

Nitrogen Export from the Mississippi River Basin: The Effects of Flood Timing and Spatial Distribution

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Management in Context

- Rider on Horse?
- Or... Flea on Elephant?

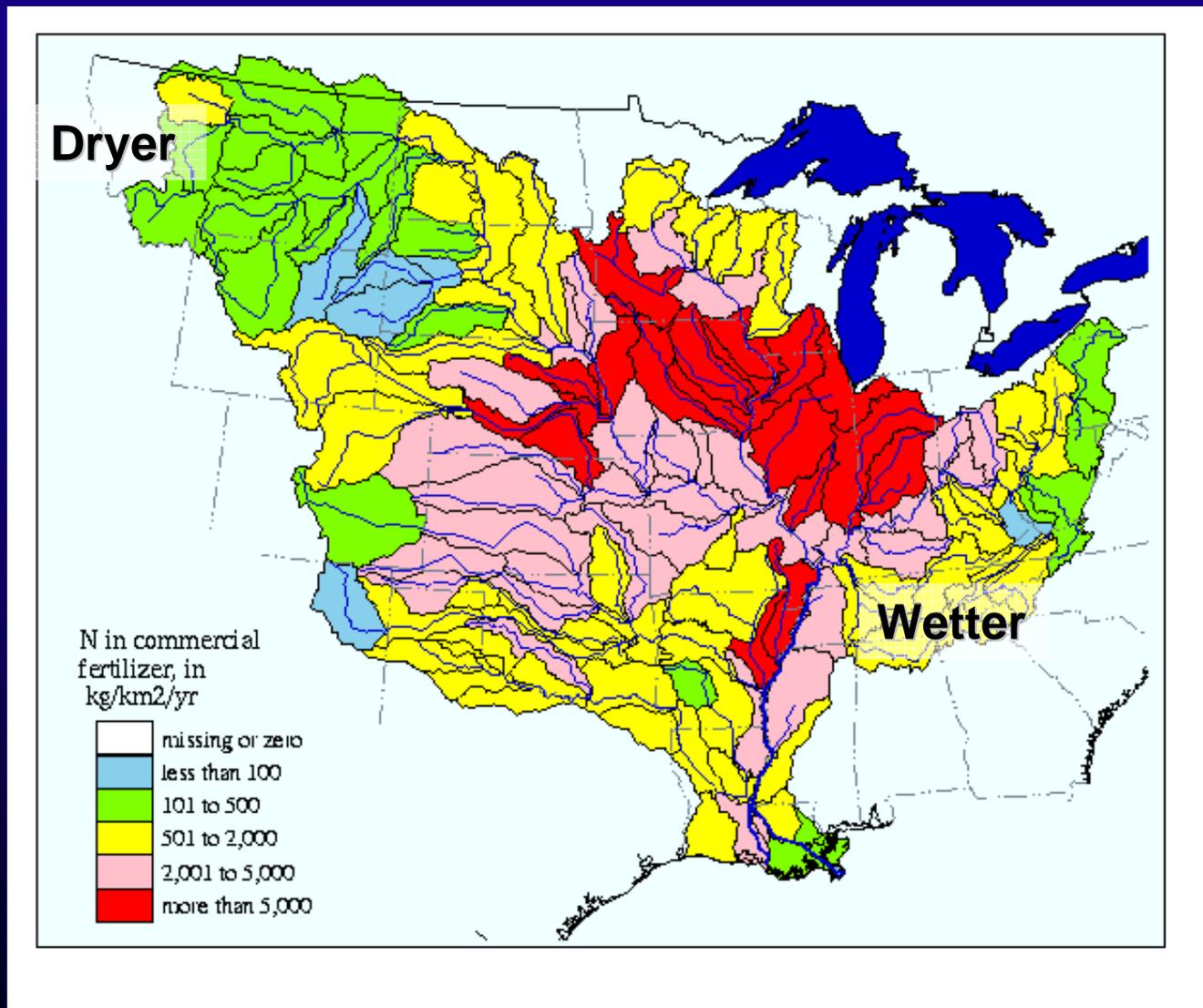


A "Multiple Use" System

- Navigation
- Ecological functioning
- Water supply
- Waste disposal
- Power generation
- Recreation
- Culture
 - History, Archeology, Religion, Art



Significant, Large-Scale Spatial Patterns

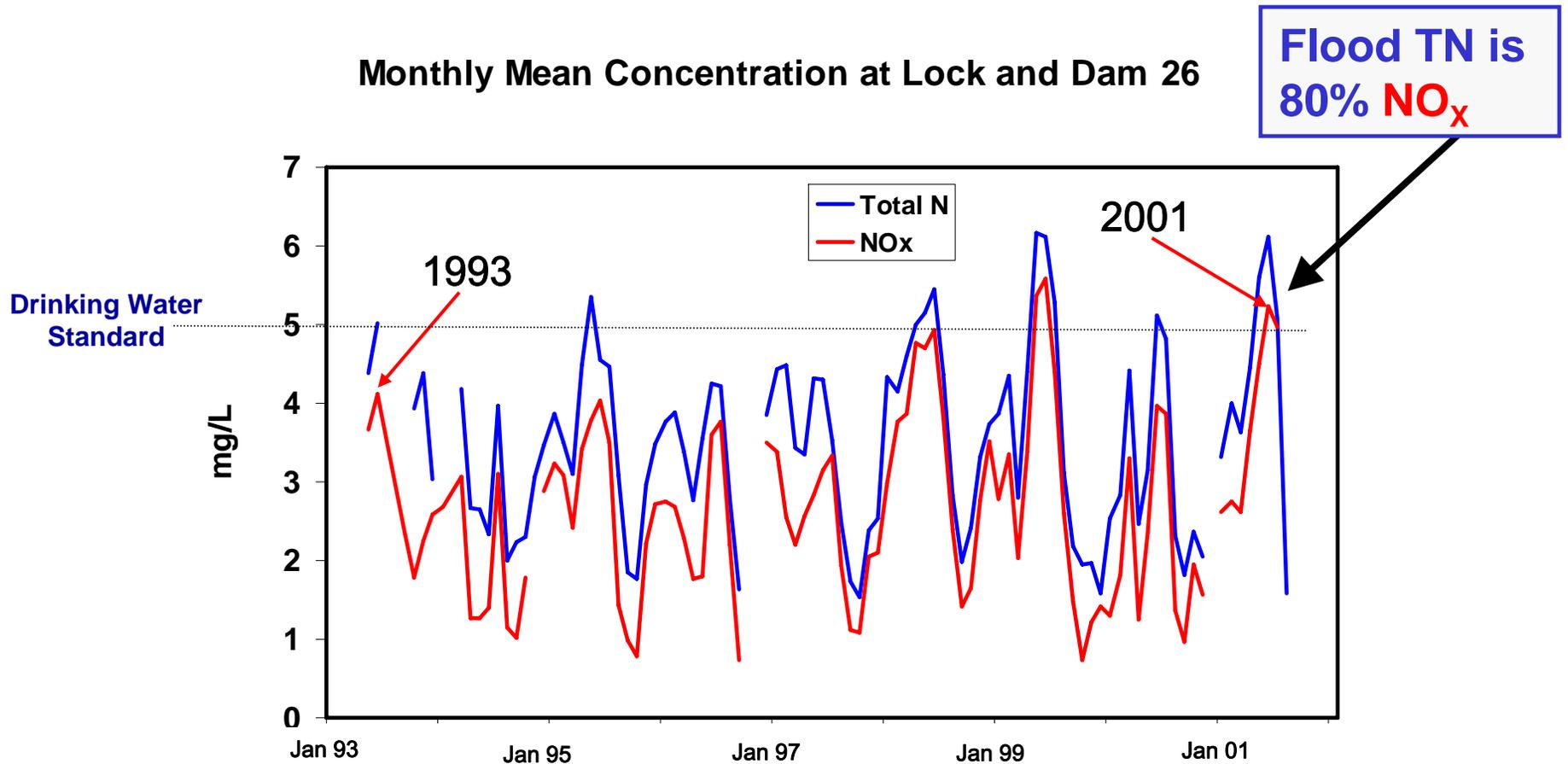


Why Floods? Why Nitrate?

