2015 SWAT Conference at Purdue University

Assessing Spatial and Temporal Distribution of Sediment, Nitrogen and Phosphorous Loading in the Missouri River Basin (MORB)

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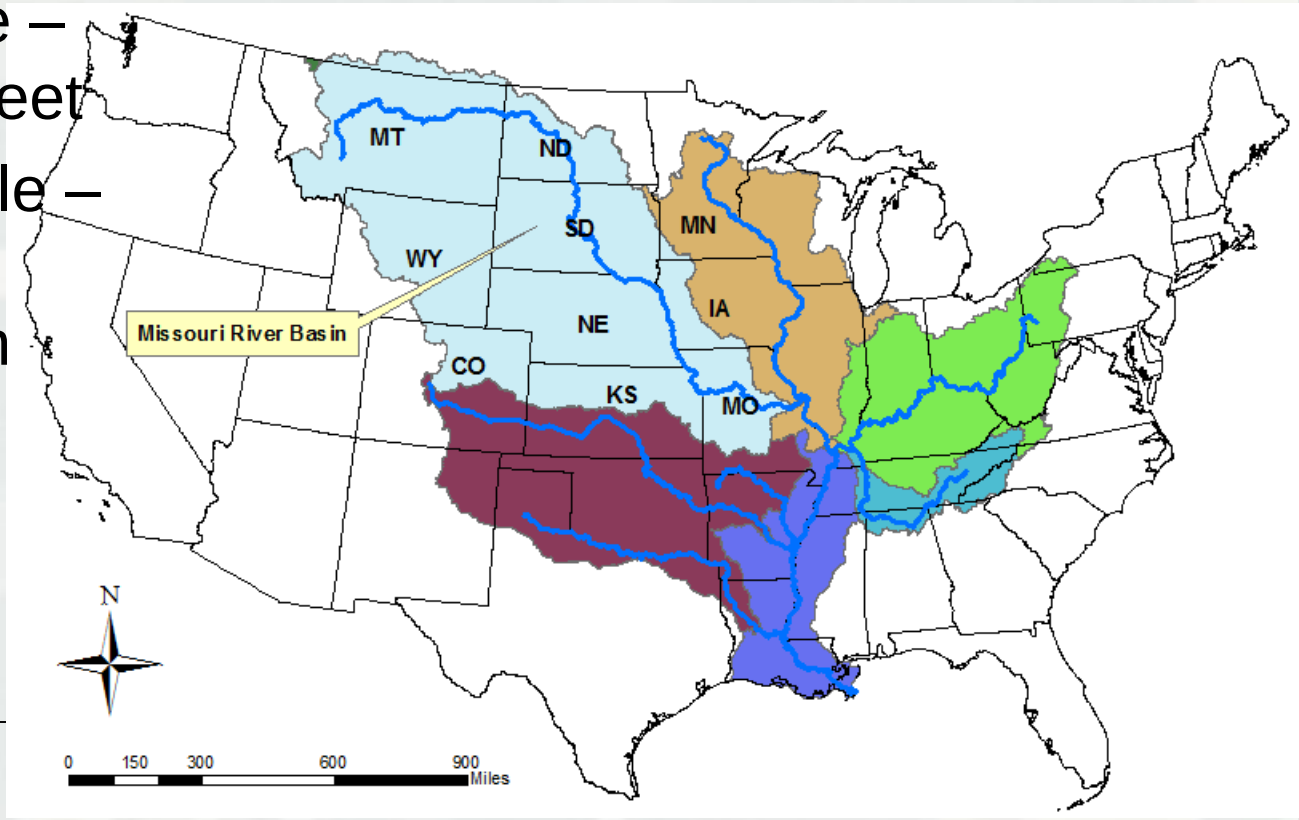
Outline

- Missouri River Basin (MORB) basics
- Baseline SWAT model/calibration results
- Future Bioenergy Production (BT2) scenario analysis
- Summary

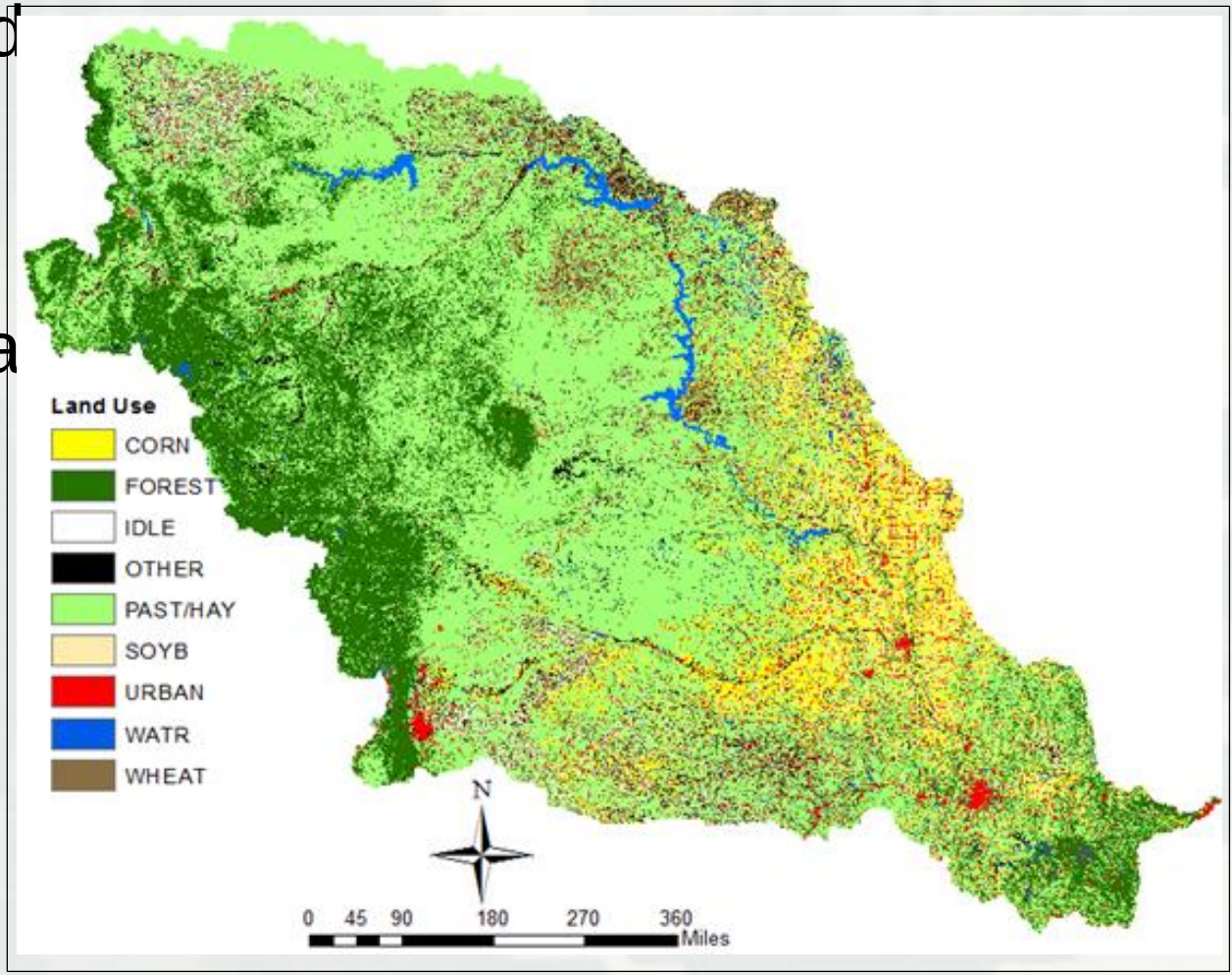
Missouri River Basin (MoRB) - Basics

- Nation's longest (2,300 miles) from Three Forks, MT to St. Louis, MO.
- Basin drains 530,000 mi^2 – 1/6 of the US
- 10 States and 2 Canadian Provinces
- Elevation range – 400 to 14,000 feet
- 12 million people – mostly in lower portion of Basin



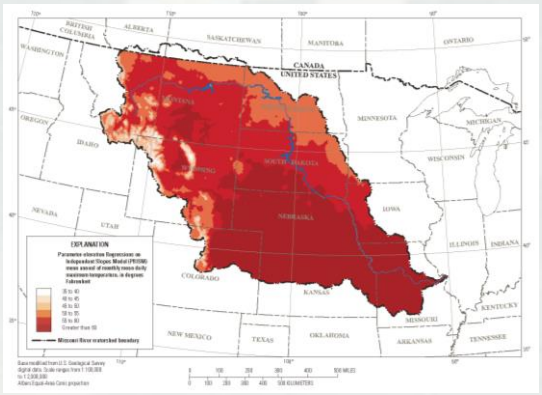
MORB Land Use

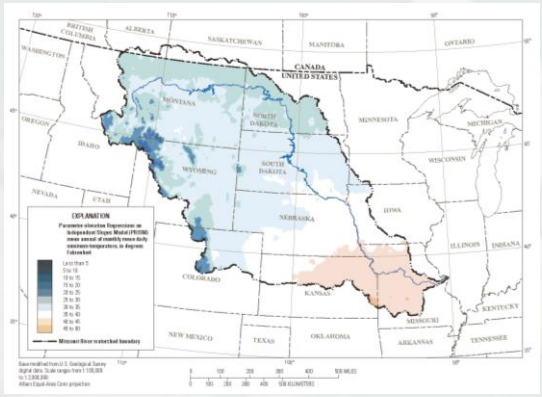
- 51% rangeland
- 25% cropland
- 9% forest
- 6% hay and pa
- 4% barren
- 3% urban
- 2% Canada

