Headwaters to the Sea— EMAP's Estimate of Nutrient Transport in the Mississippi River Basin

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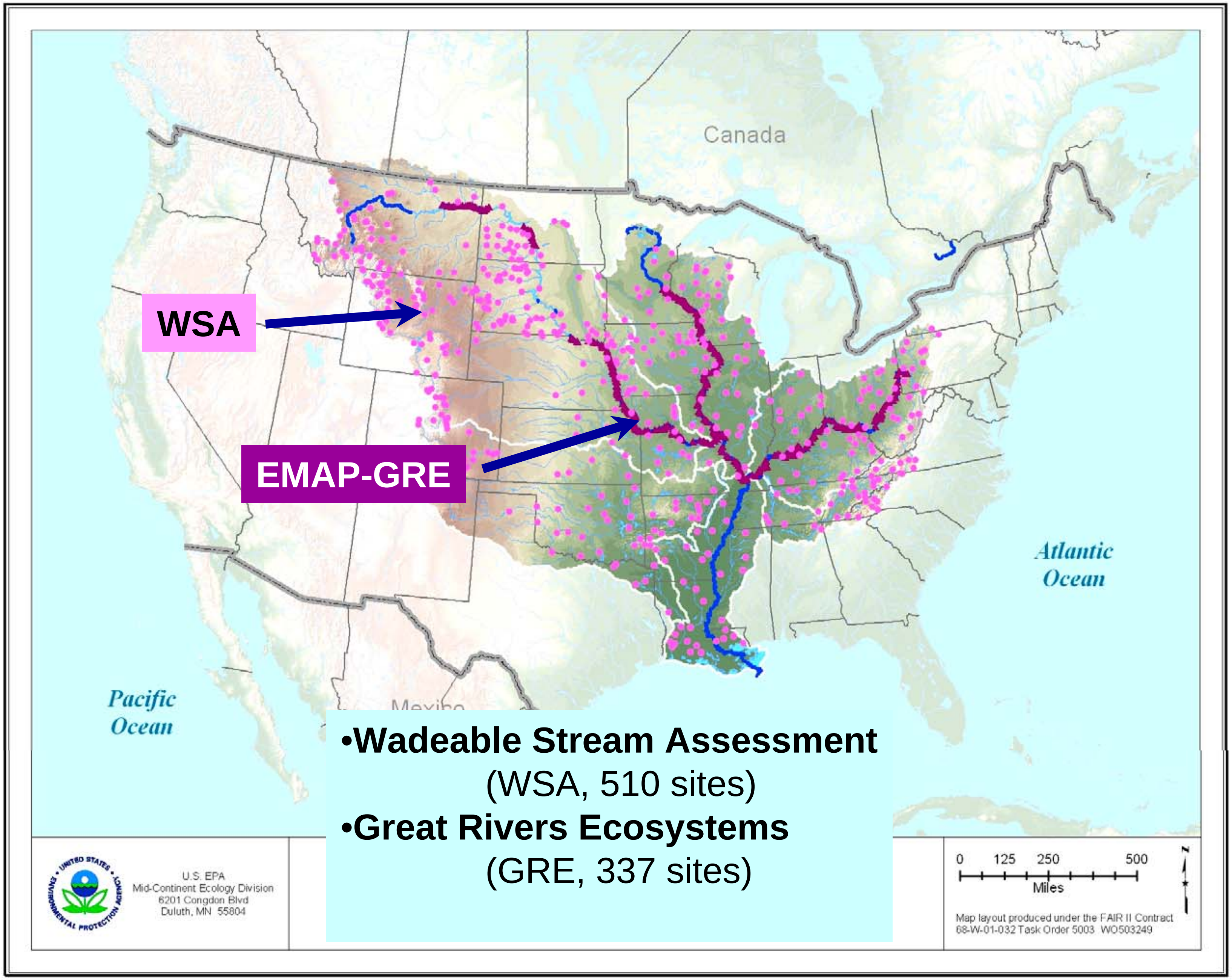
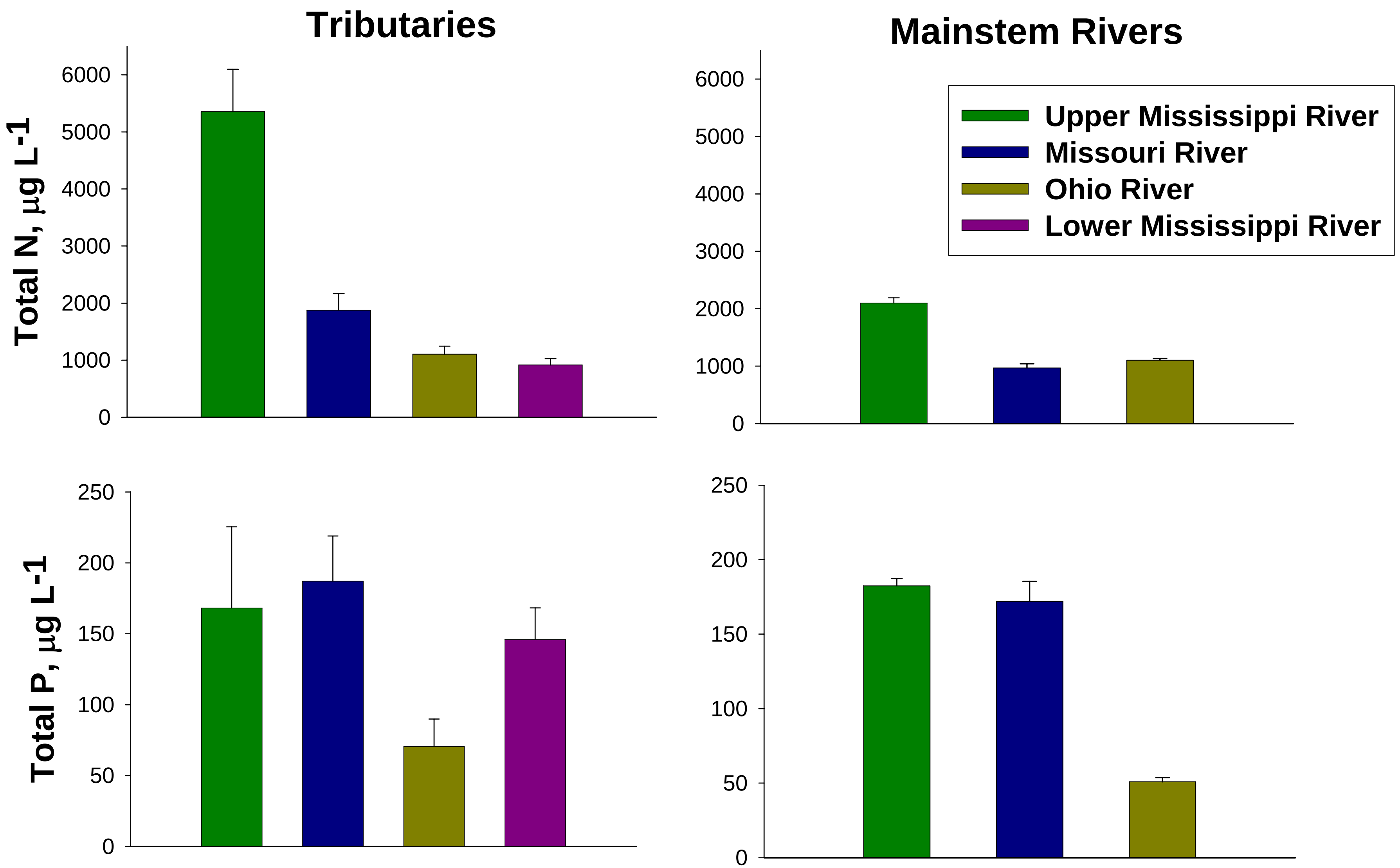
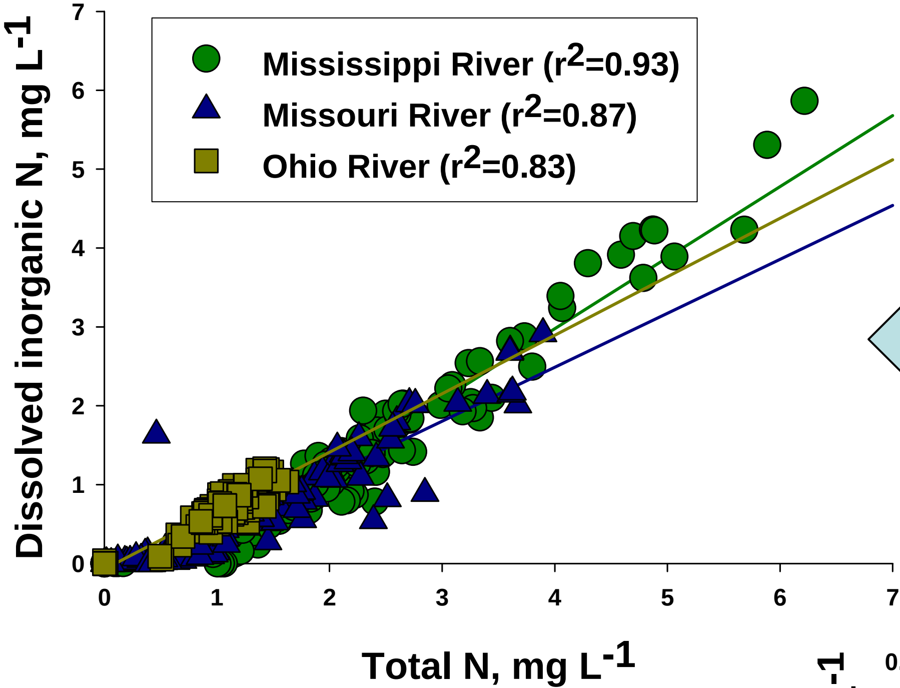


