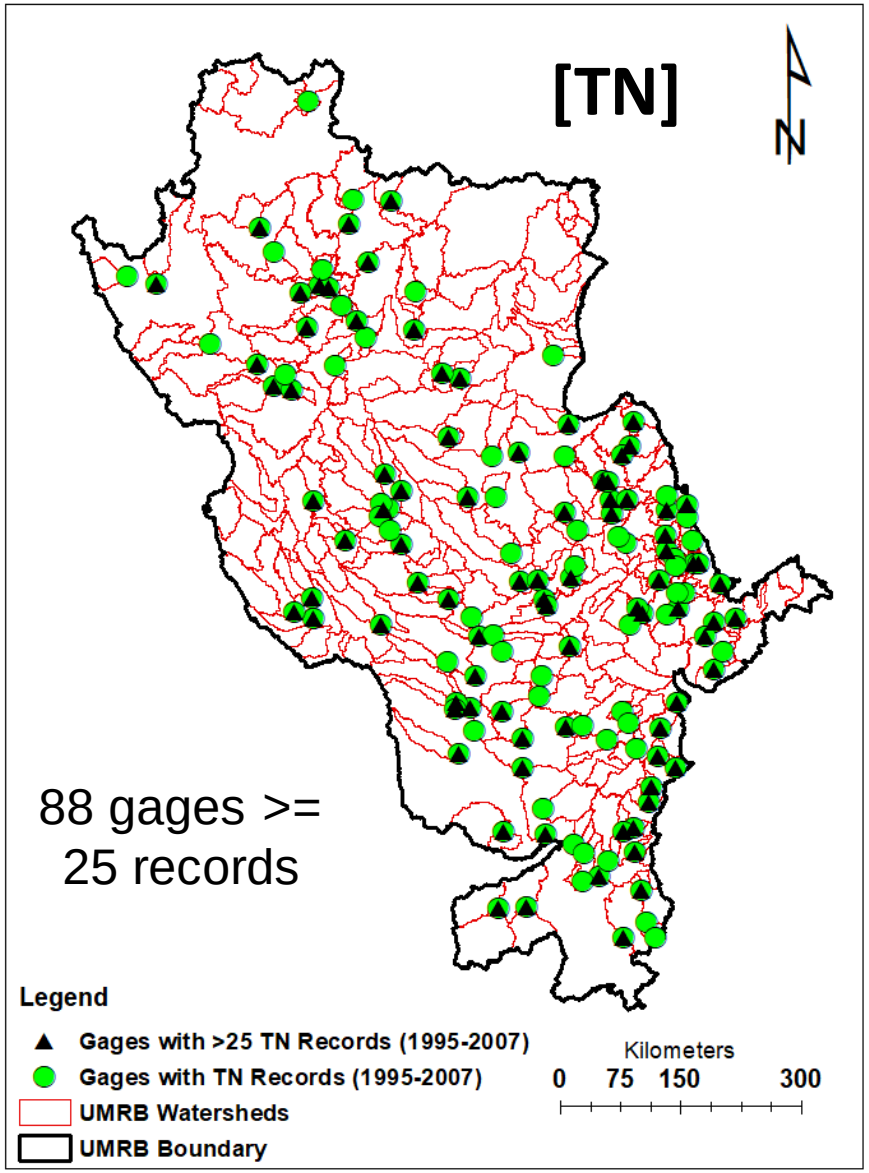
# EXPLANATORY VARIABLES

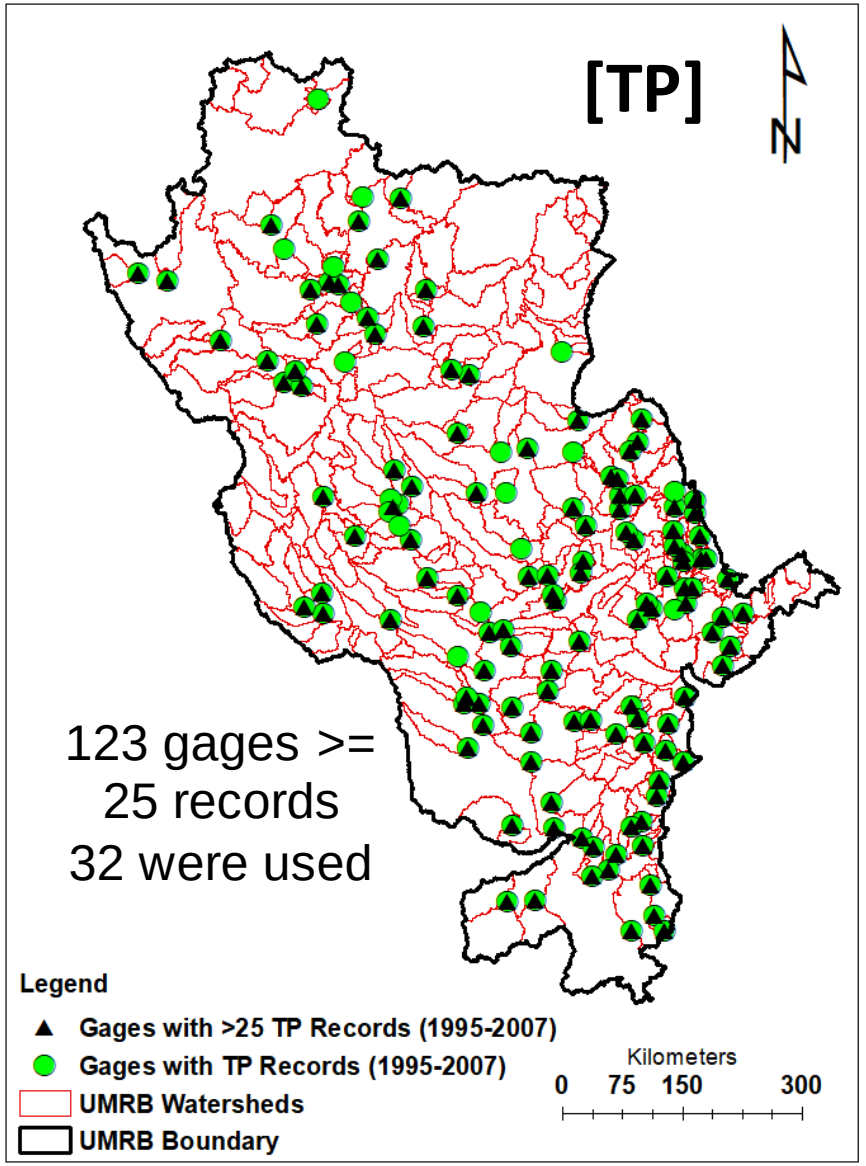
**Geospatial Data**
e.g., land cover, agriculture and atmospheric N and P inputs