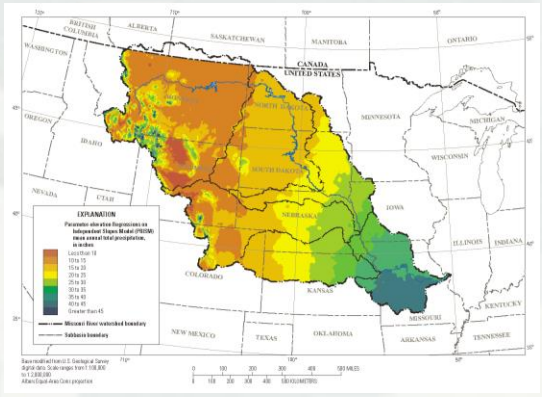


MORB Climate

- Mean annual minimum temps ranged from <5 to >45 ^{O}F
- Mean annual maximum temps ranged from 35 to >60 ^{O}F
- Mean annual total precipitation ranges from **14** in/yr (NW portion) to **41** in/yr







Courtesy of USGS

MORB Hydrology

Upper Missouri

Yellowstone

Middle Missouri

Platte

Kansas

Lower Missouri

25% Contribution

15% Contribution

<20% Contribution

45% Contribution

Tributary outlet

MORB outlets

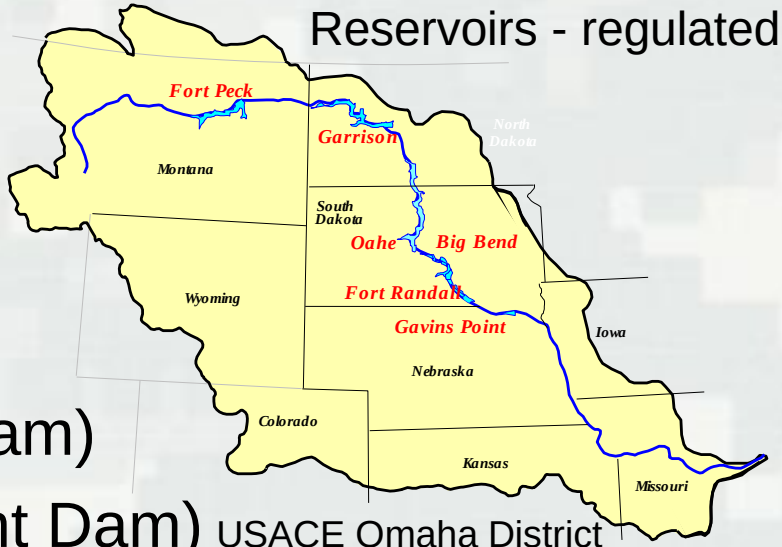
N

180 270 360

Miles

Missouri River Mainstem Reservoir System

- Six major mainstem reservoirs
  - ► Fort Peck (Fort Peck Dam)
  - ► Sakakawea (Garrison Dam)
  - ► Oahe (Oahe Dam)
  - ► Sharpe (Big Bend Dam)
  - ► Francis Case (Fort Randall Dam)
  - ► Lewis and Clark (Gavin's Point Dam)

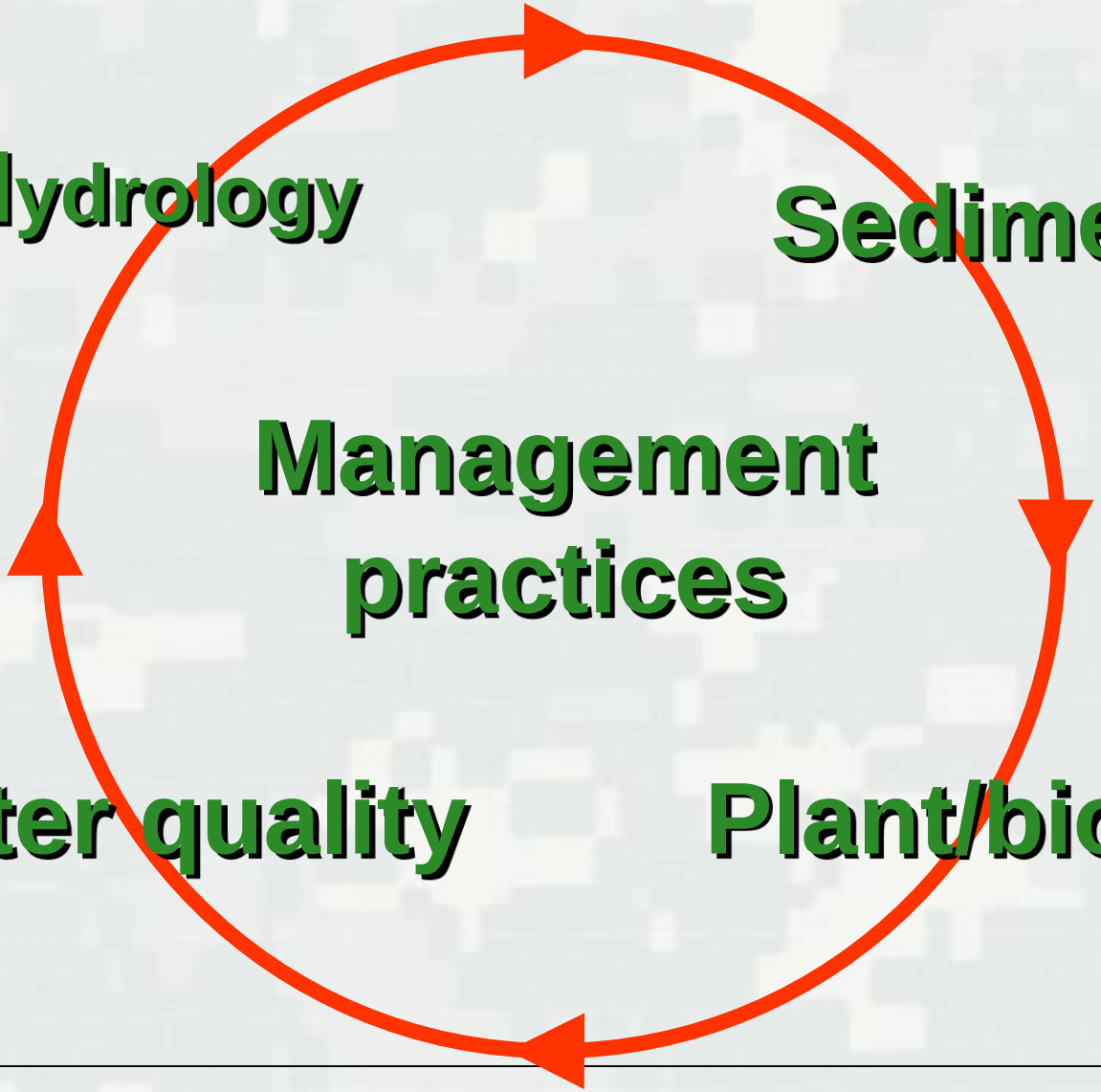


- Authorized purposes: flood control, navigation, irrigation, hydropower, water supply, fish and wildlife, water quality, and recreation.
- Six large dams have altered the river's natural flow.

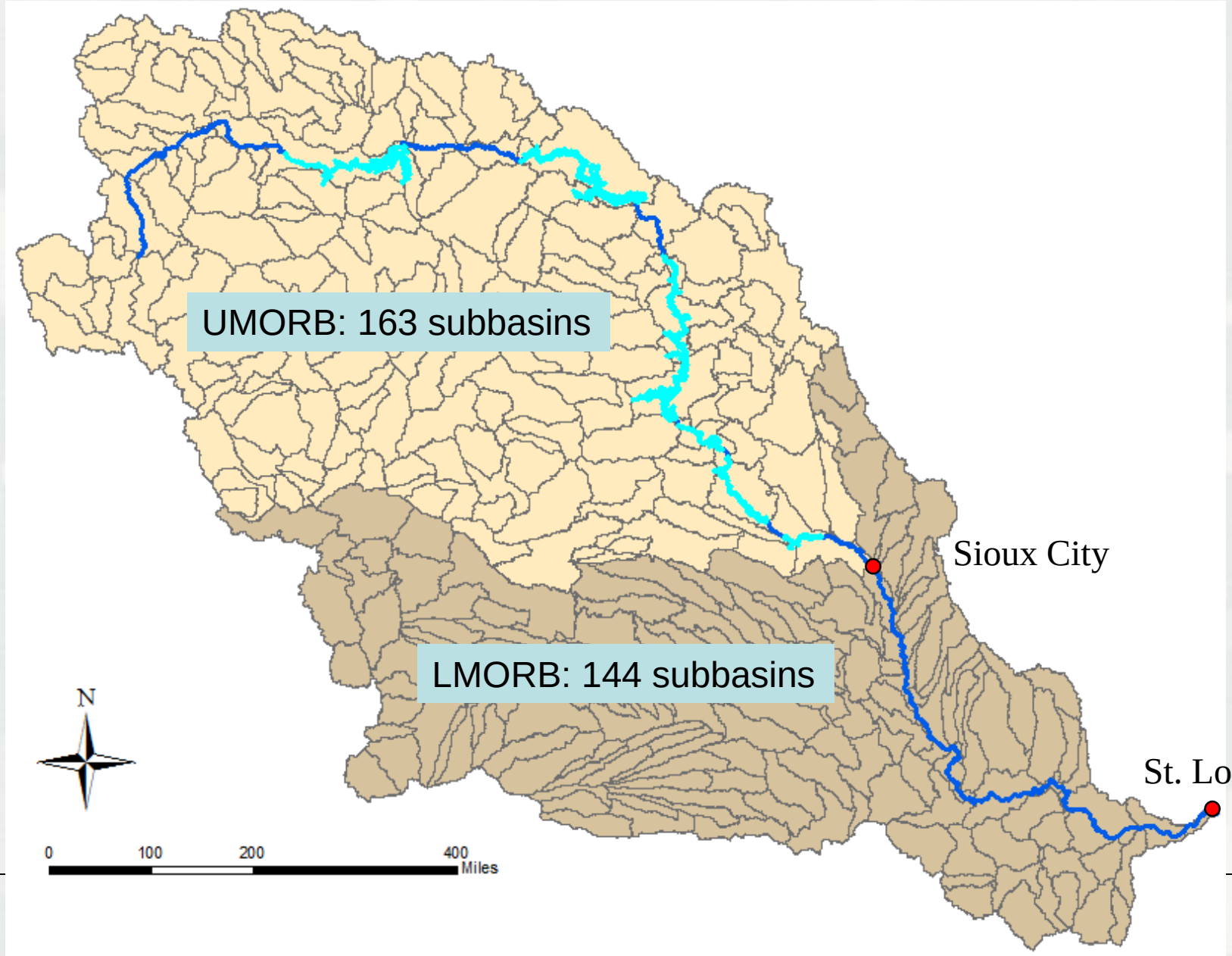
Overall Objectives

- Quantify relationships between increased biofuel production, land conversion, and water quality
- Develop an appropriate watershed model to link landscape changes associated with increased bioenergy production and their impacts on water quality.
  - Conducting an assessment of baselines
  - Estimating changes in water quality (sediment and nutrient loadings) associated with increased biofuel feedstock production to meet projected targets set by the energy goal.