- **Wadeable Stream Assessment** (WSA, 510 sites)
- **Great Rivers Ecosystems** (GRE, 337 sites)

N &P in basin tributaries vs. rivers

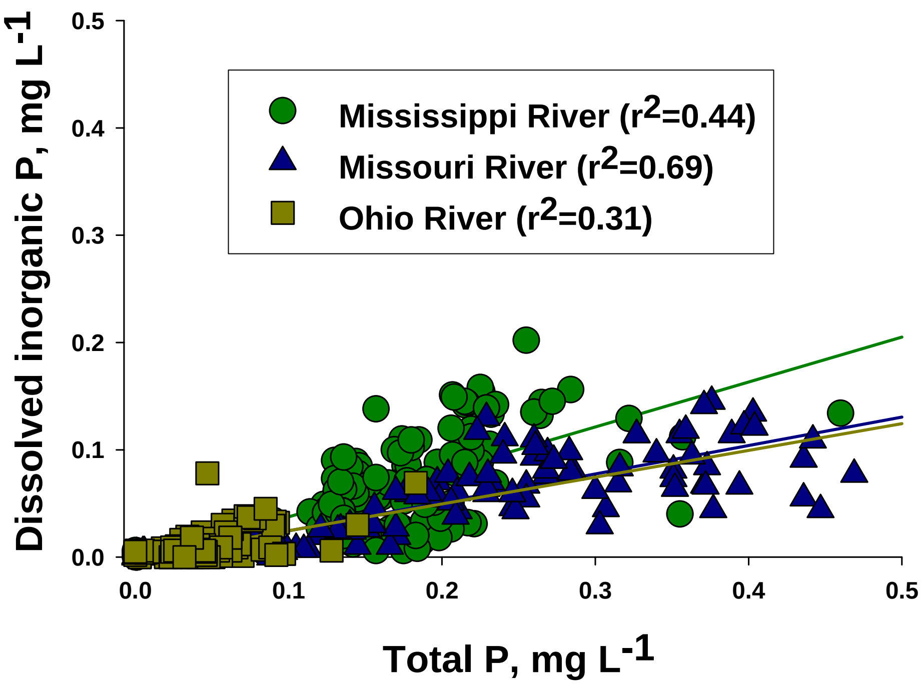


Dissolved vs. total nutrients

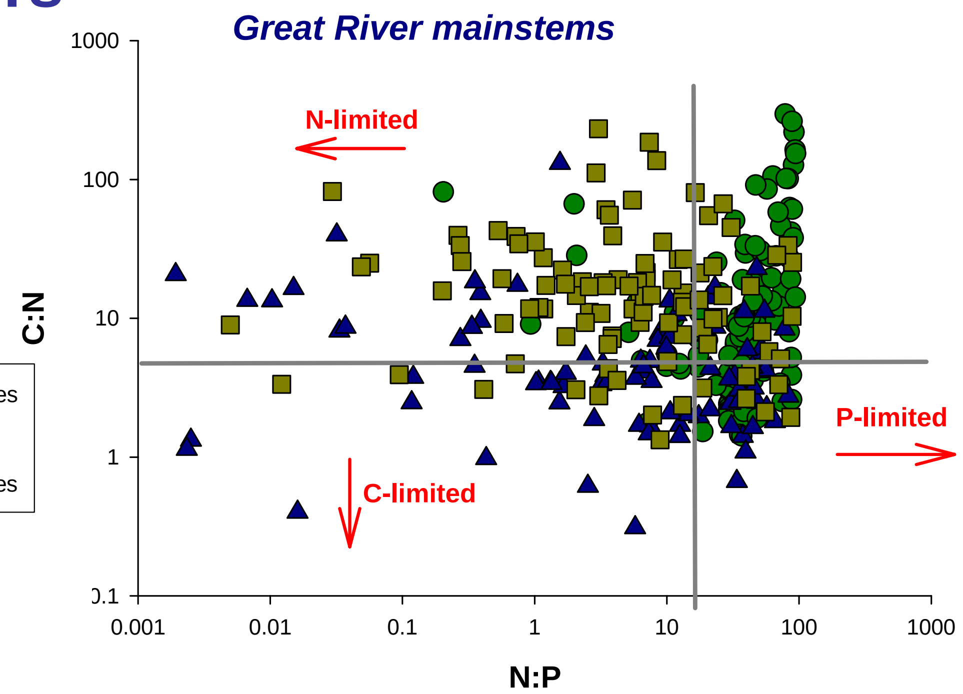