**Climate Data**
e.g., precipitation

**Wetland and Wetland Flowpath Metrics**
e.g., area & type, flowpath frequency & magnitude

# RESPONSE VARIABLES

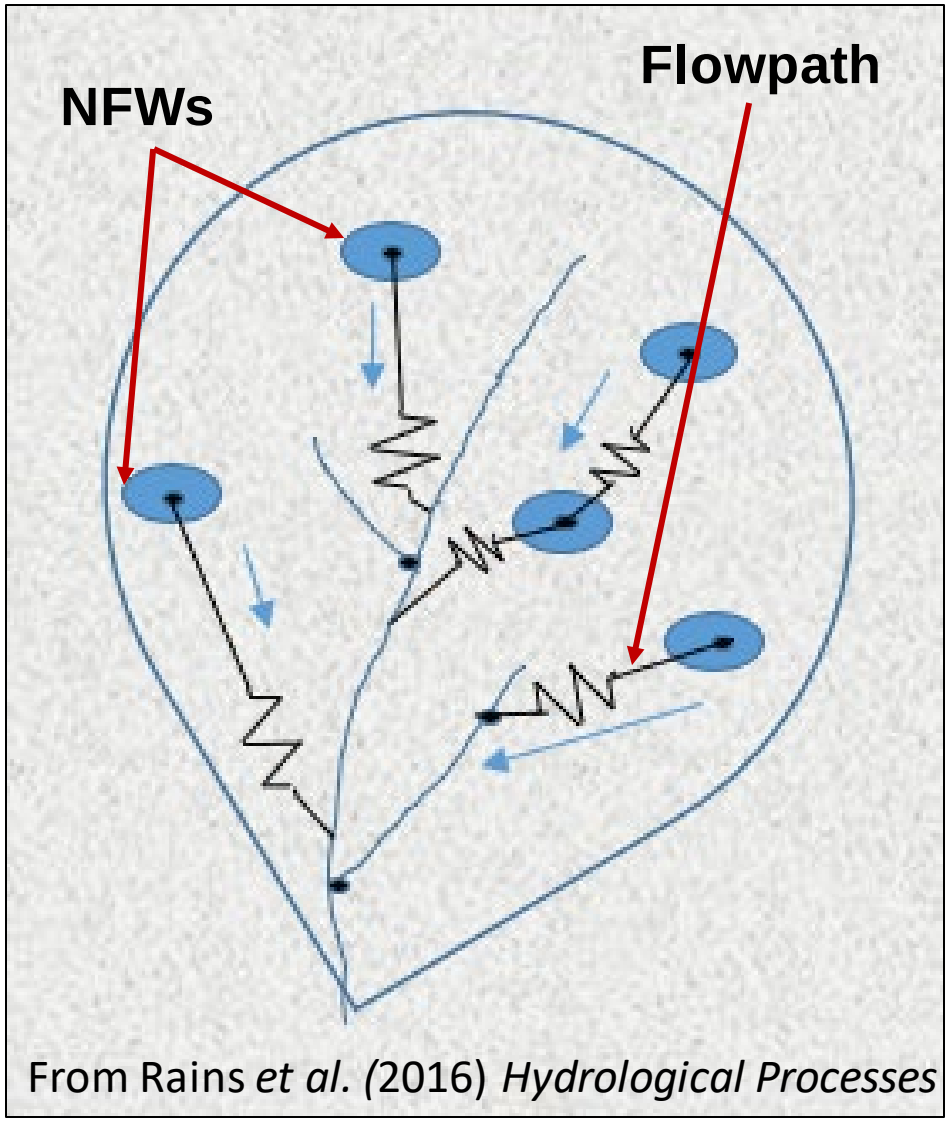



Mengistu *et al.* (*In prep*)

# Wetland flowpath metrics to nearest surface water

- ***Type*** – Riparian (bidirectional), non-riparian surface, non-riparian subsurface
- ***Magnitude*** – Very fast, fast, moderate, slow, very slow travel times
- ***Frequency*** – High, moderate, low
- ***Impact*** – None, low, high



From Rains *et al.* (2016) *Hydrological Processes*

Leibowitz *et al.* (*Submitted*)

# Summary of Results

- Agriculture is statistically related to elevated TN and TP in UMRB watersheds.
- Wetland flowpath metrics improved the prediction of TN and TP concentrations.
- Wetlands and their water flow path-associated characteristics revealed mediating roles to reduce TN and TP concentration in streams.
- Wetland transport metrics related to attenuating flows along the wetland to stream flowpath (e.g., high porosity, Manning's N) and variables such as the density of wetlands were related to lower TN and TP concentrations.

# Next, we are…

…Integrating NFWs into large-scale process-based watershed models for future water quality projections

What does this mean, exactly? We're considering NFWs and surface depressions in models to predict flood, drought, and nutrient conditions across watersheds. This typically does not happen.