Why SWAT?


Hydrology
Sediment
Management practices
Water quality
Plant/biomass

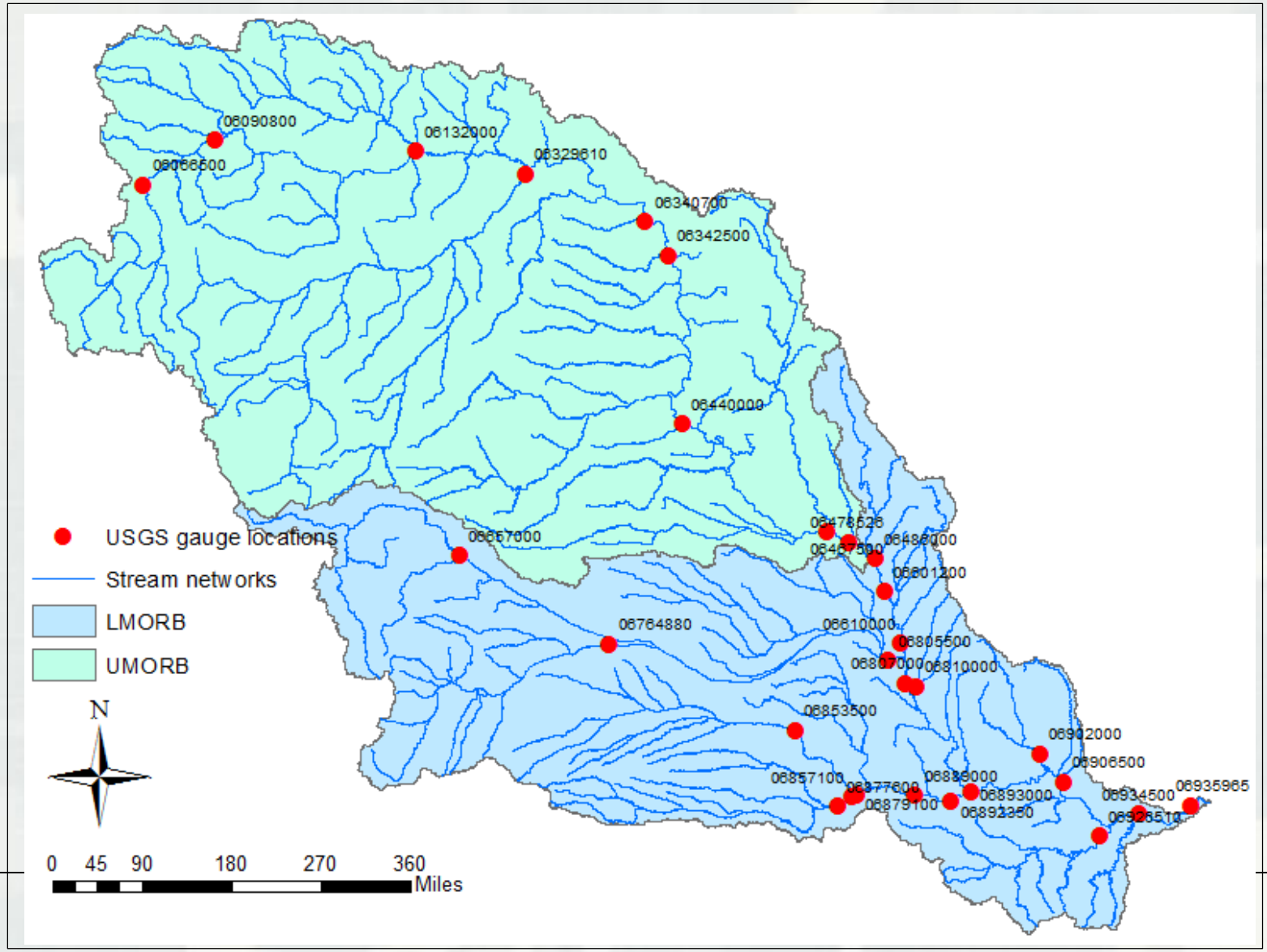
MORB SWAT Models



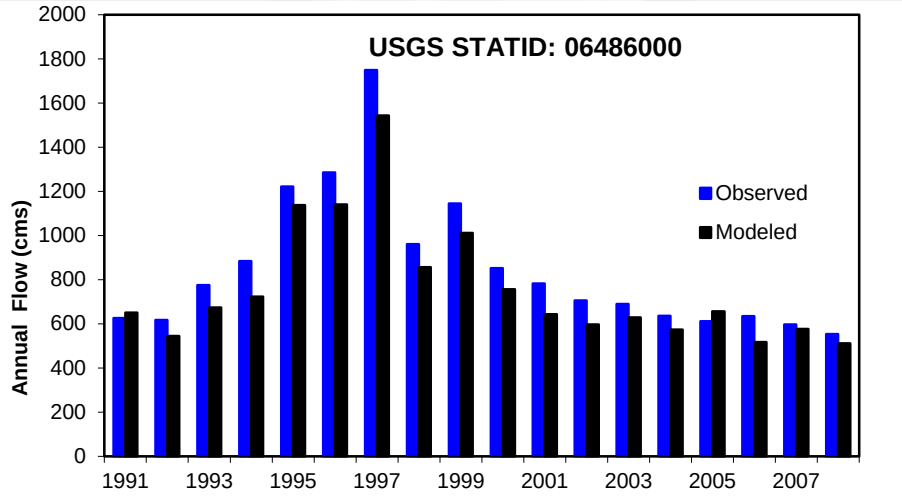
SWAT Model Inputs

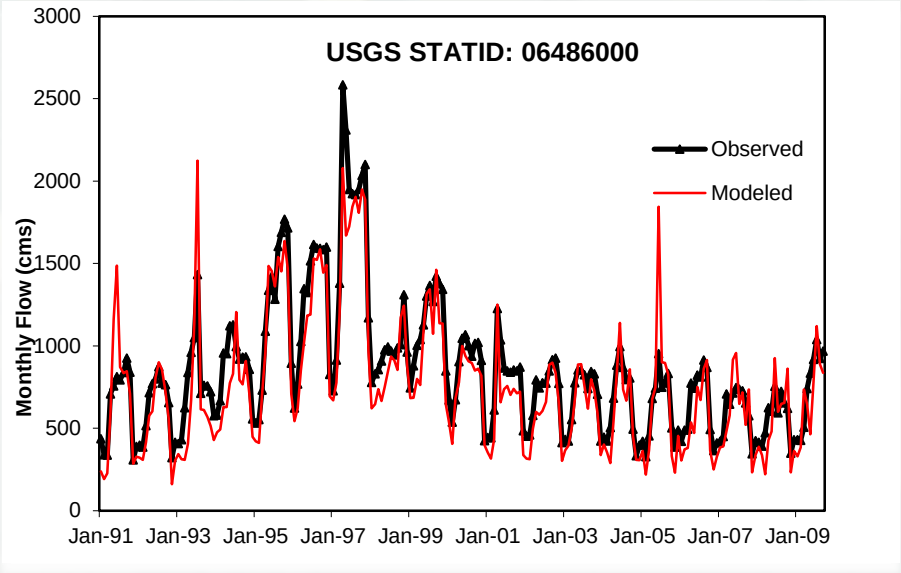
- Spatial data
  - Digital Elevation Model (DEM)
  - 8-digit Hydrologic Unit Code (HUC)
  - Stream network (RF1)
  - Land use and land cover (CDL 2007-2010)
  - Soil (STATSGO)
  - Tillage practices
  - Fertilizer application
  - **Reservoirs**
  - Atmospheric deposition
  - Point Sources
- Time series data
  - Precipitation and temperature (1990-2009)
  - Observed gauge data for the calibration and validation (1990-2009)