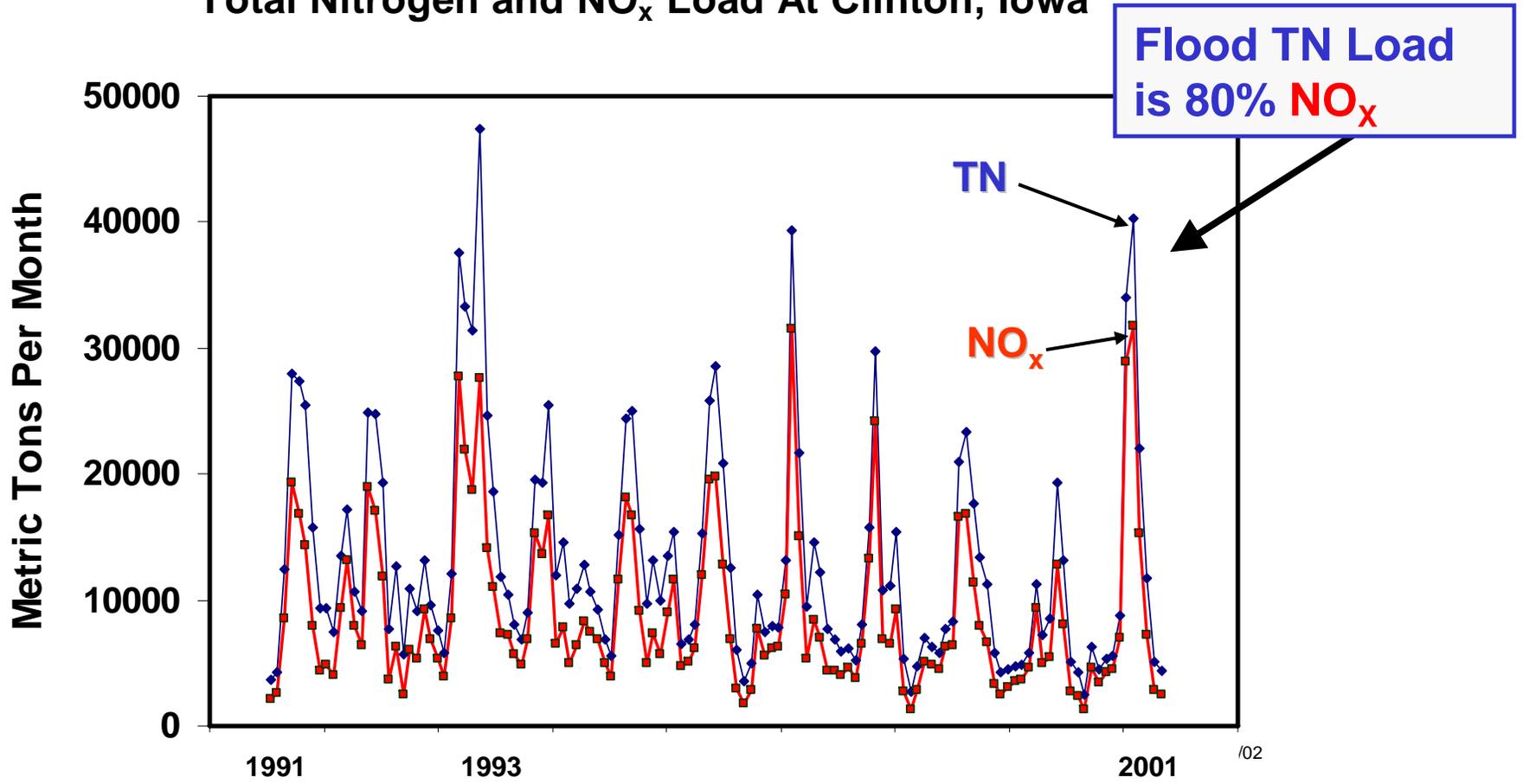


Nitrogen Concentration (mostly nitrate) Increases With Discharge

Monthly Mean Concentration at Lock and Dam 26



Total Nitrogen and NO_x Load At Clinton, Iowa



Nitrogen forms can have direct toxic effects

- Ammonia (NH_x)
- Nitrate (NO_3)
- Nitric Oxide (NO)
 - smog
 - acid rain

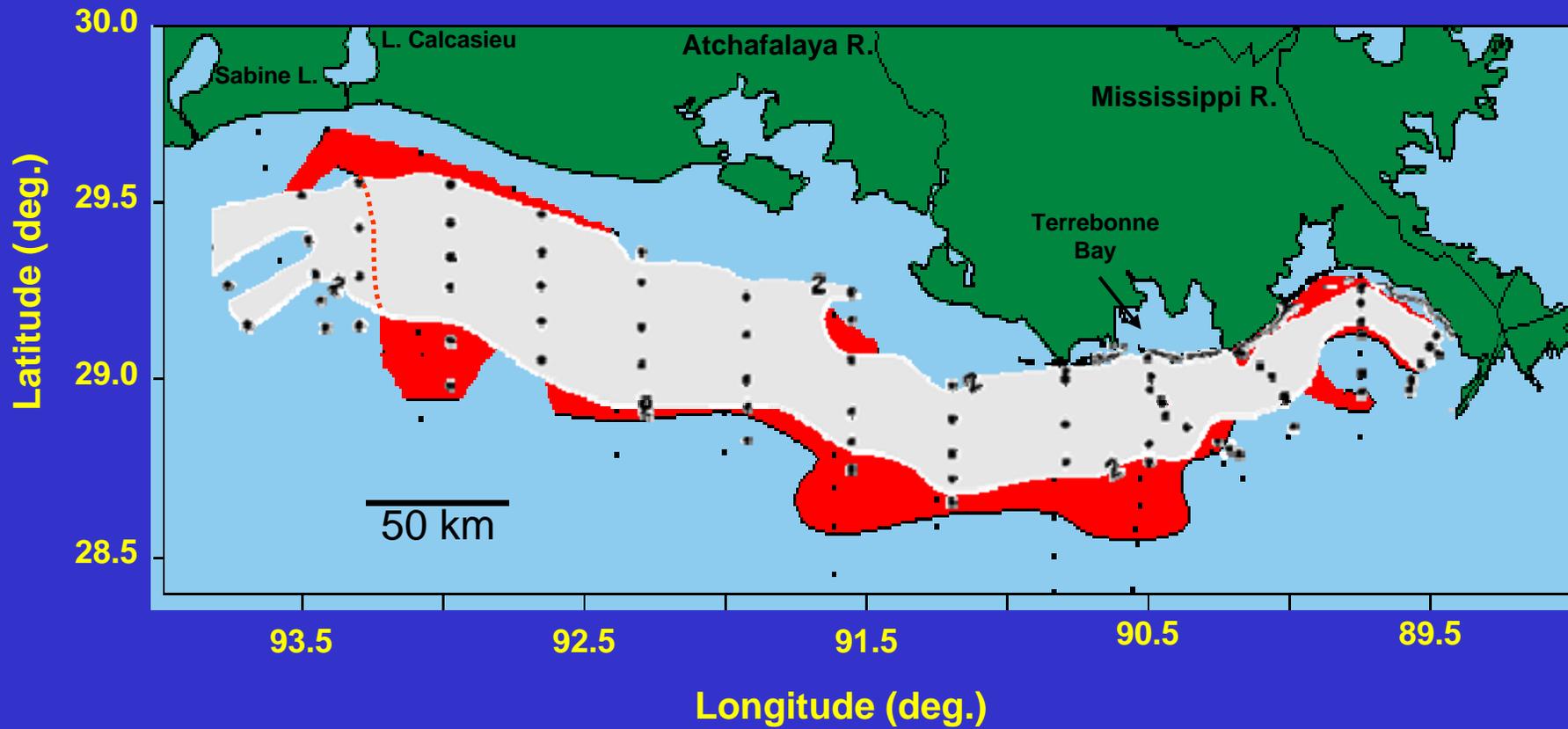