# Landscape and Floodplain Storage

## Improved accuracy with spatially explicit inclusion of landscape water storage capacity

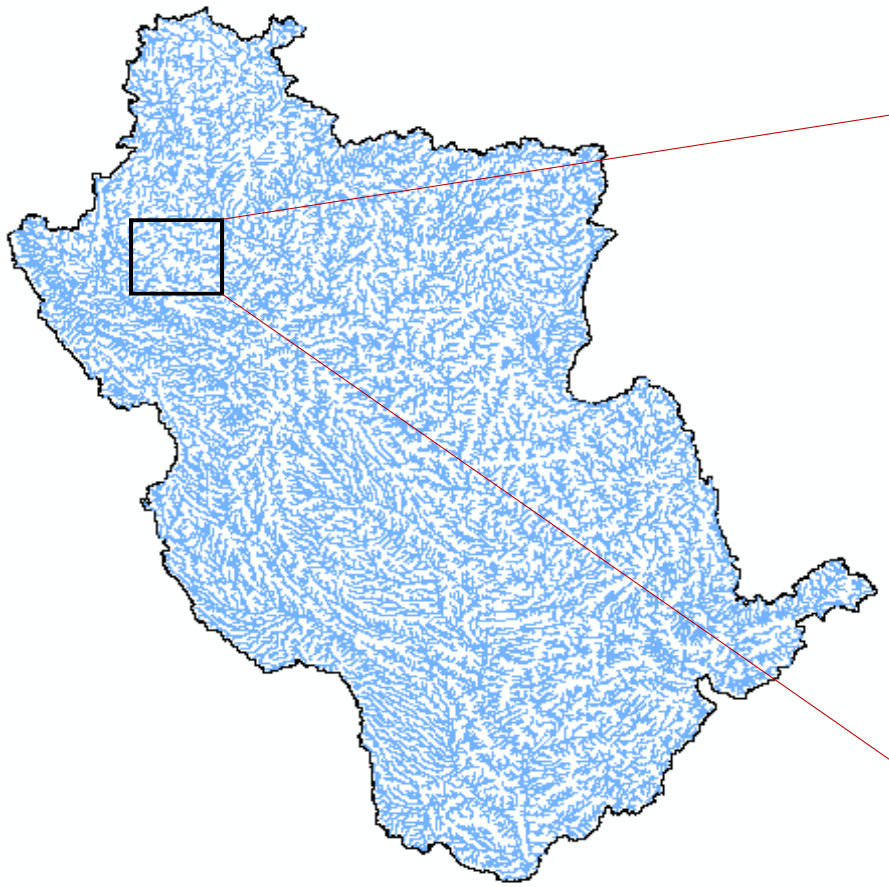
**High-resolution SWAT model**

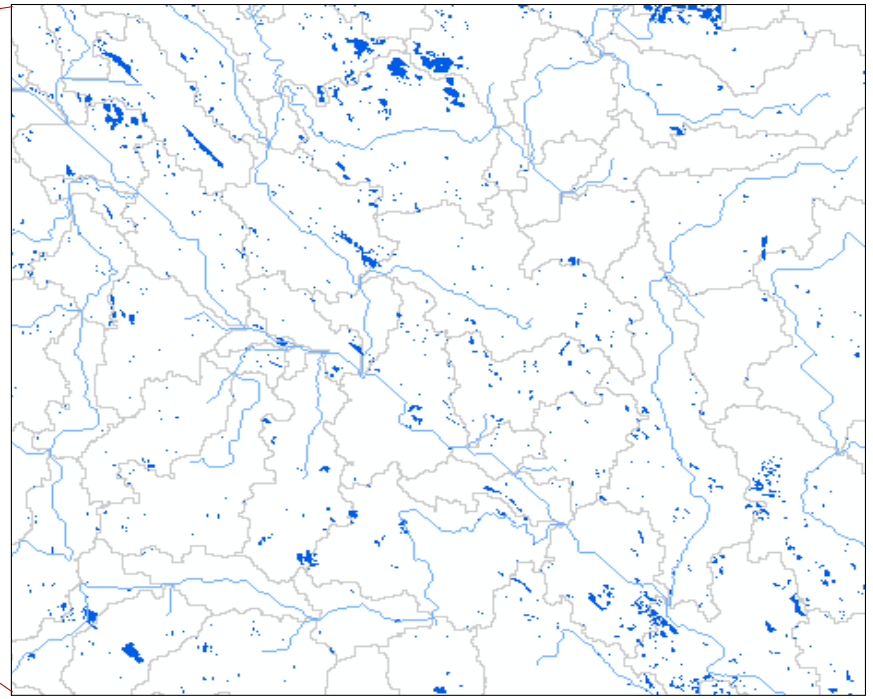