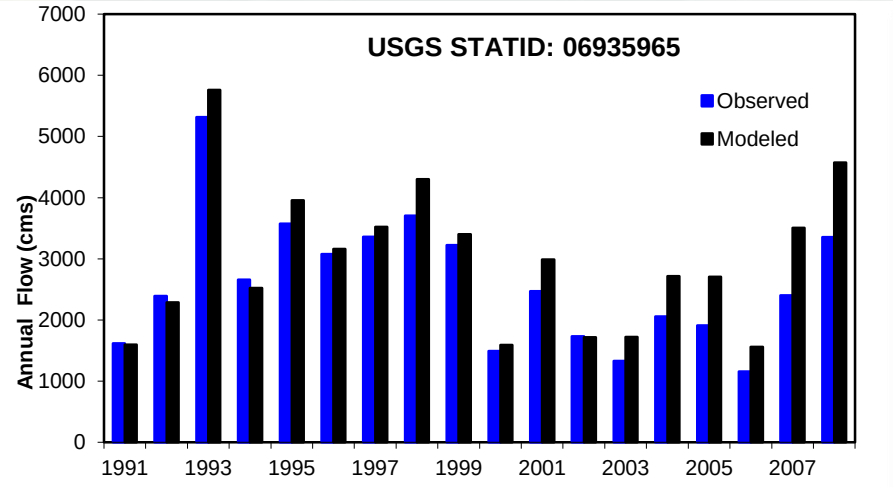
Model Calibration/Validation Sites

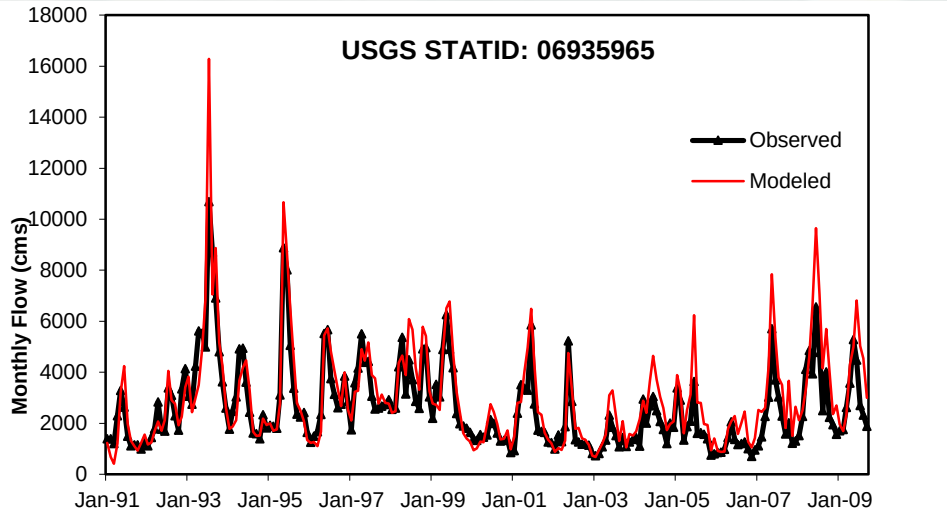


Model Calibration/Validation Results









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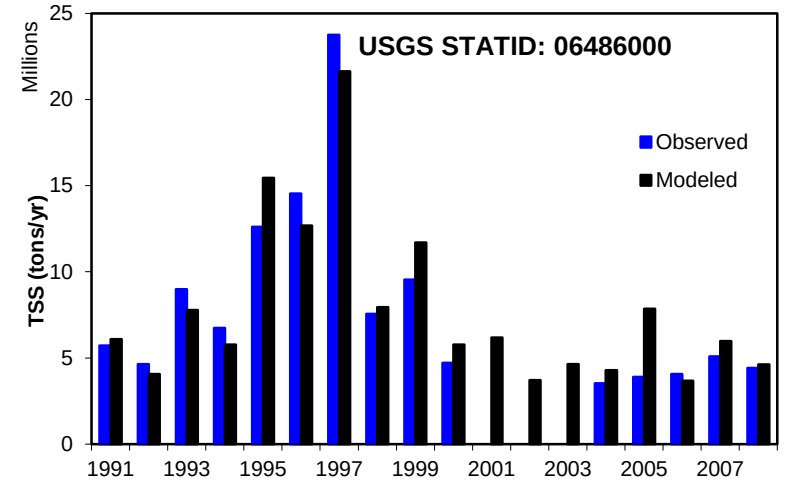

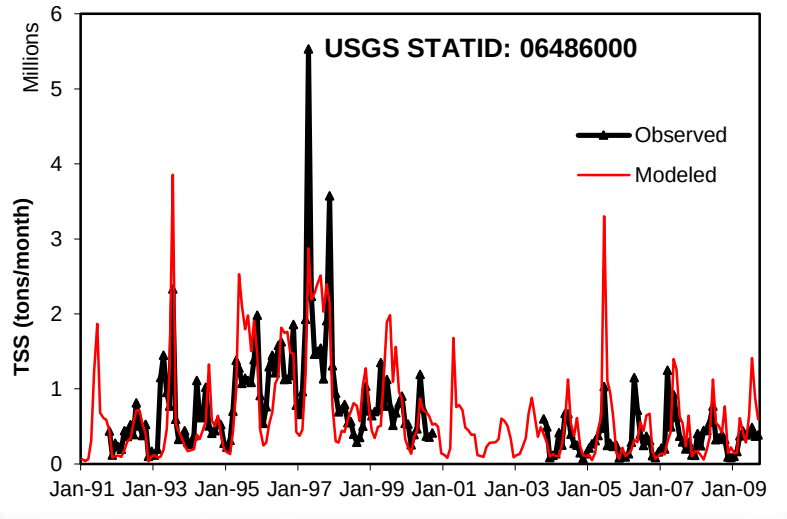

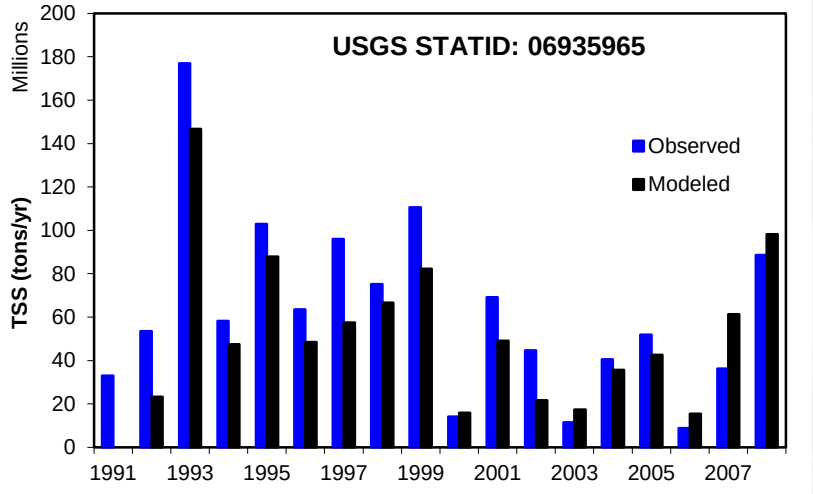

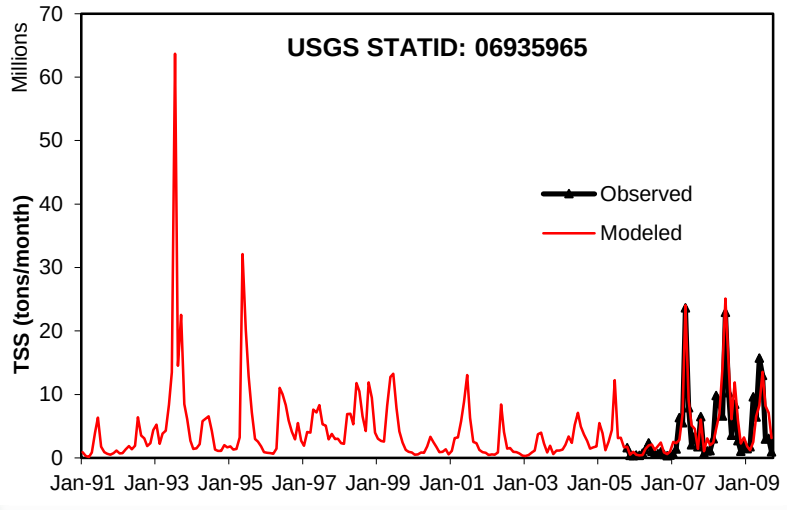

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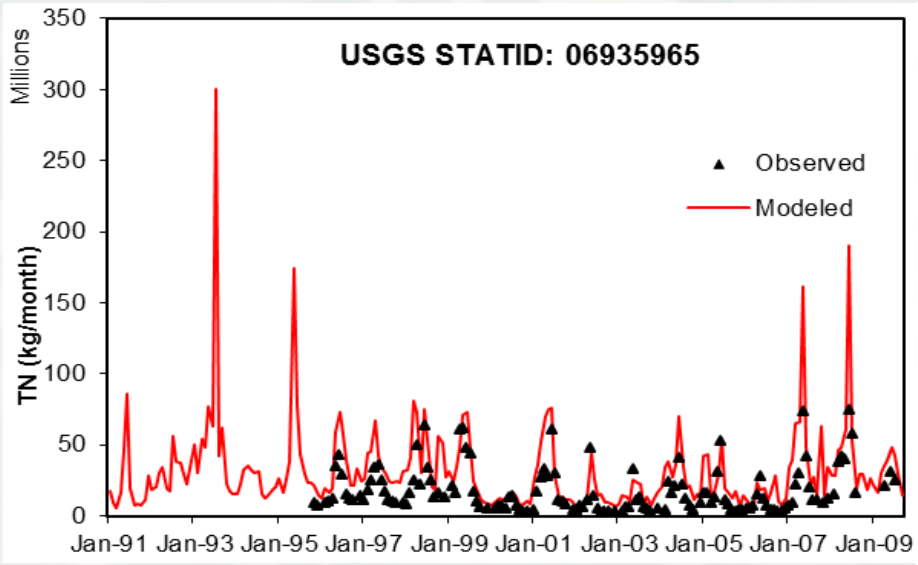