**Nitrogen USUALLY limits
algal production in the
coastal oceans**

**Nitrogen enrichment can
over-stimulate algal growth
in the near-shore area**



Bottom Dissolved Oxygen Less than 2.0 mg/L



July 1999

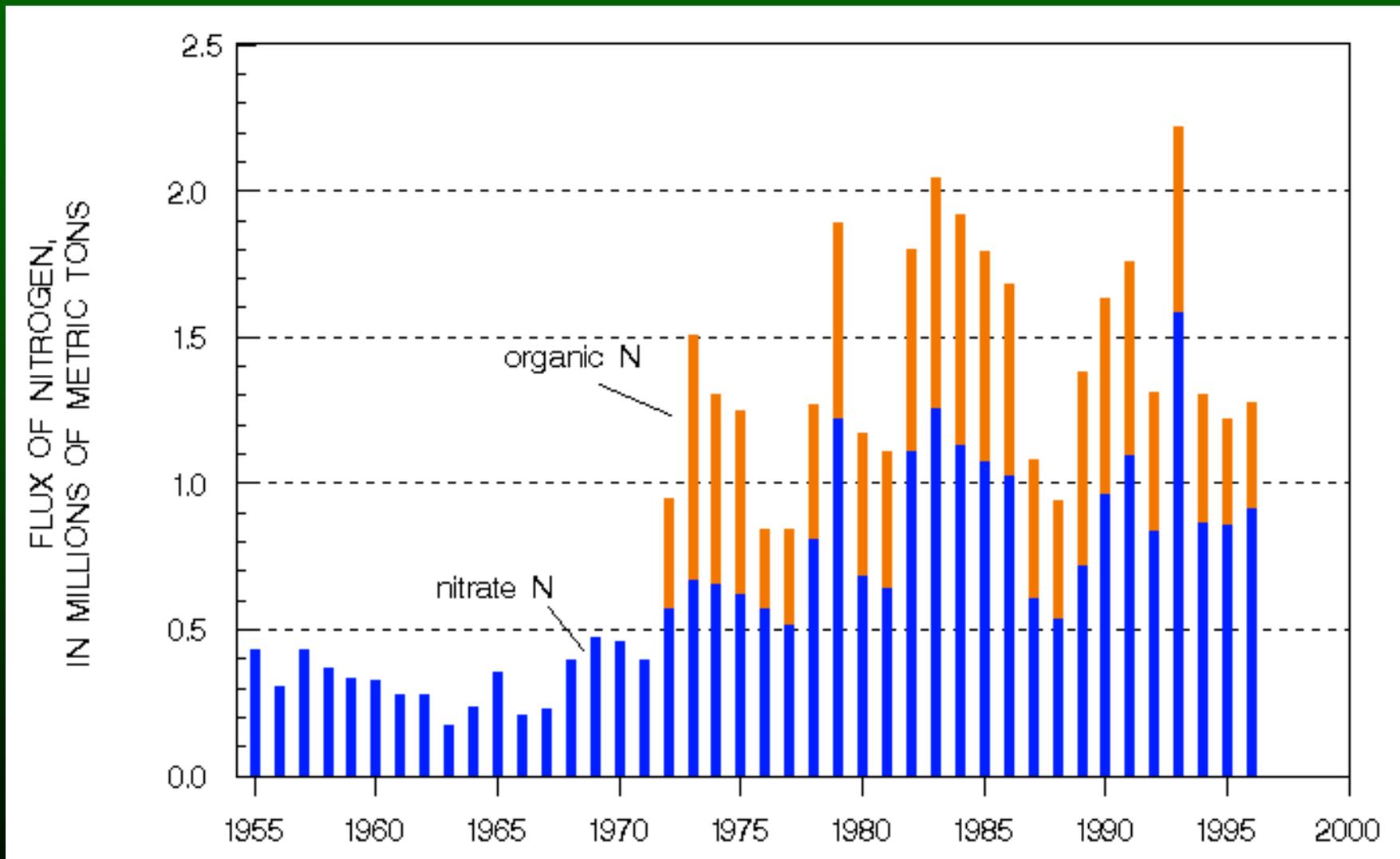
July 2001

(Rabalais, Turner & Wiseman)

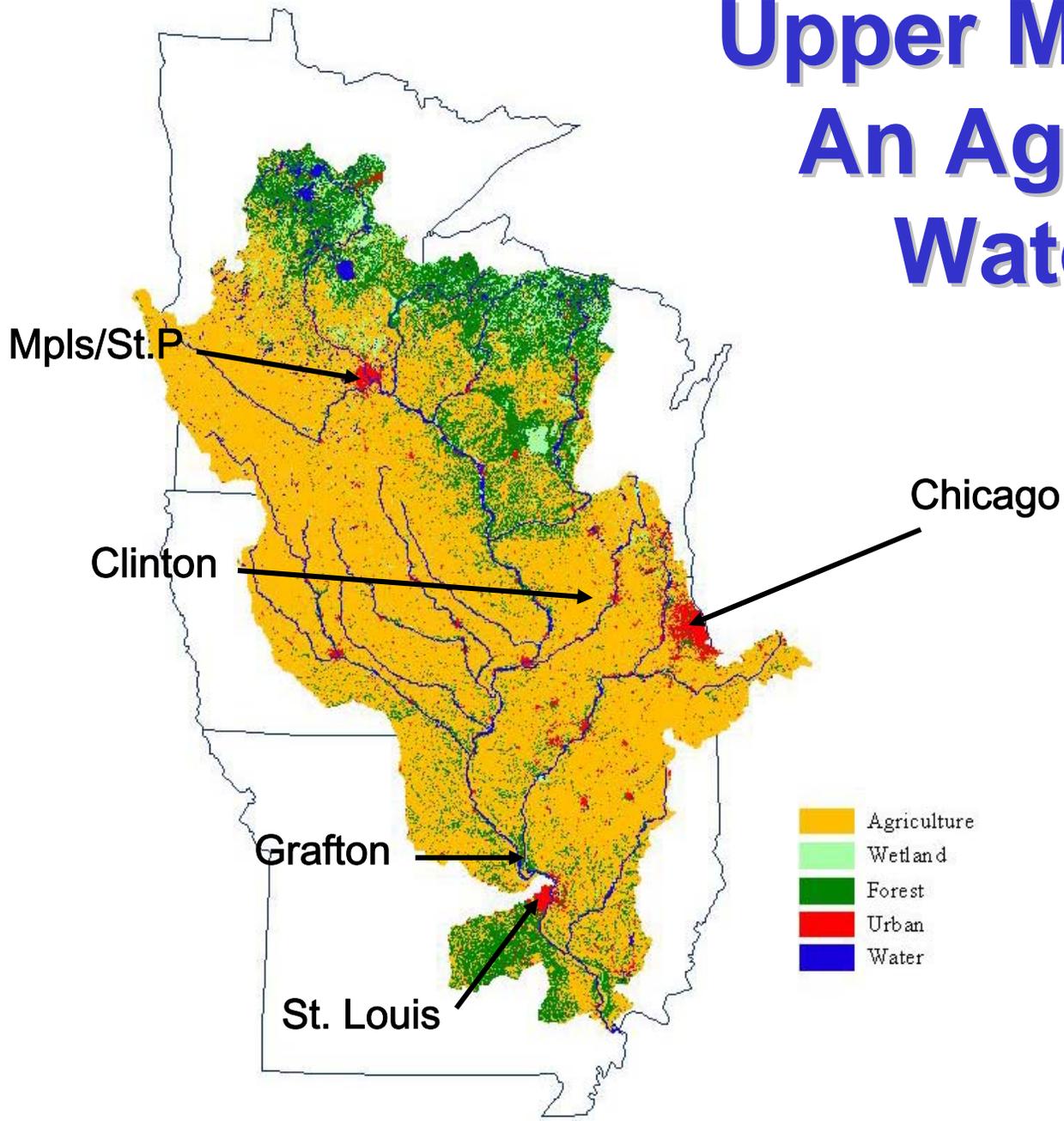
Hypoxia (Low Oxygen)