~ 16,000 river reaches

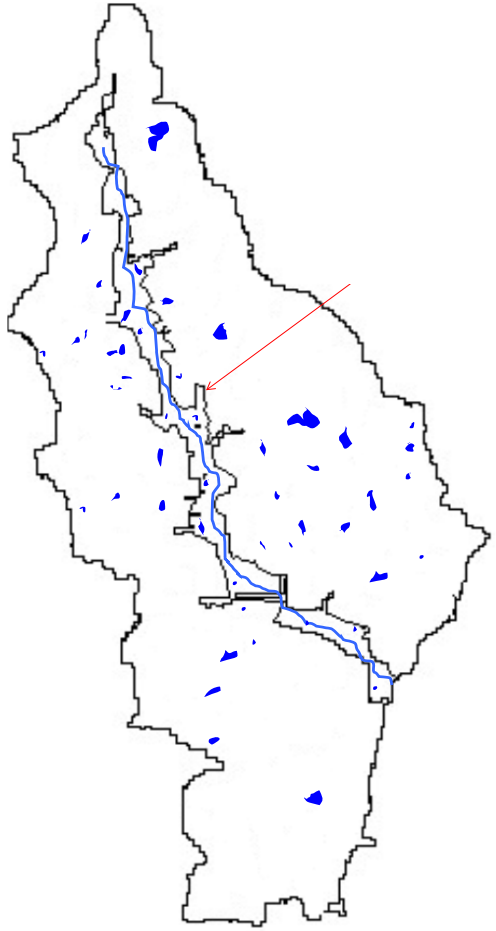
~ 0.5 million sq km basin

10m DEM and Water body inventories → Surface storage: area and volume → Spatially explicit inclusion in a modified SWAT model