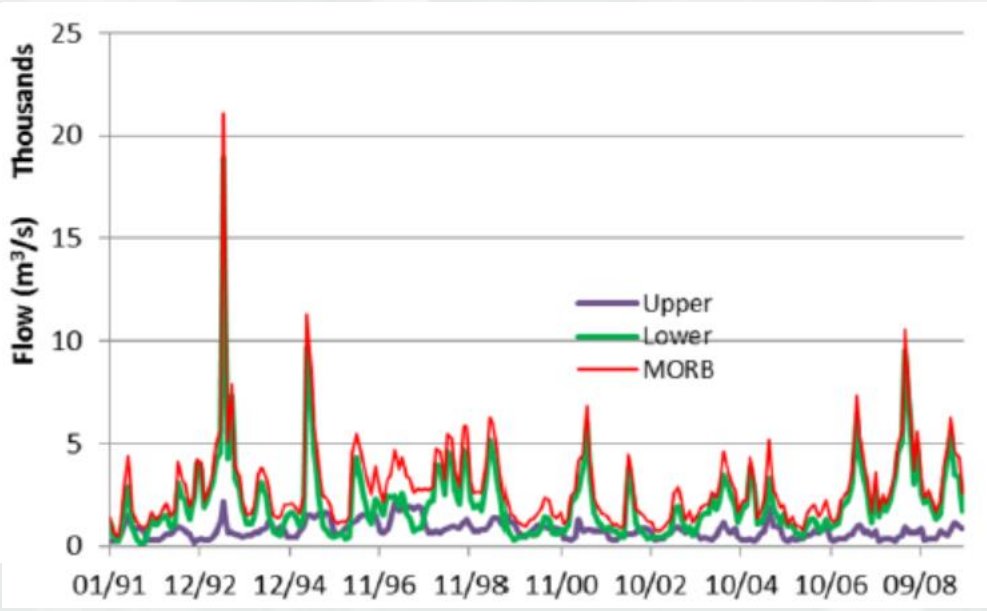

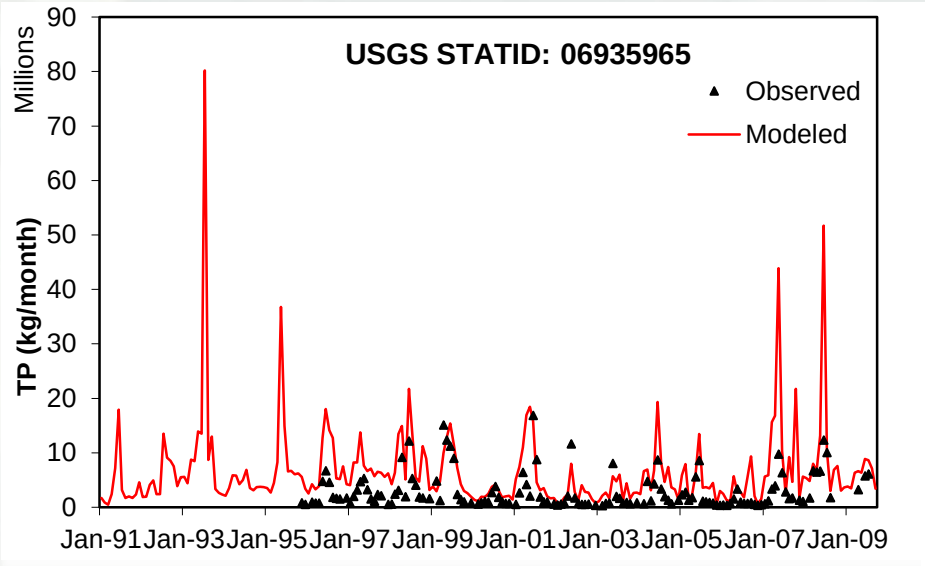

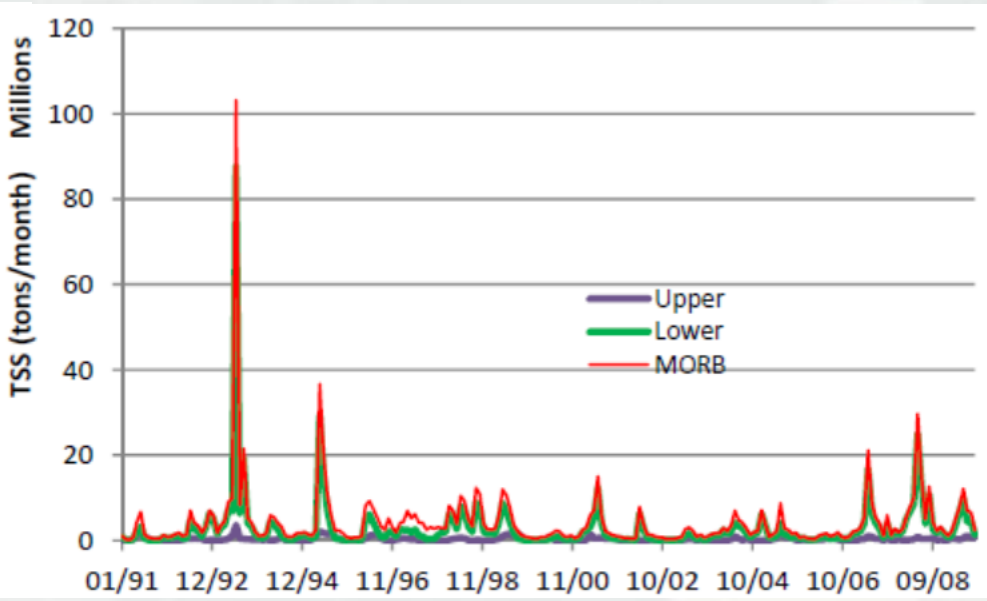

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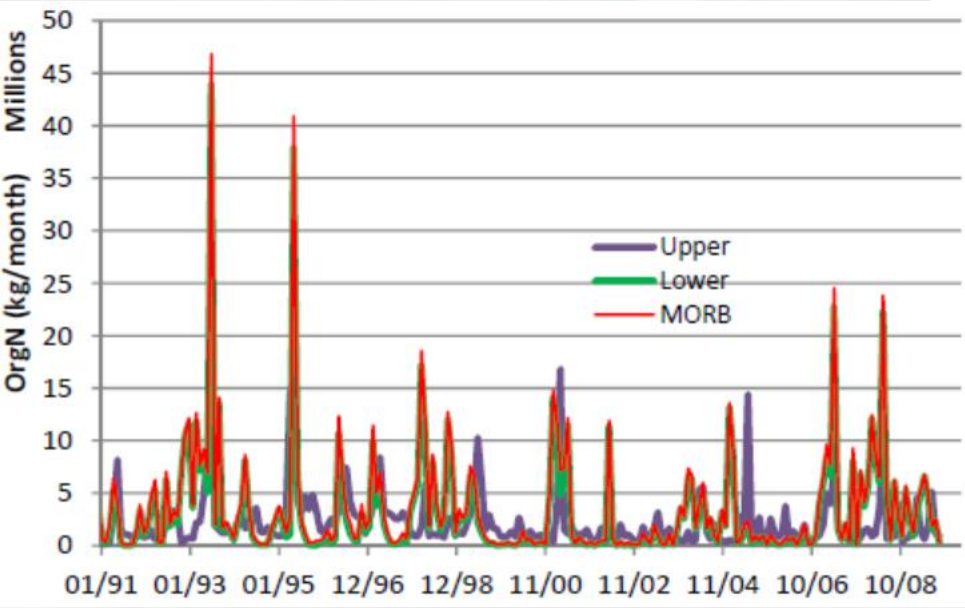
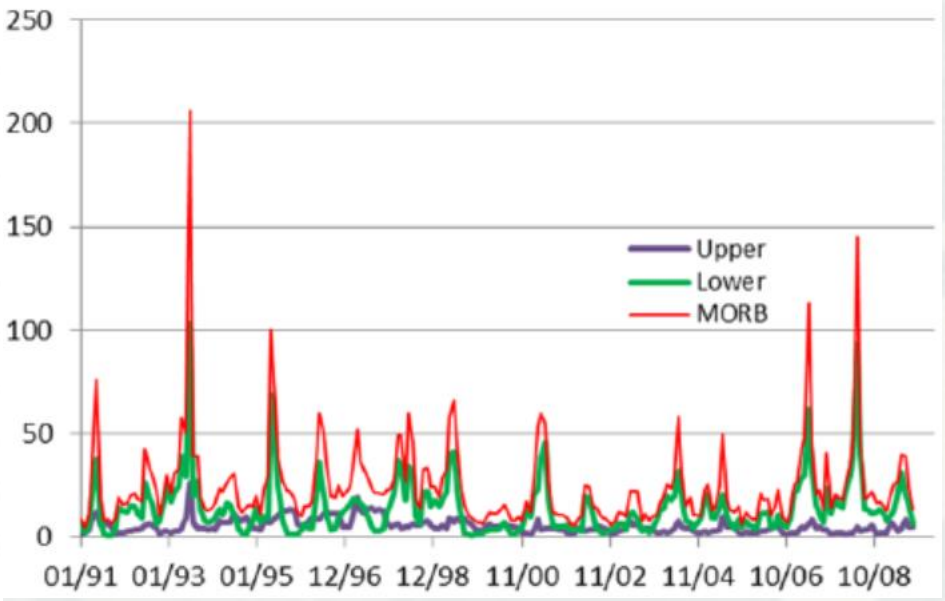
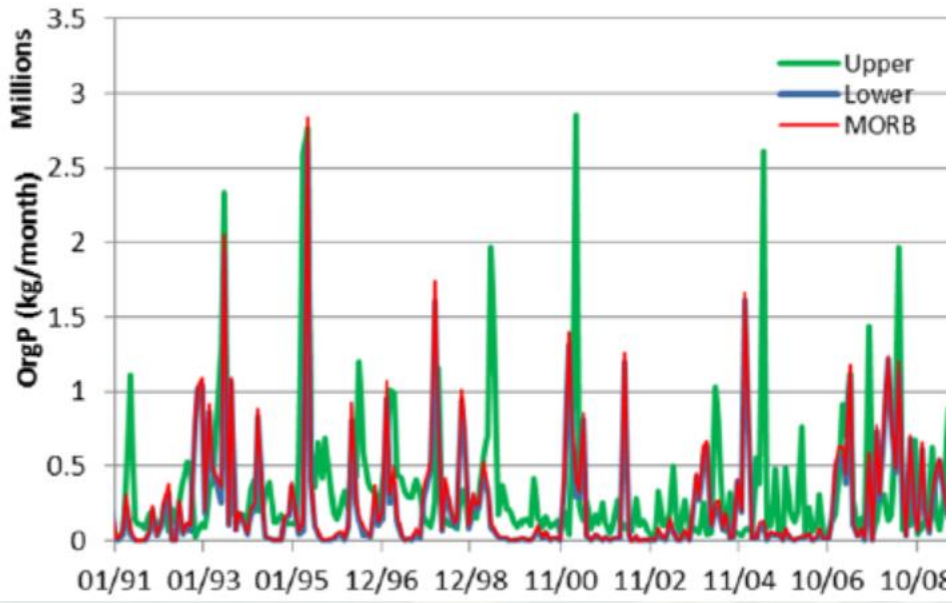
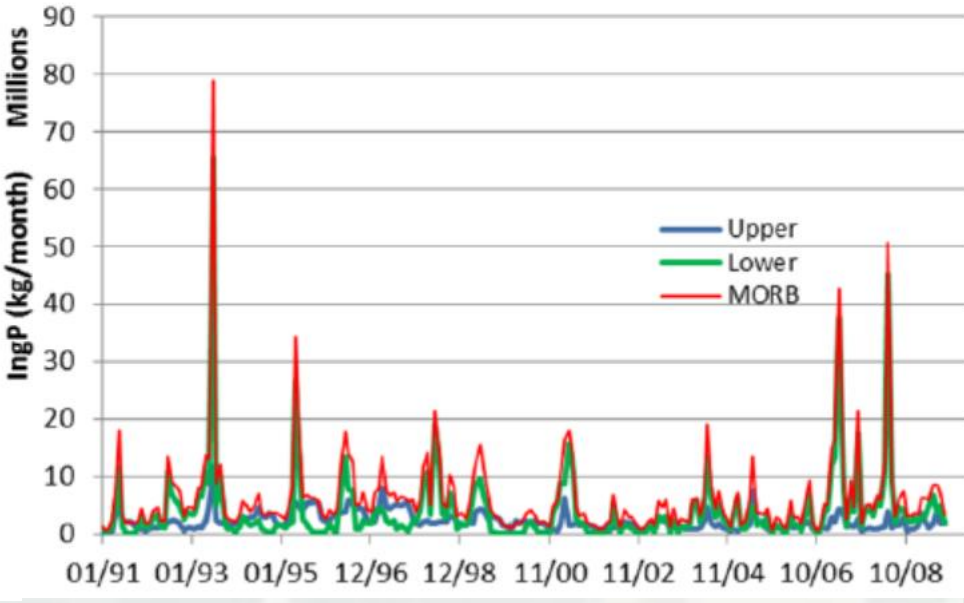