Long Term Trend in Nitrogen Delivery



Upper Miss. Basin: An Agricultural Watershed



Flooding Not Uniform Or Simultaneous



Flood Location and Timing

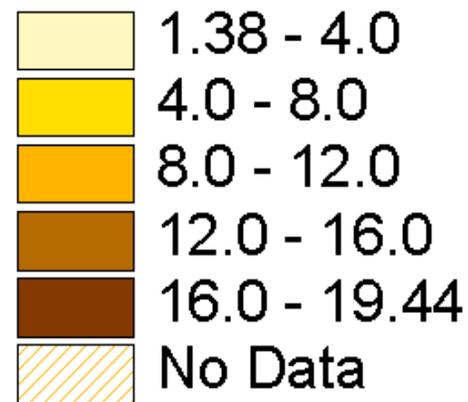
- Flood in high-yield subbasins increases the mass and concentration of NO_x exported
- Sequencing of high- and low-yield flooding influences downstream concentration and ecological response
- Dry conditions (months-years) prior to flood increases NO_x concentration in the flood



The Basin is Heterogeneous

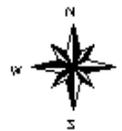
Total Nitrogen Yield

Kilograms / Hectare / Year



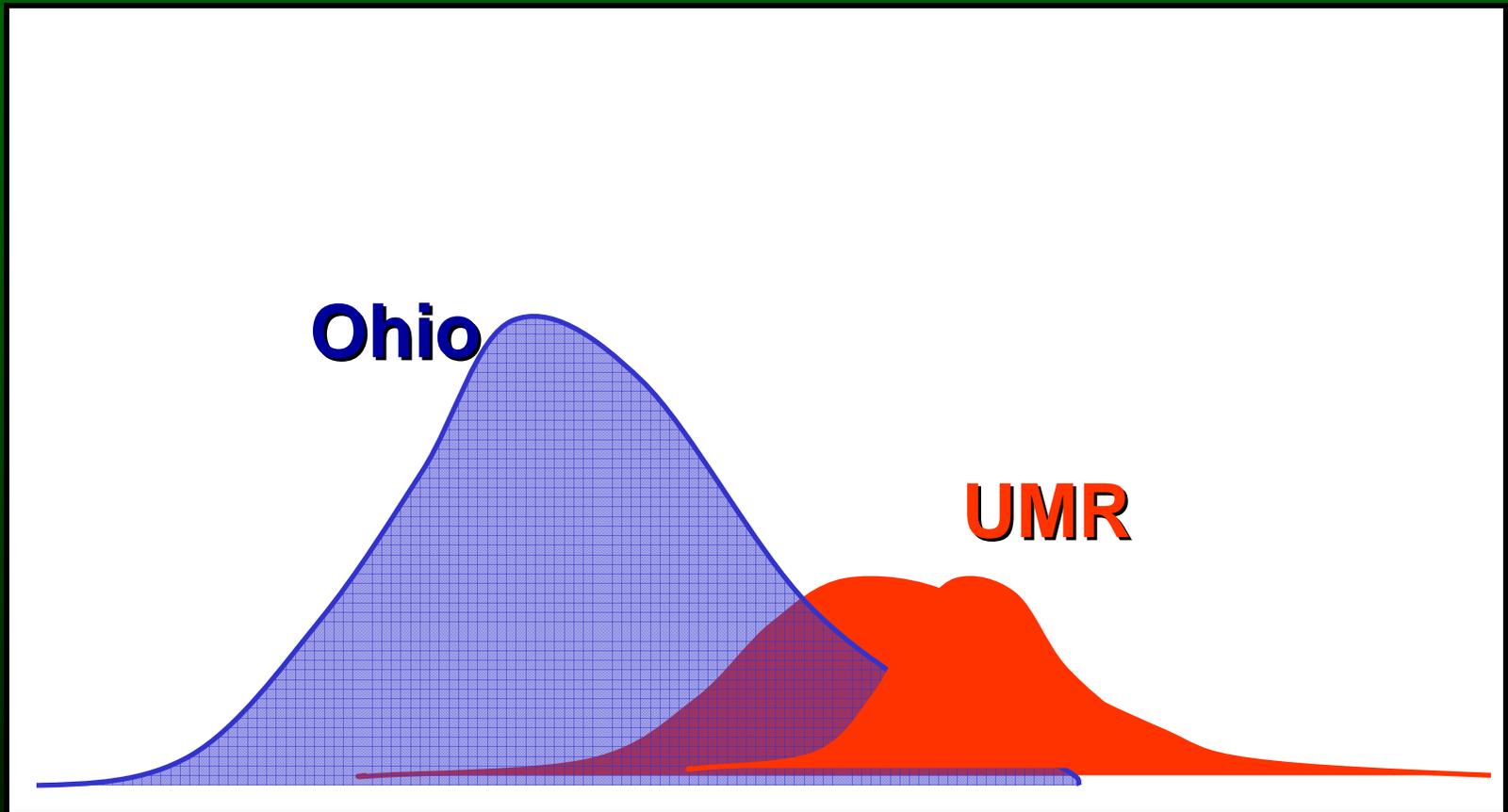
Mean annual yield from USGS gaging stations and selected LTRMP monitoring sites in the upper Mississippi River basin