~ nearly 0.9 million modeled surface depressions

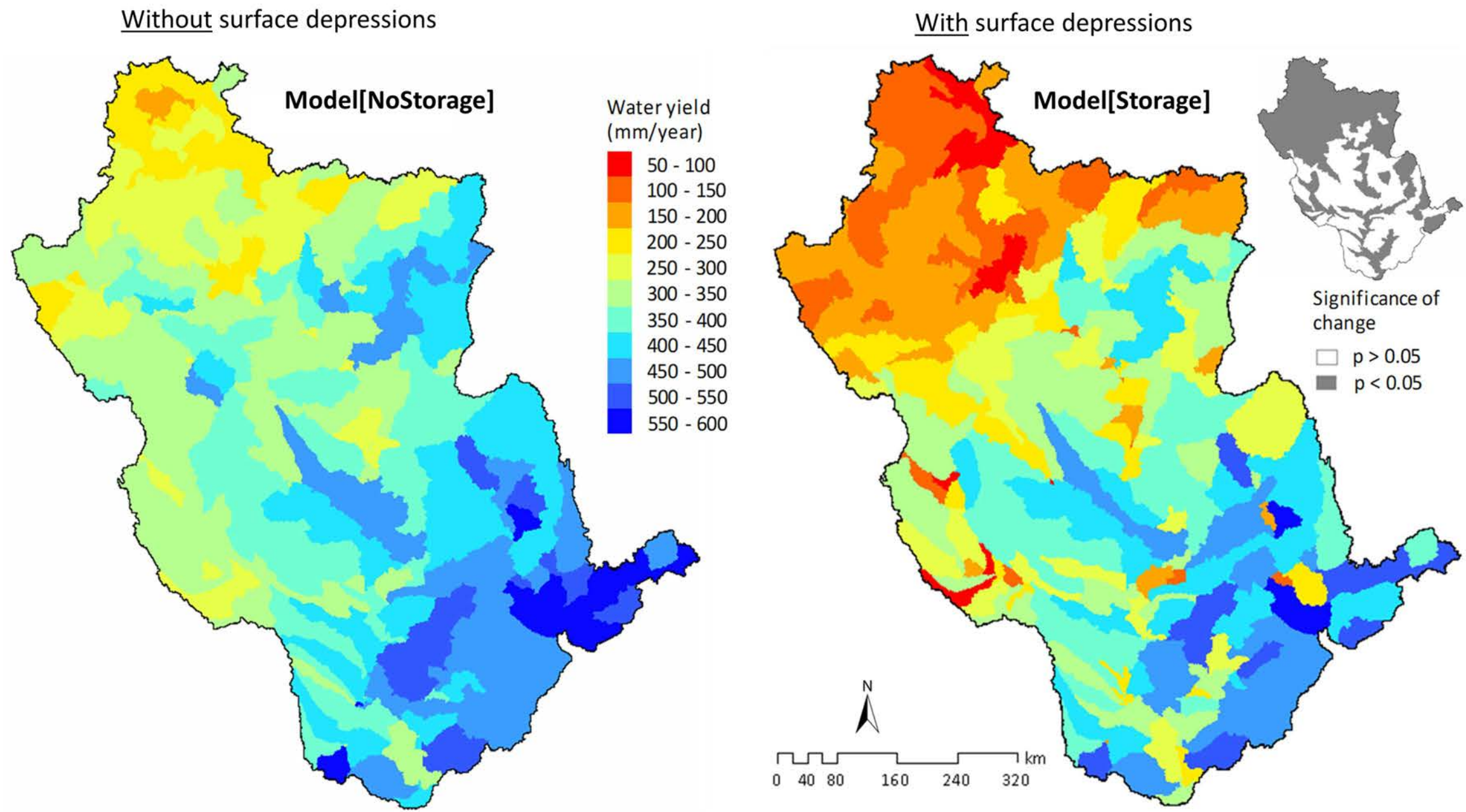




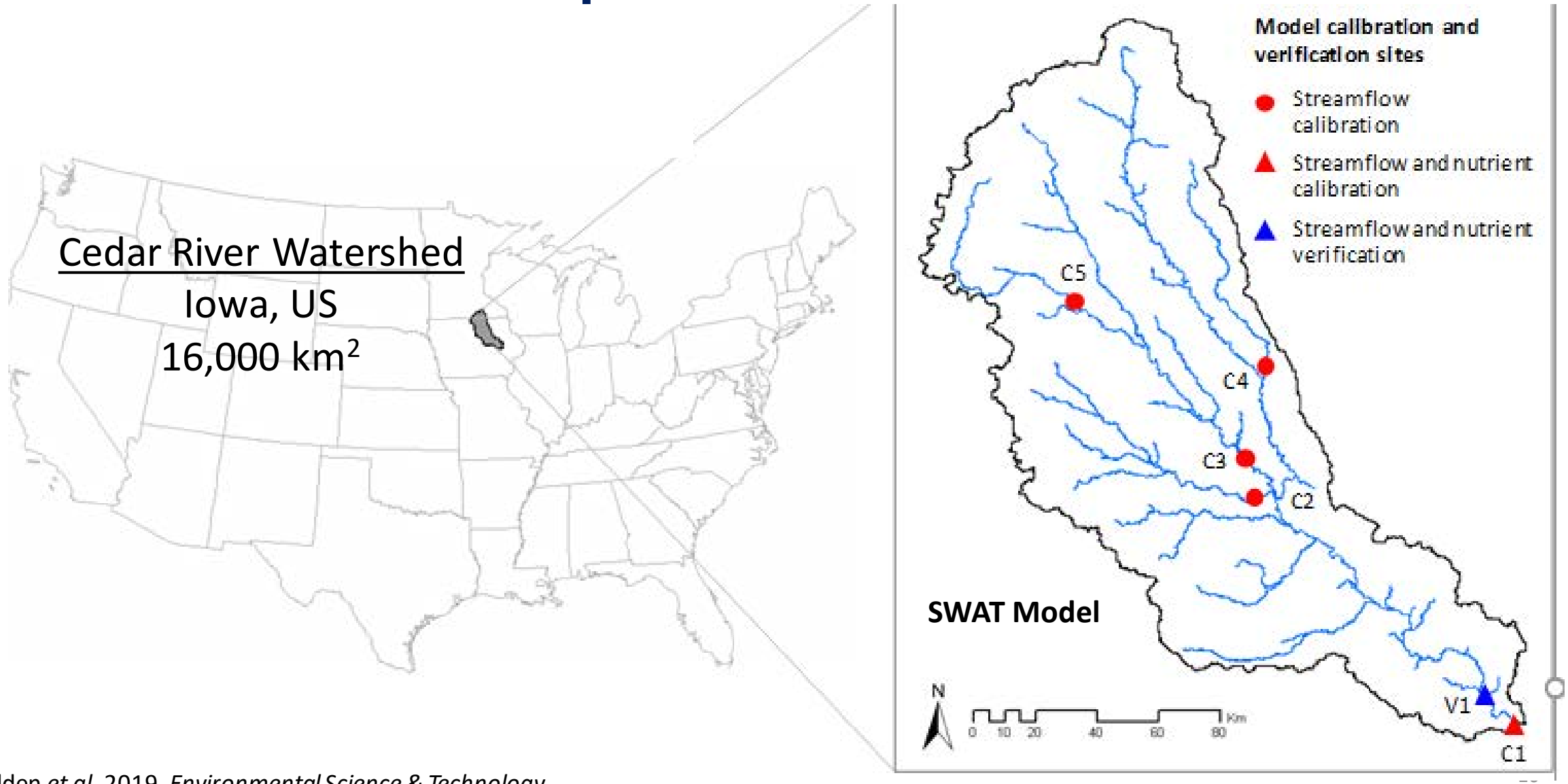


# BASIN HYDROLOGIC DYNAMICS

**Average annual water yield**



# Integrating NFWs into watershed models: impacts on nutrients

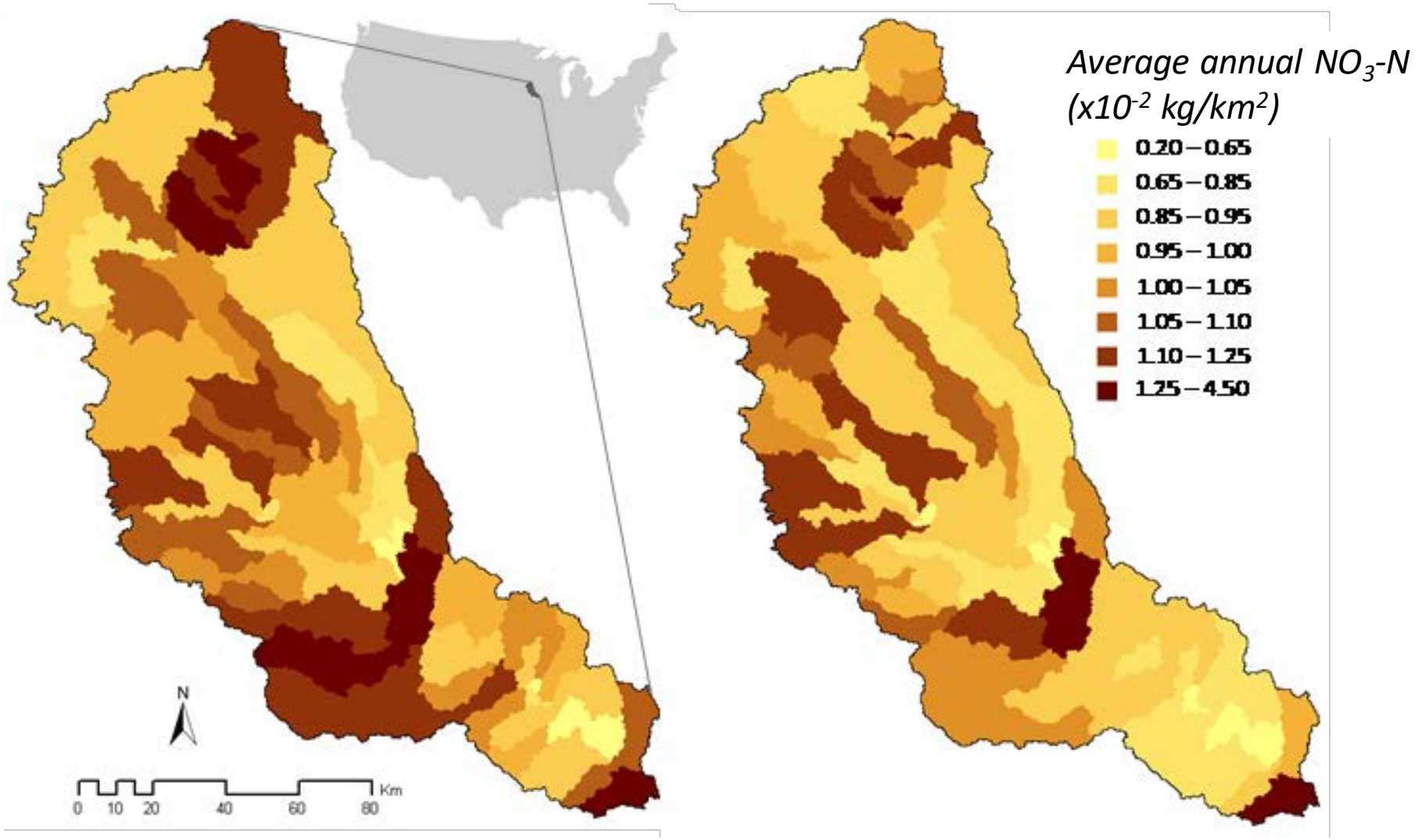



Golden *et al*. 2019, *Environmental Science & Technology*

# Subbasin Yields of Nitrate-N

a) Model without non-floodplains wetlands

b) Model with non-floodplains wetlands




Golden *et al*. 2019, *Environmental Science & Technology*

# Take-home

- Water storage features, and specifically NFWs, show promise for mediating watershed-scale aquatic nutrient conditions ***but*** more research is needed

- Integrating NFWs into process-based watershed models is critical for getting the “best” water quality projections for climate variations, land cover change, and other future management scenarios

# What's next?

- Asking questions such as: Where in the UMRB can nutrients be most efficiently processed and removed for decreased N and P loading to surface waters?
- Applying data mining approaches to wetland flowpath metrics with TN and TP as response variables
- Linking SWAT floodplain/wetland and hydrological modeling to nutrients across the river basin to do this
- Begin transferring what we learned to other large river basins
- Thoughts and feedback welcome! *golden.heather@epa.gov*; *lane.charles@epa.gov*; *christensen.jay@epa.gov*