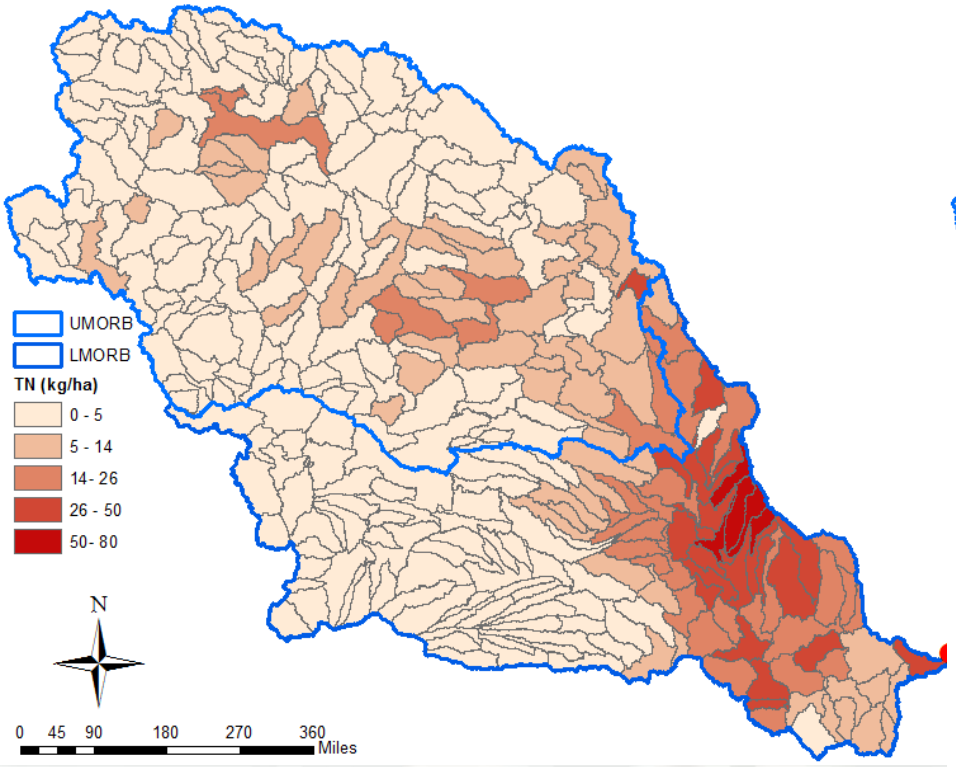


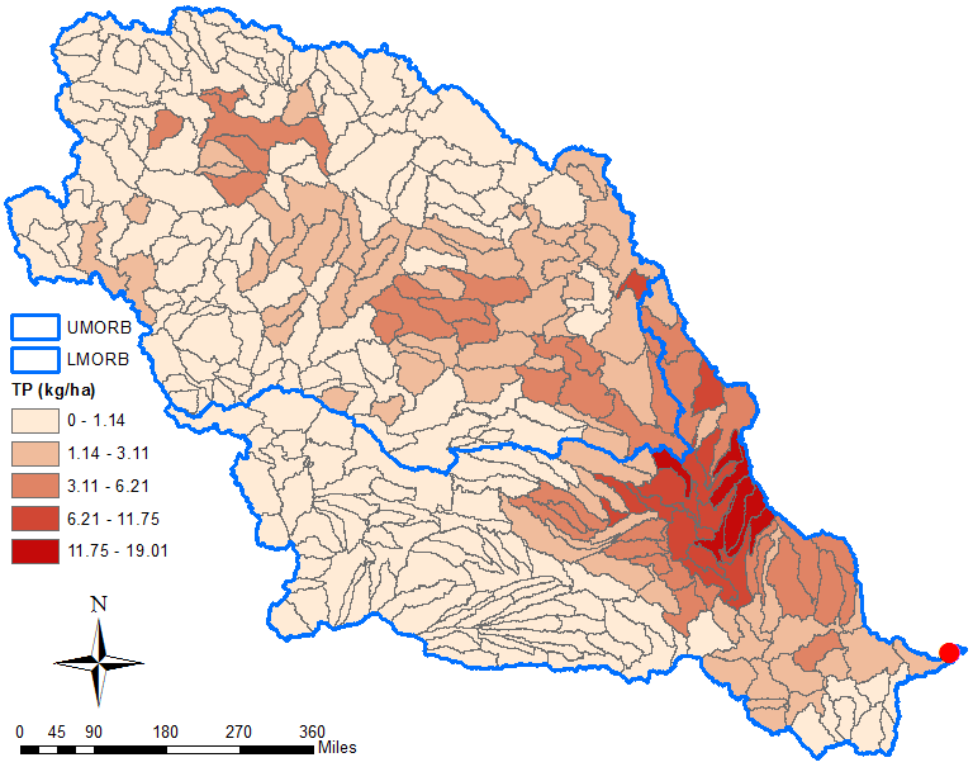




Distributions of Modeled Sediment, Nitrogen, and Phosphorus Loadings

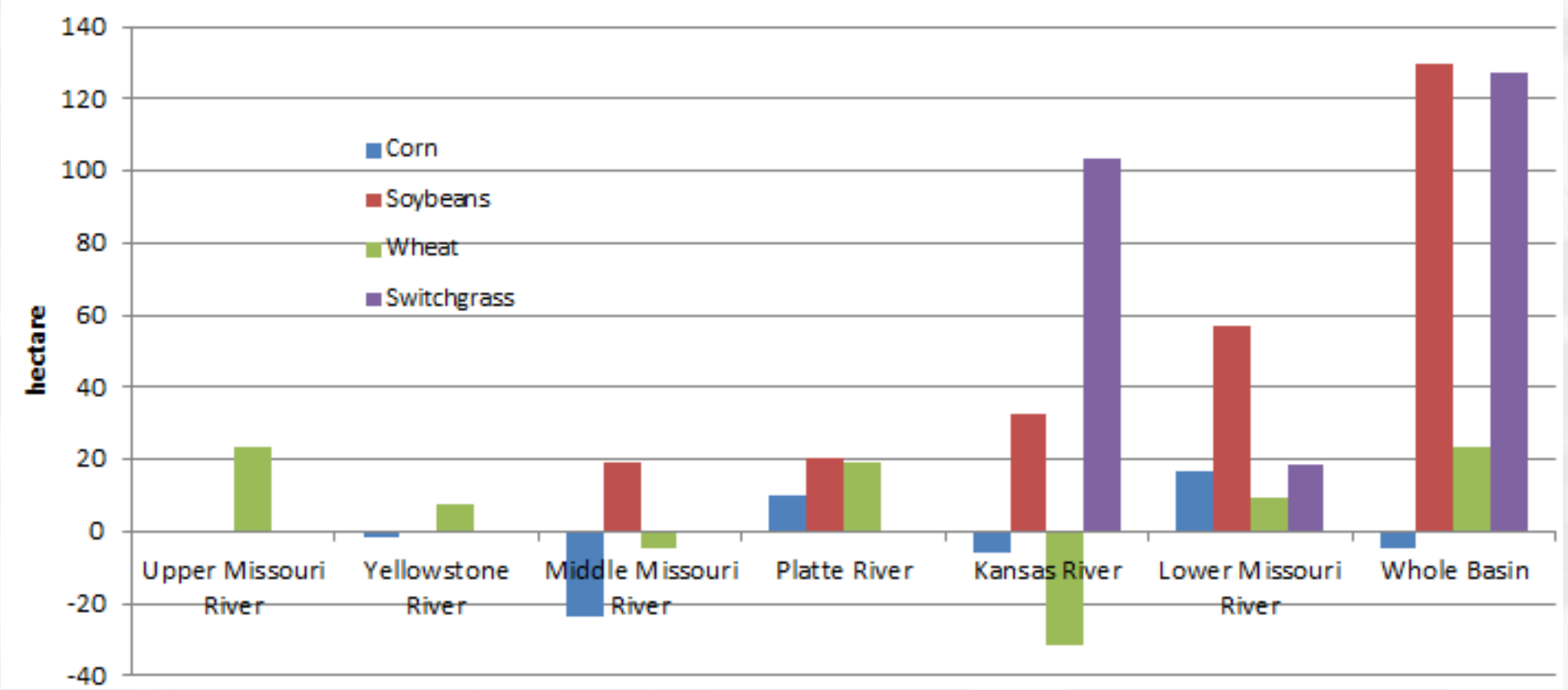
Statistics	TSS (dry metric tons/ha)	OrgN (kg/ha)	NO_3 (kg/ha)	TN (kg/ha)	OrgP (kg/ha)	SolP (kg/ha)	TP (kg/ha)
Mean	3.70	6.44	2.16	8.60	0.83	0.07	1.88
Median	1.05	2.49	0.36	3.18	0.30	0.01	0.68
Standard deviation	6.86	10.26	4.33	12.8	0.13	0.13	2.98
Maximum	53.59	68.28	39.41	78.43	9.51	1.17	19.01





Impacts of Land Use Change on Water Quality