100 0 100 200 Miles



Timing of Concentrated and Diluted Sources

Discharge



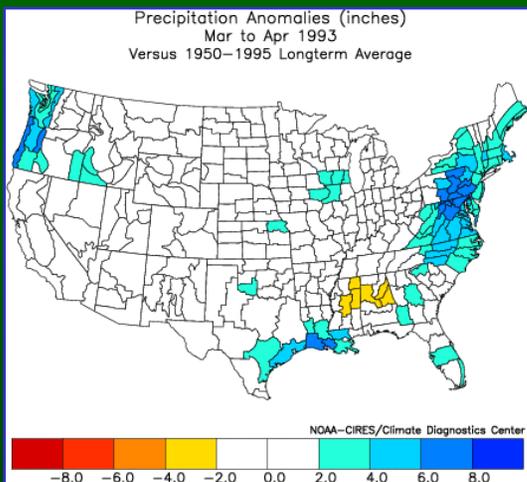
Time



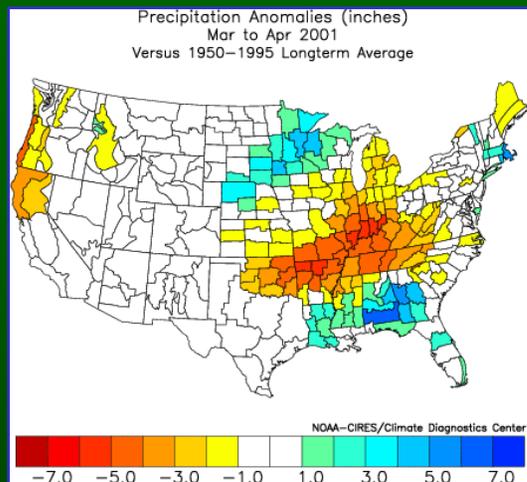
Precipitation Anomalies

Spring

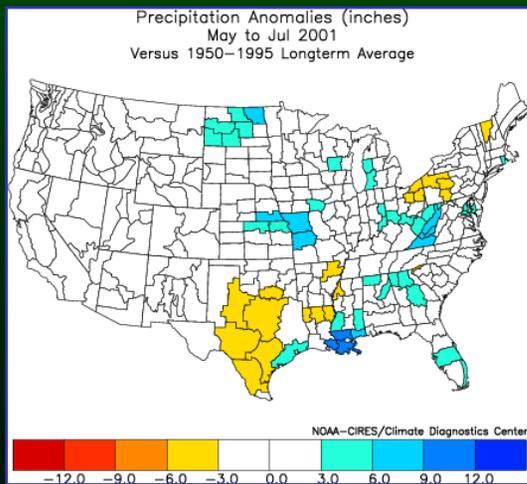
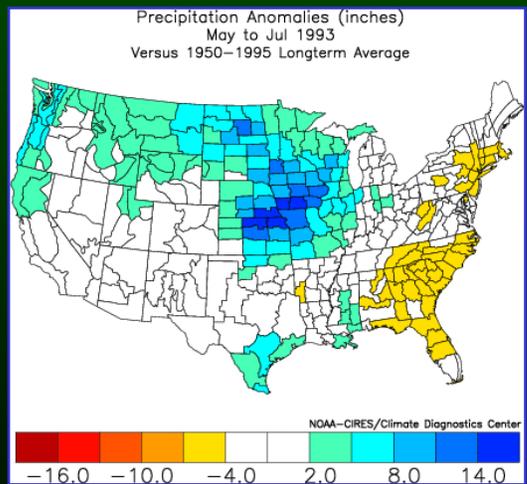
1993