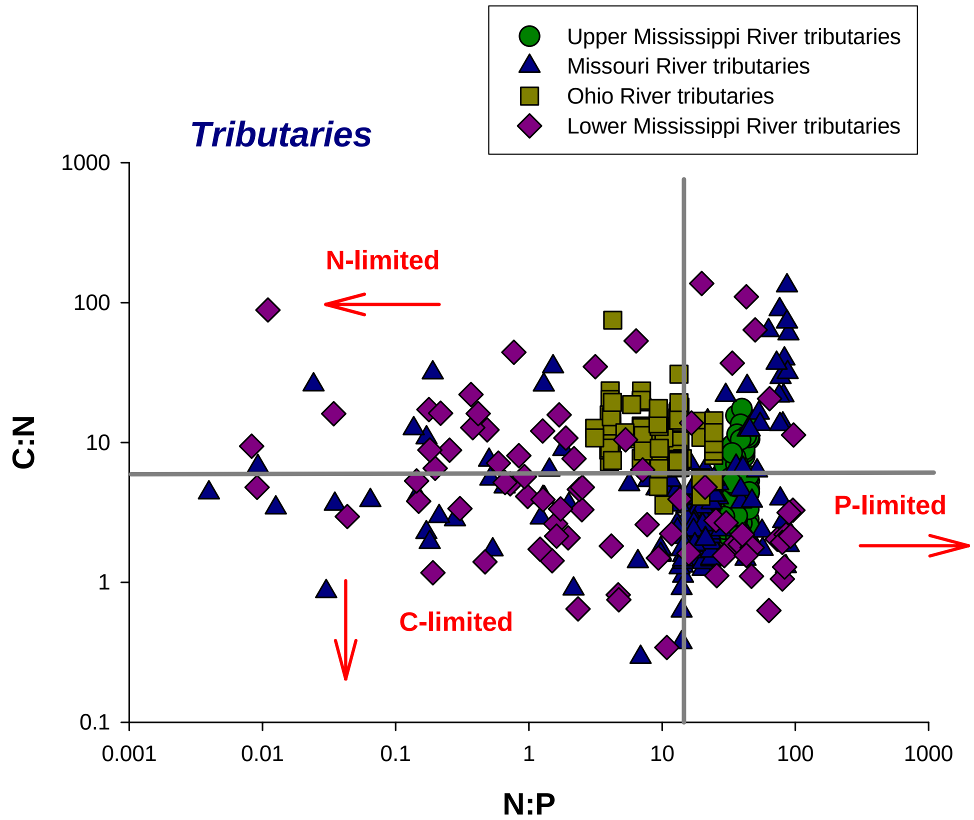
TN and DIN are interchangeable

DIP grossly underestimates available P

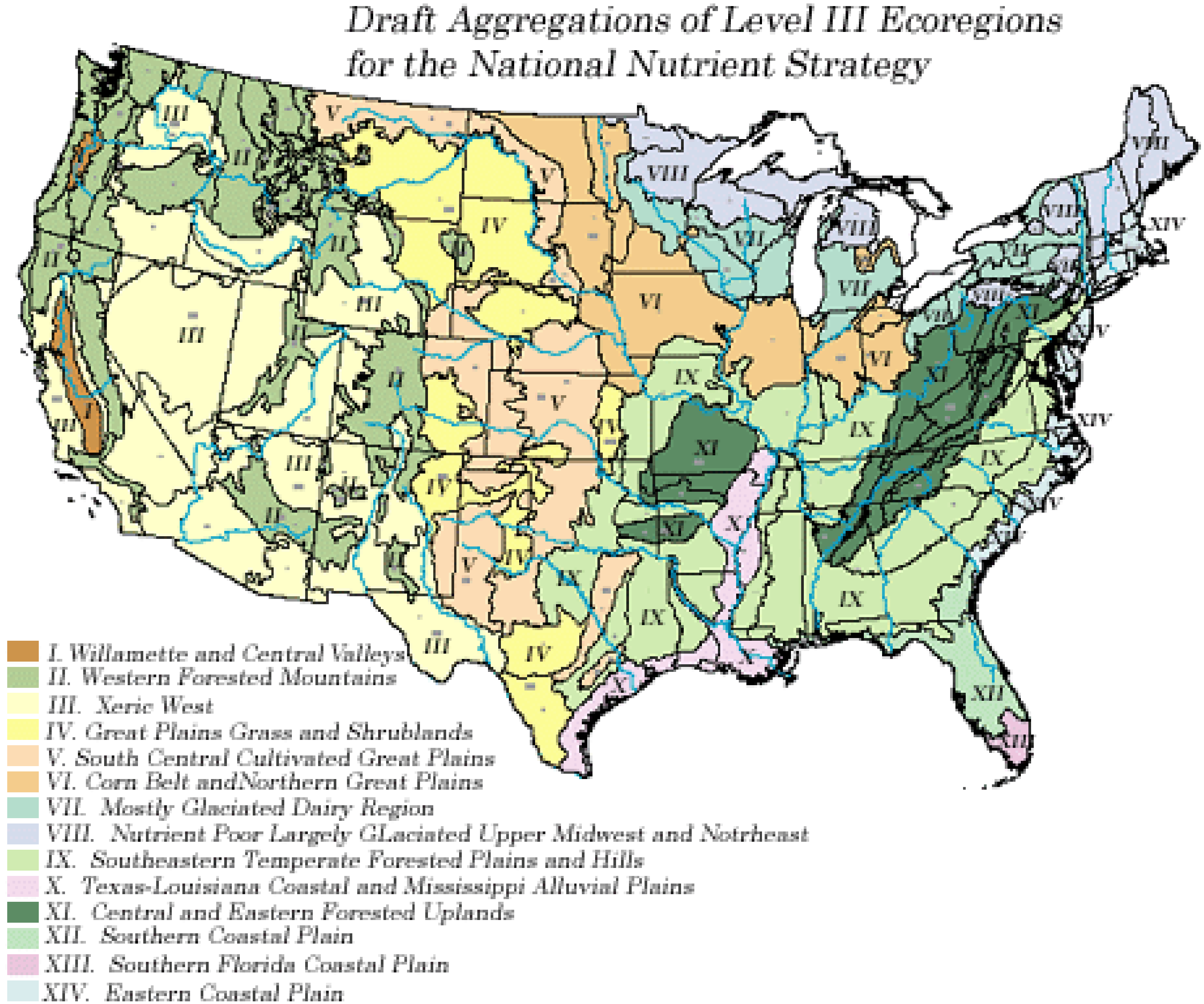


Nutrient stoichiometry—
tributaries vs. mainstem rivers