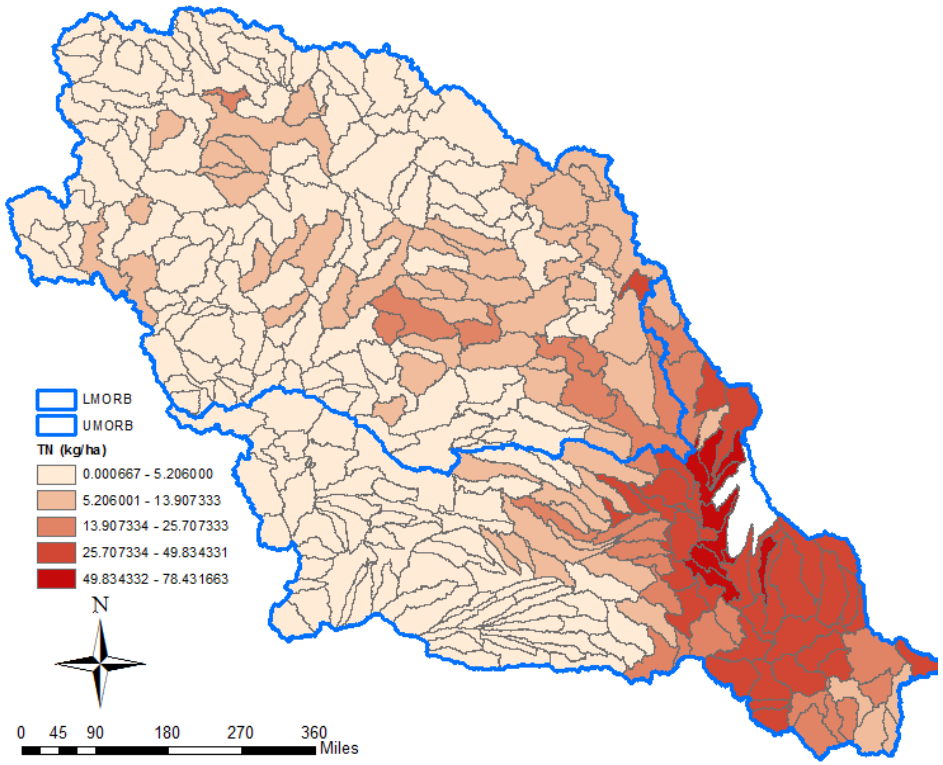
Projected Land Use Changes Involving Four Major Crops

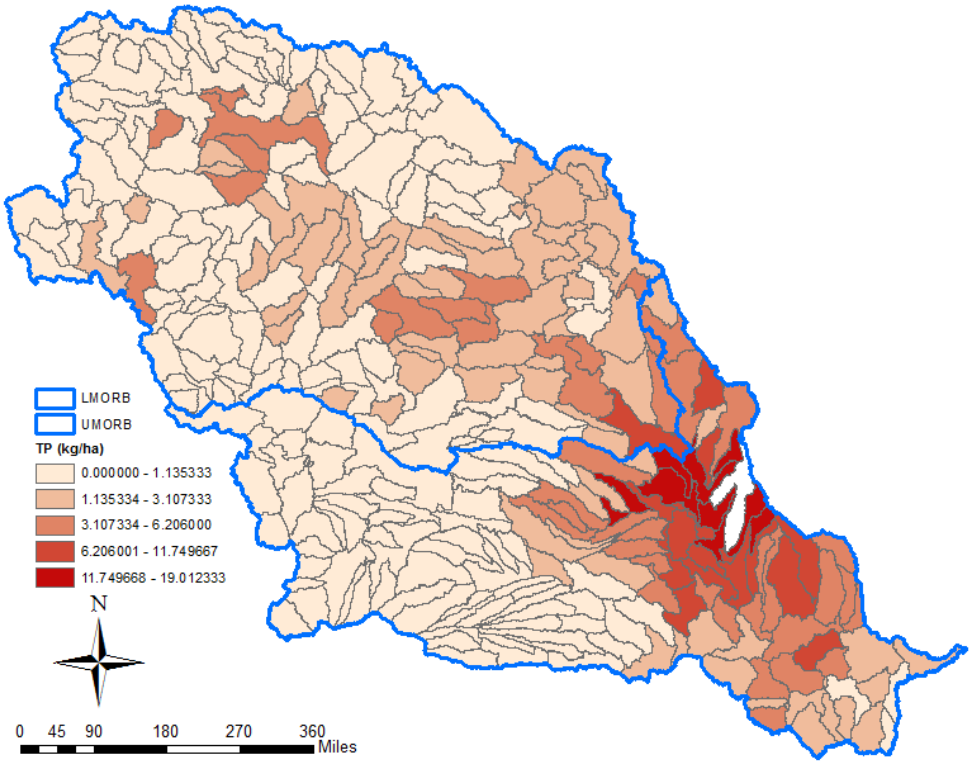


Impacts of Land Use Change on Water Quality

Projected Land Use Changes Involving Four Major Crops

Statistics	TSS (ton/ha)	OrgN (ton/ha)	NO3 (ton/ha)	TN (ton/ha)	OrgP (ton/ha)	SolP (ton/ha)	TP (ton/ha)
Mean	5.19	8.22	2.87	11.09	1.00	0.07	2.21
Median	1.38	2.88	0.38	3.78	0.36	0.007	0.85
Standard deviation	9.08	13.41	5.34	17.26	1.62	0.15	3.44
Maximum	63.82	91.46	29.07	104.19	11.07	1.54	20.22