2001



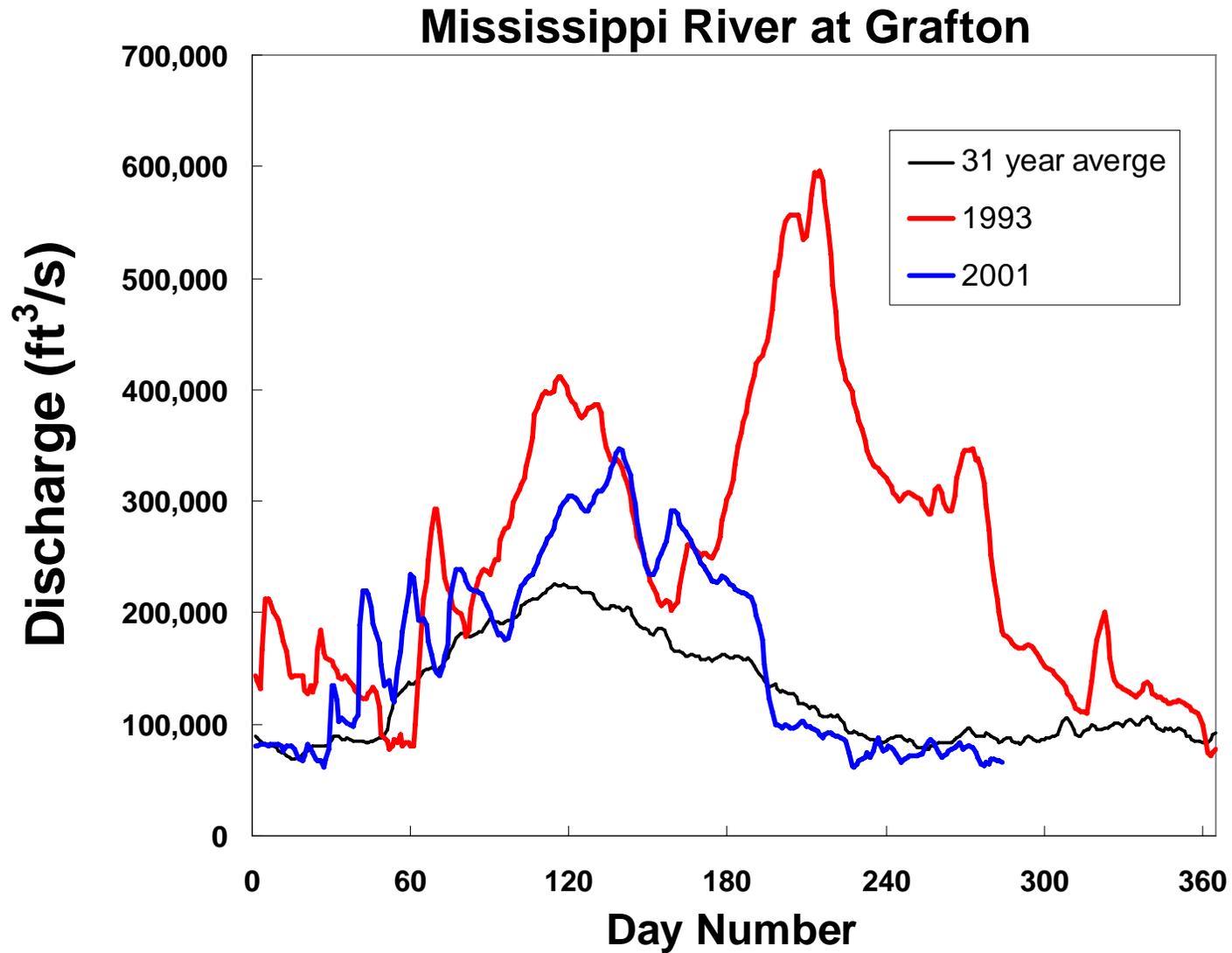
Summer



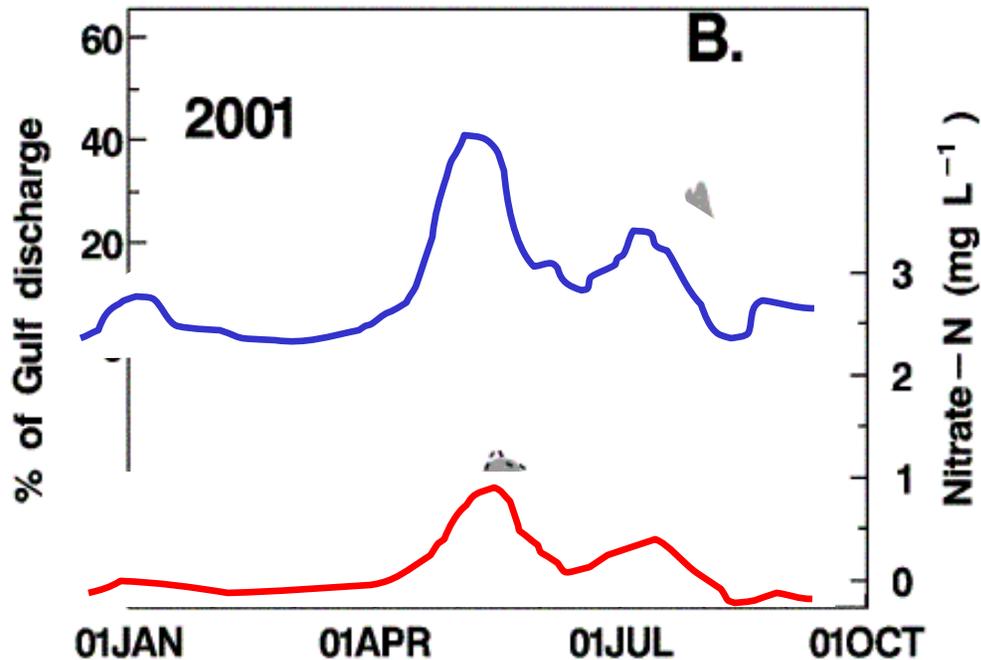
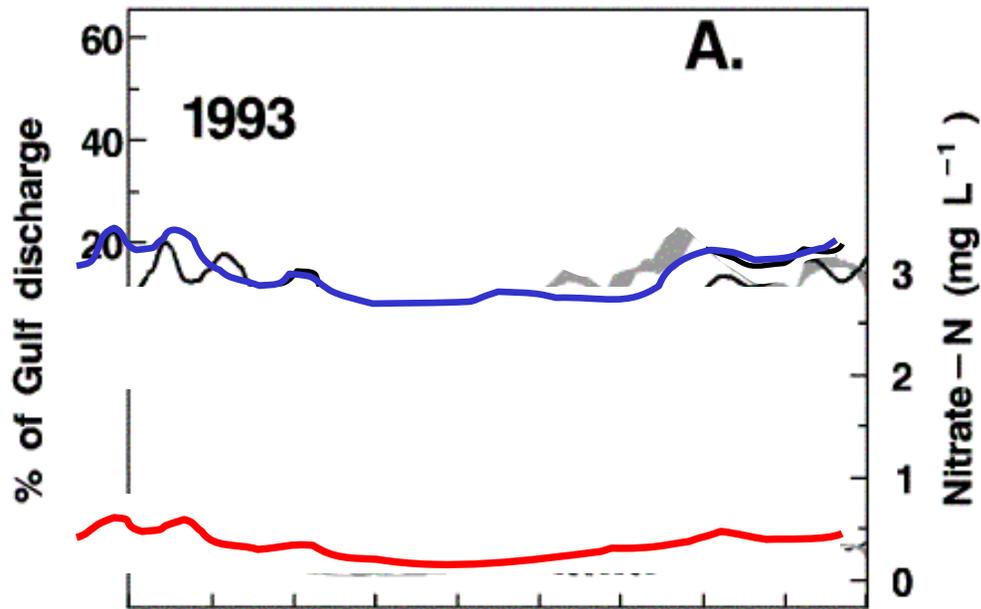
NOAA Precipitation Data & Graphics:
<http://www.cdc.noaa.gov/USclimate/USclimdivs.html>



Spring vs. Summer Flood



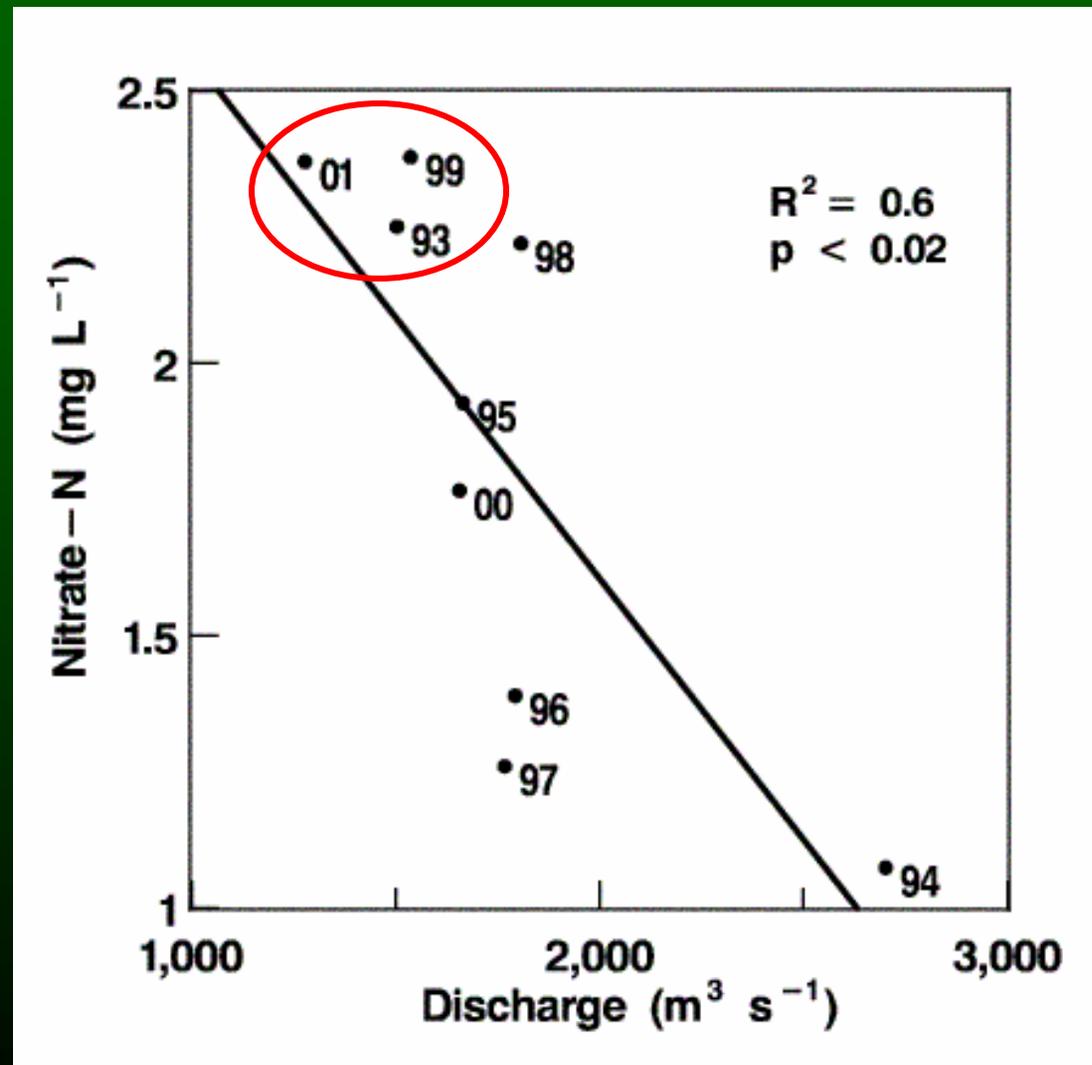
Contrasting UMR Contributions of Water and Nitrate to The Gulf of Mexico



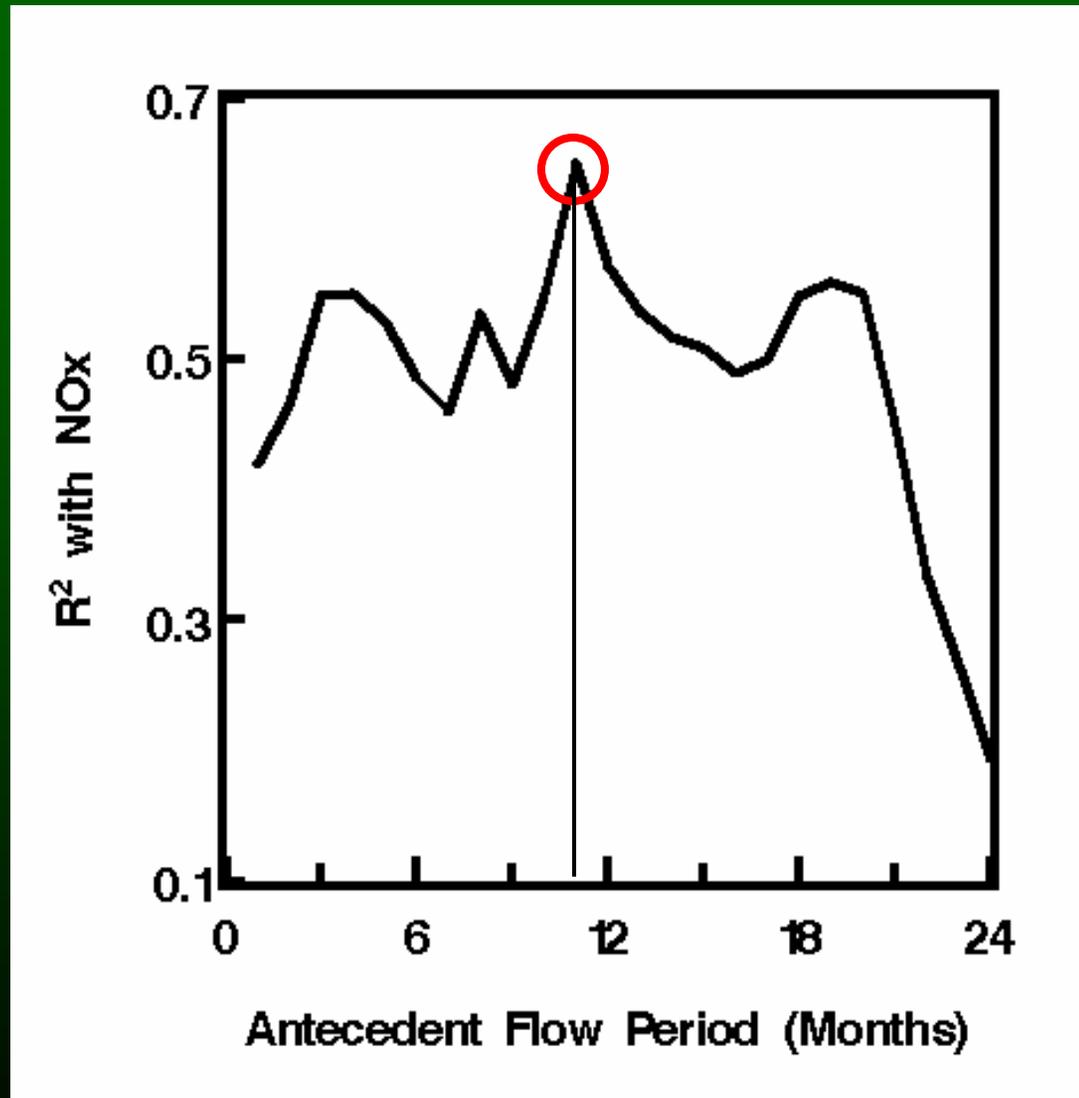
Discharge Prior to The Flood (Antecedent Conditions)



[Nitrate] vs. 12-month Antecedent Discharge at Grafton



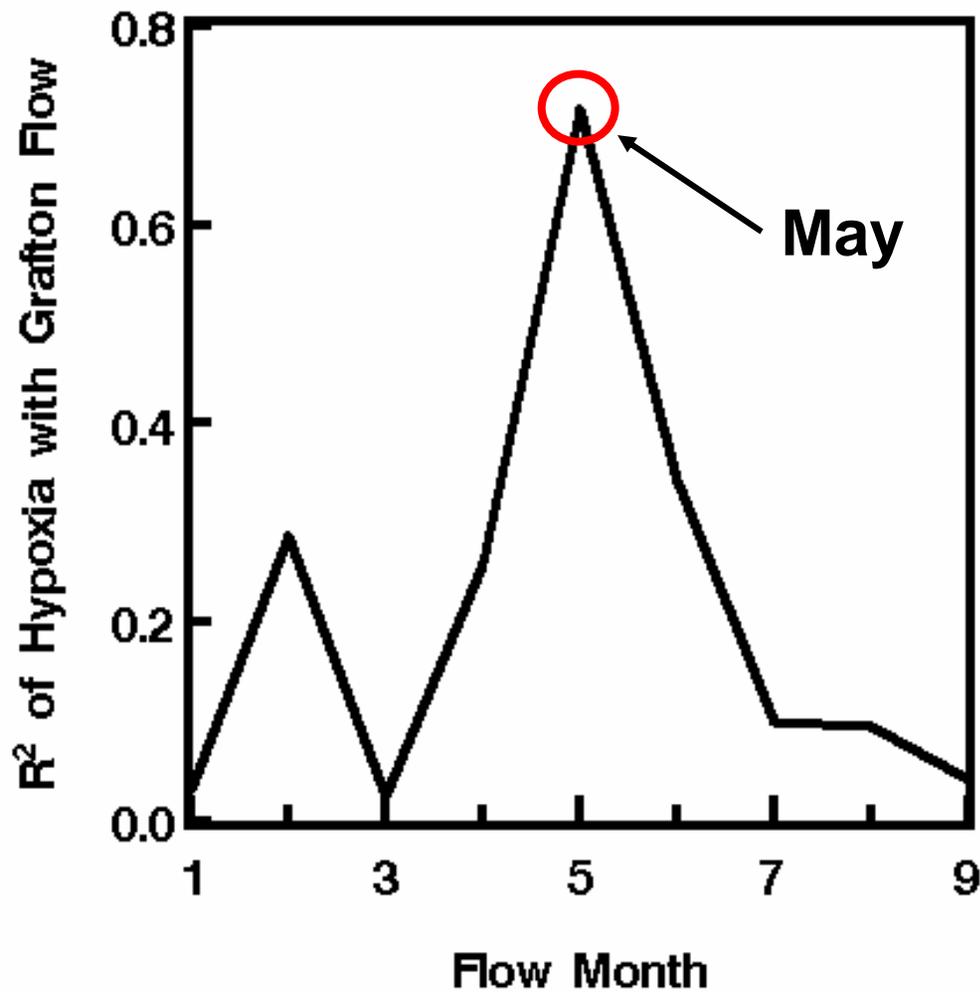
R^2 of [Nitrate] in UMR Flood vs. Antecedent Flow Period at Grafton