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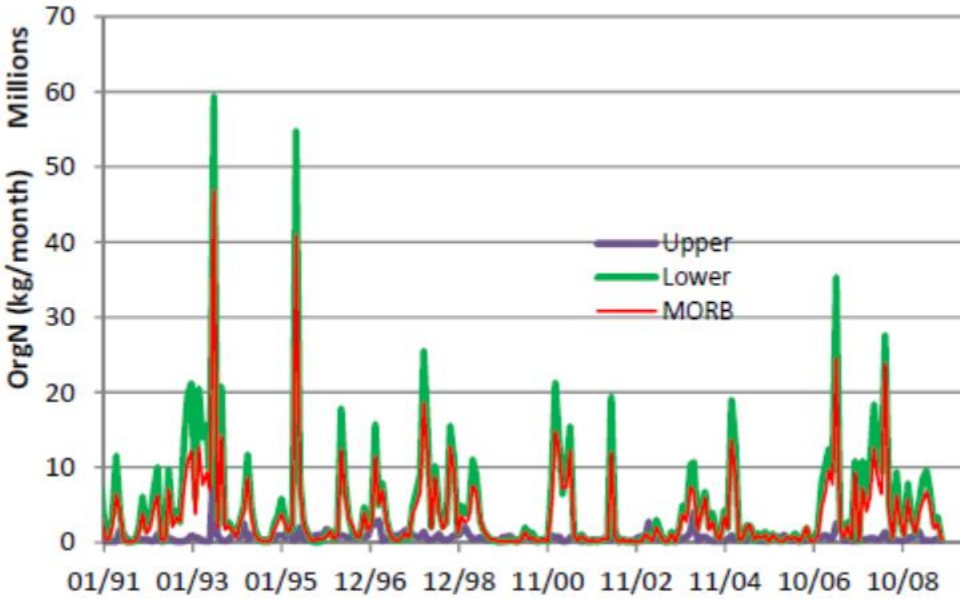
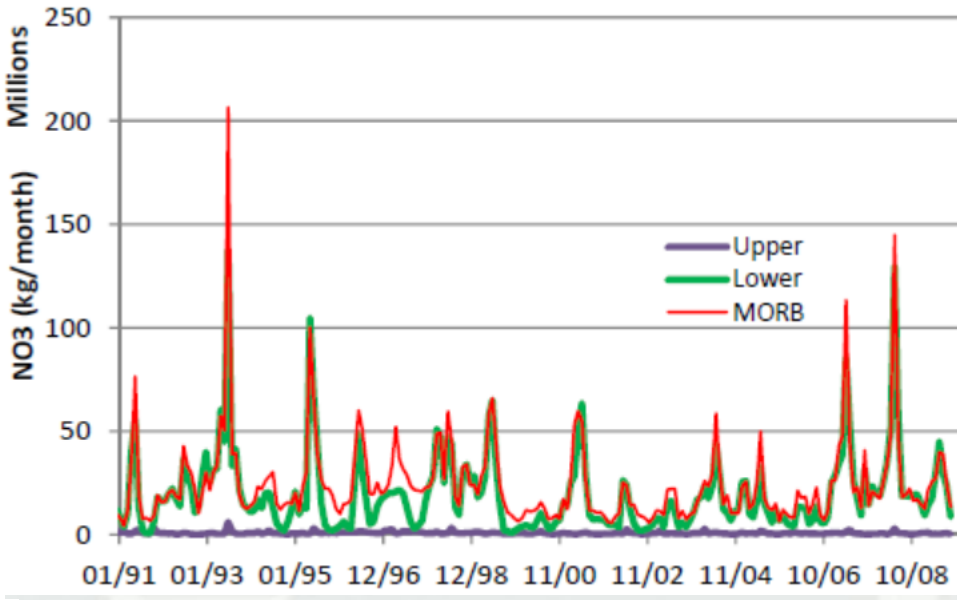
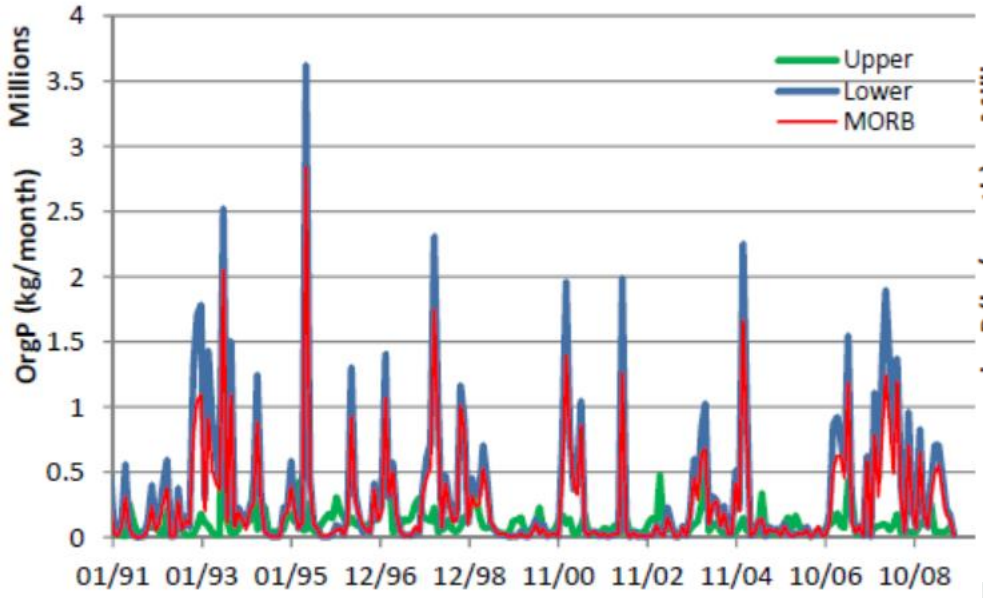
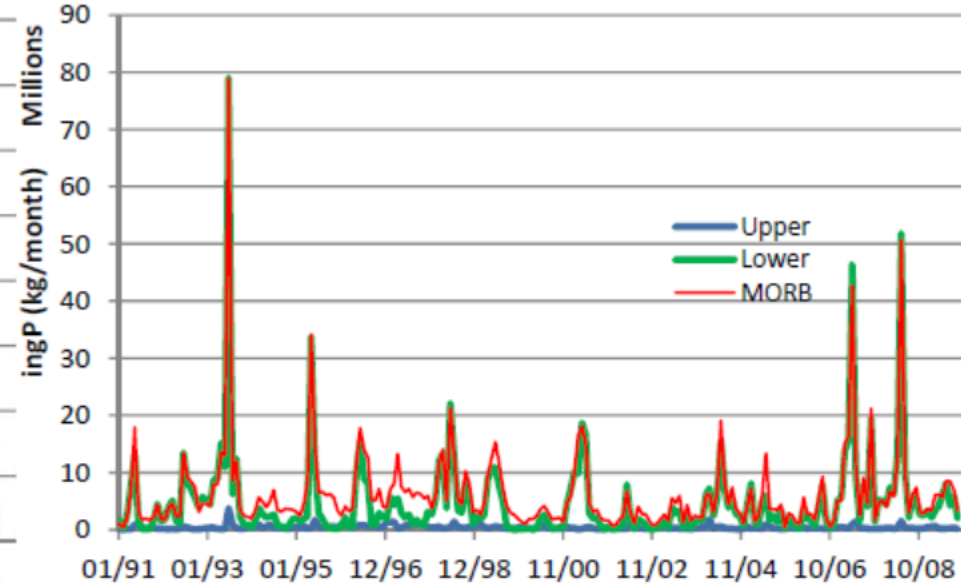
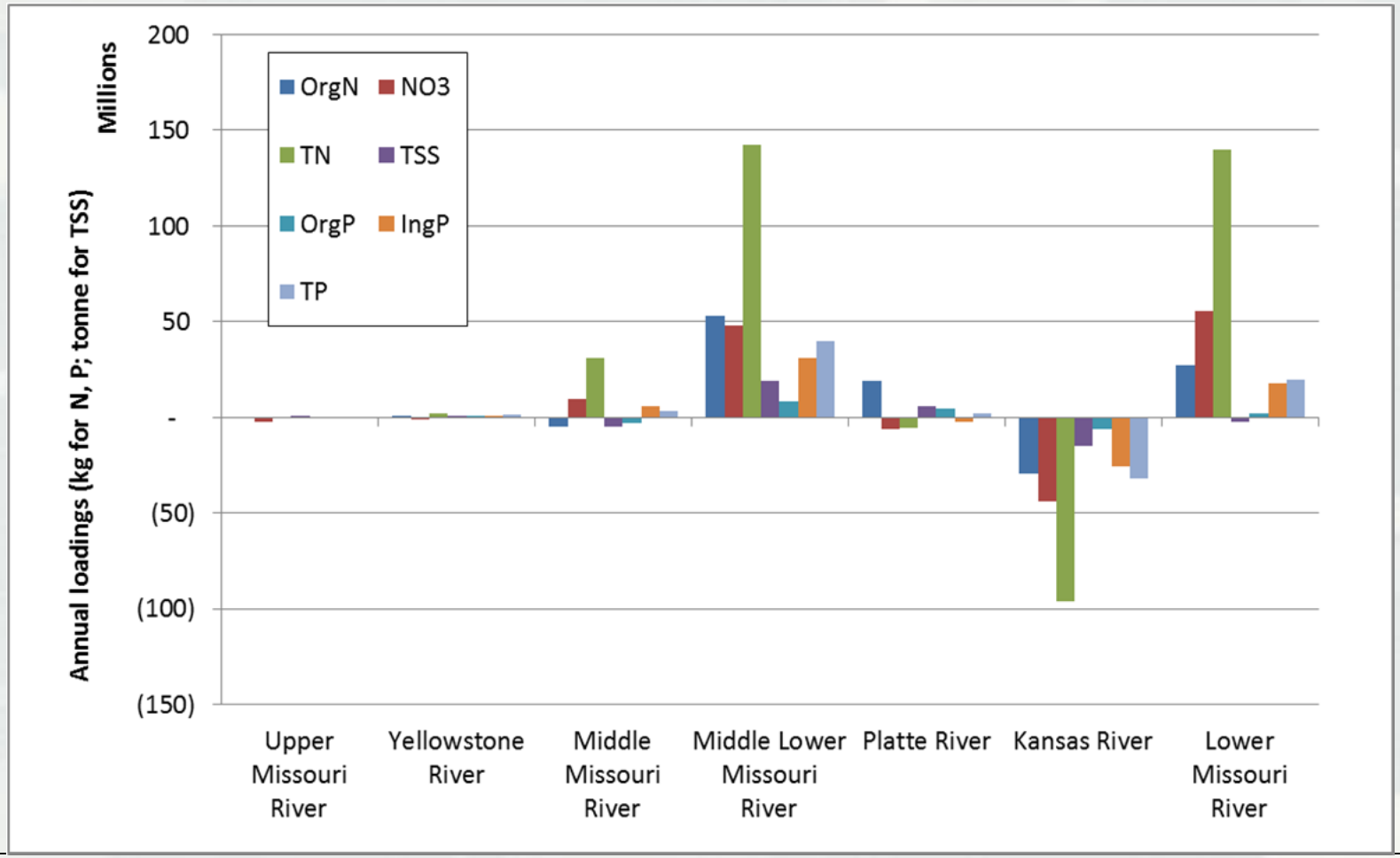








Comparison of Sediment, Nitrogen, and Phosphorus Loadings and Potential Water Quality Impacts



Summary

- Two SWAT models were developed and used to quantify the magnitudes of sediment, nitrogen, and phosphorus loading responses to historical land uses and projected land use changes within the MORB.
- Projected land use conversions in the MORB could have modest impacts on sediment and nutrient exports from the basin, will add additional nutrients into the Mississippi River if not accompanied by conservation measures.
- The study identified subbasins with the highest nutrient and sediment loss. These hot spots need to be further investigated and mitigated by adopting land use change practice and other BMPs.