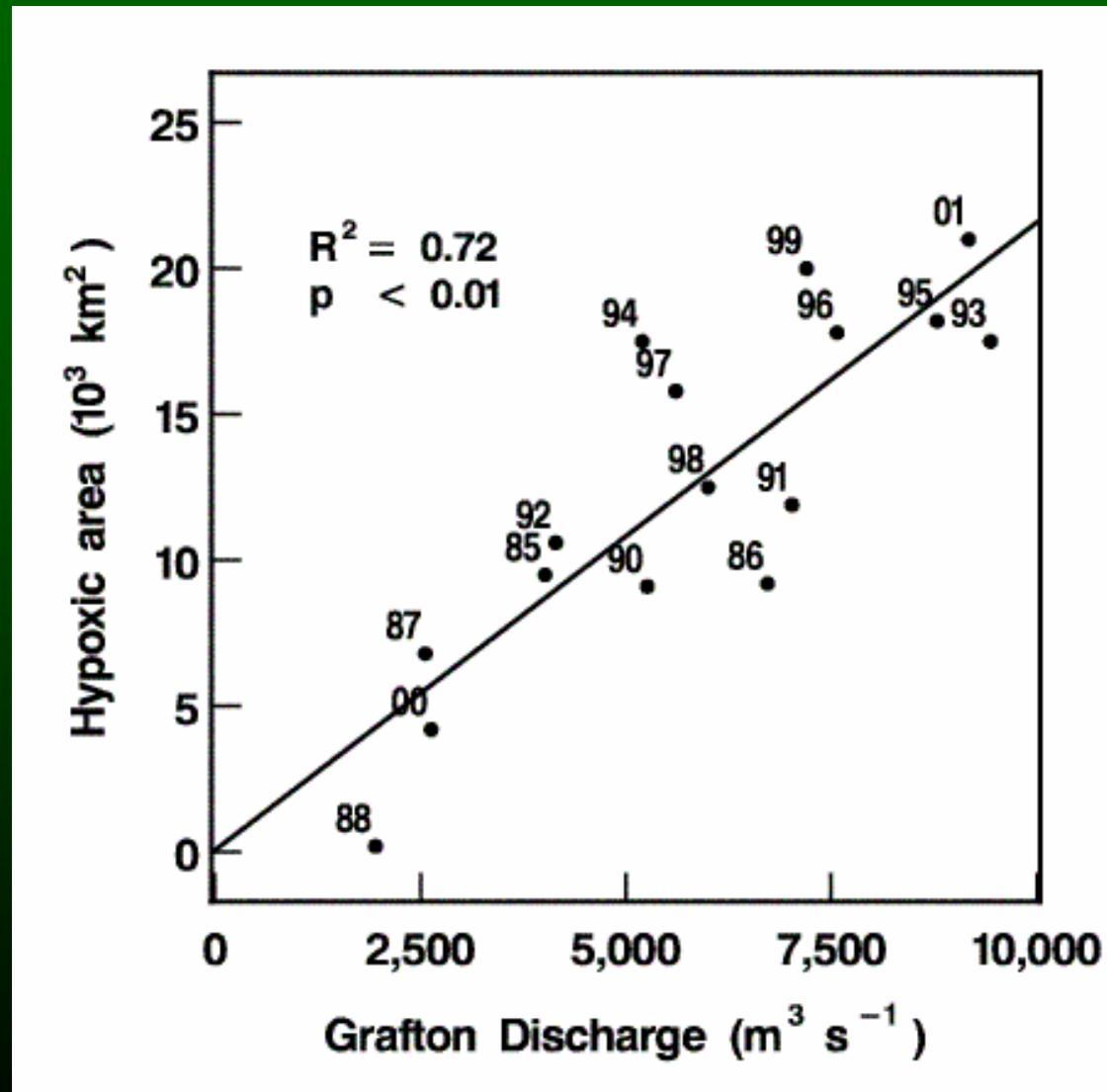
H: Ecological response is linked to flood magnitude, seasonal timing, and concentration of constituents.



R² of Gulf Hypoxic Area With Flow at Grafton

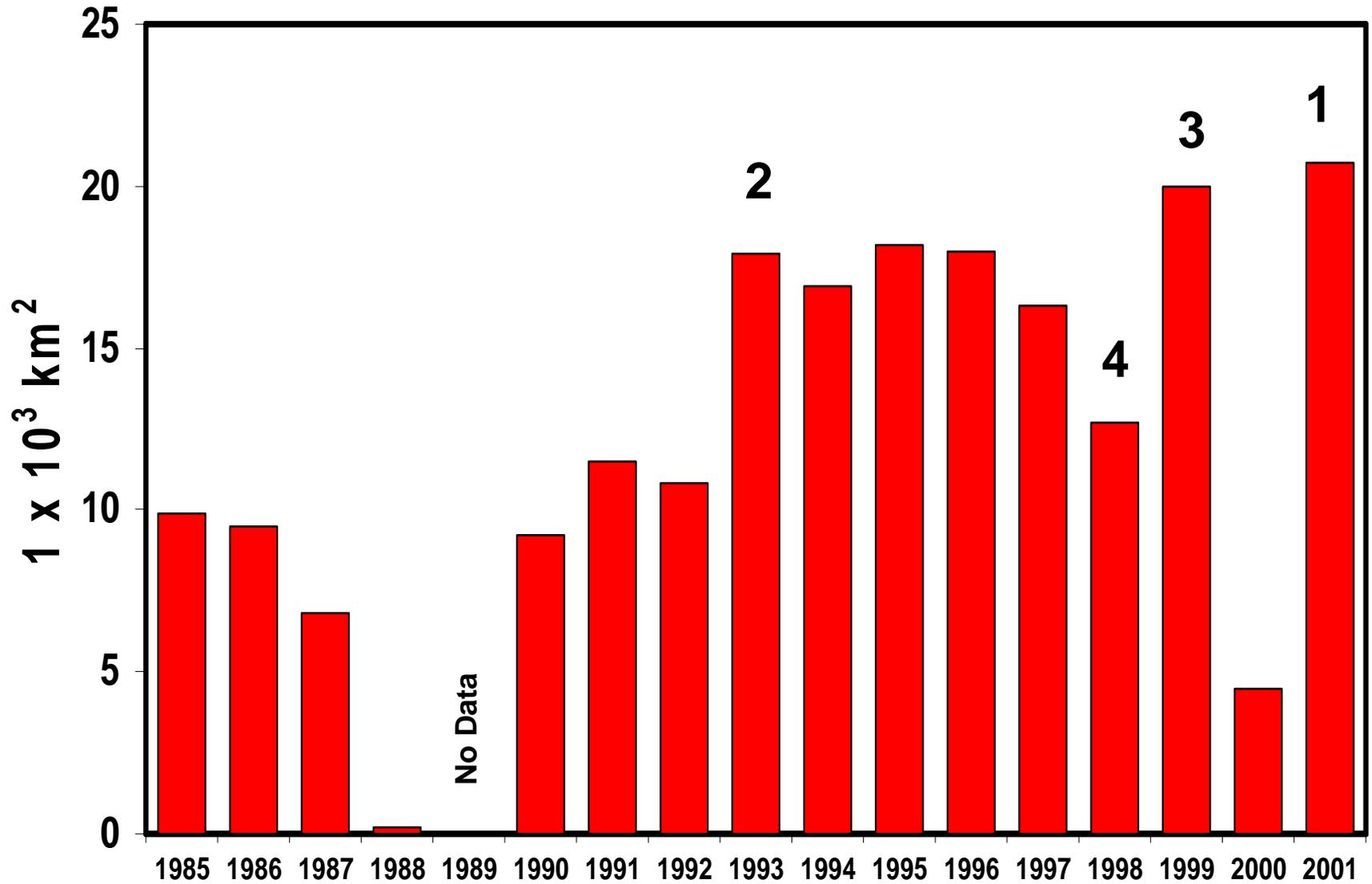


R² of Gulf Hypoxic Area With May Discharge at Grafton



Gulf of Mexico Hypoxic Zone Area

Top 4 [nitrate] floods at Grafton labeled



Summary

- The mass and concentration of Nitrate exported from the UM basin is linked to flood distribution in space & time at multiple scales.
- The influence of UMR exports downstream is conditioned by exports (primarily water) from other tribs.
- Natural climatic/hydrologic processes drive much of the variation in nitrate export.
- The link to Gulf hypoxia and ecological responses within the River are under investigation.