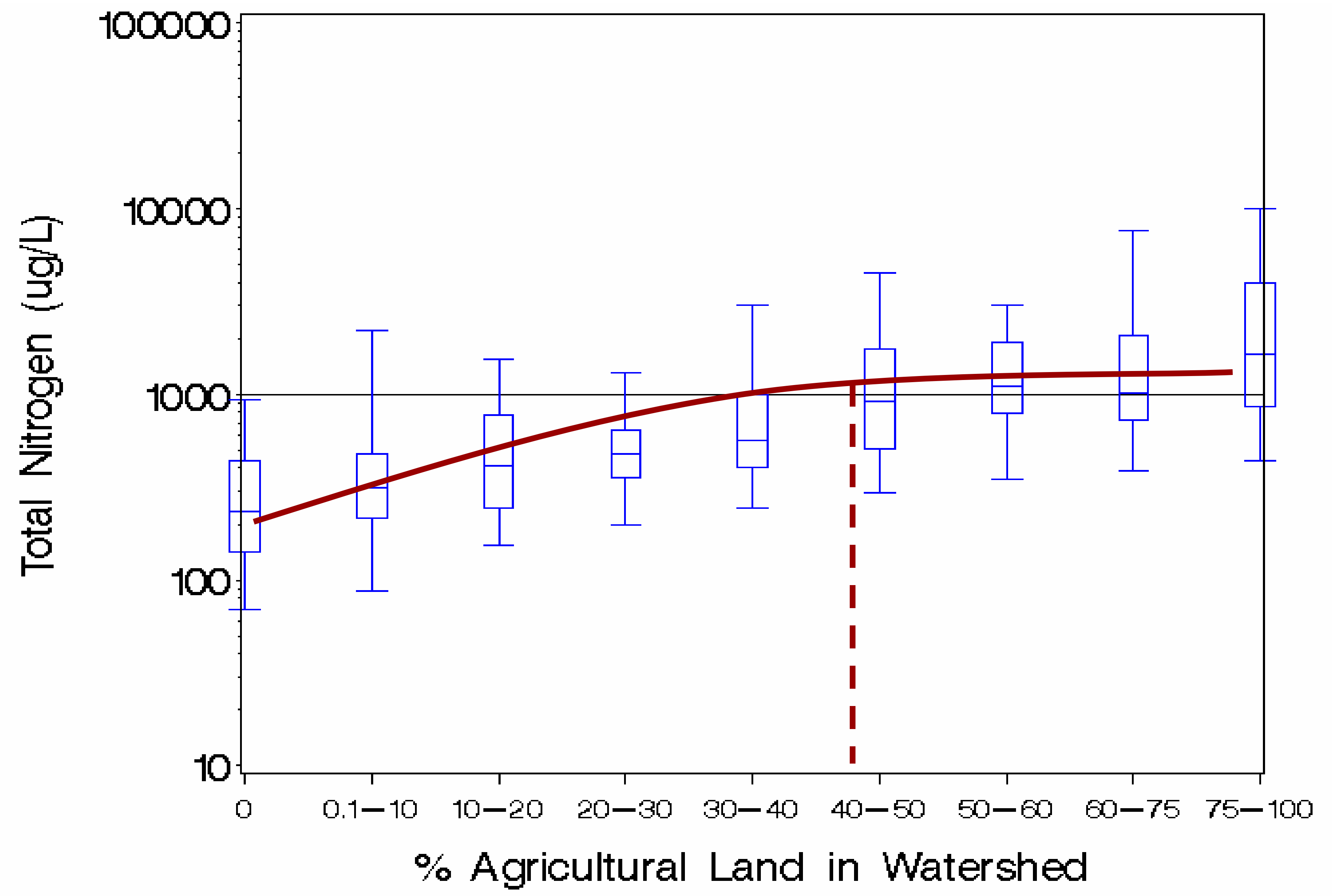




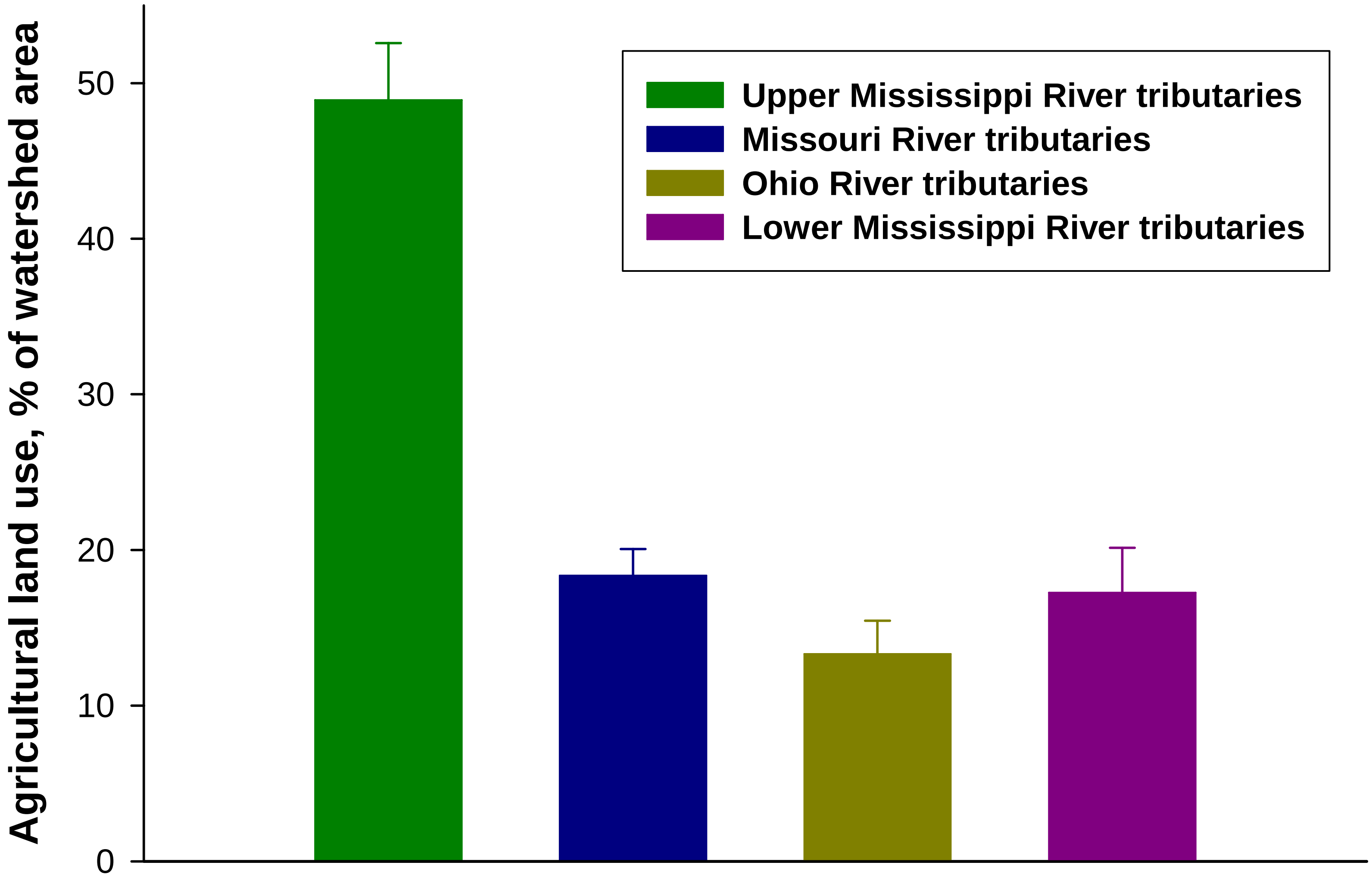
Redfield ratio—
N:P 16:1
C:N 8:1


Draft Aggregations of Level III Ecoregions
for the National Nutrient Strategy
I. Willamette and Central Valleys
II. Western Forested Mountains
III. Xeric West
IV. Great Plains Grass and Shrublands
V. South Central Cultivated Great Plains
VI. Corn Belt andNorthern Great Plains
VII. Mostly Glaciated Dairy Region
VIII. Nutrient Poor Largely GLaciated Upper Midwest and Notrheast
IX. Southeastern Temperate Forested Plains and Hills
X. Texas-Louisiana Coastal and Mississippi Alluvial Plains
XI. Central and Eastern Forested Uplands
XII. Southern Coastal Plain
XIII. Southern Florida Coastal Plain
XIV. Eastern Coastal Plain

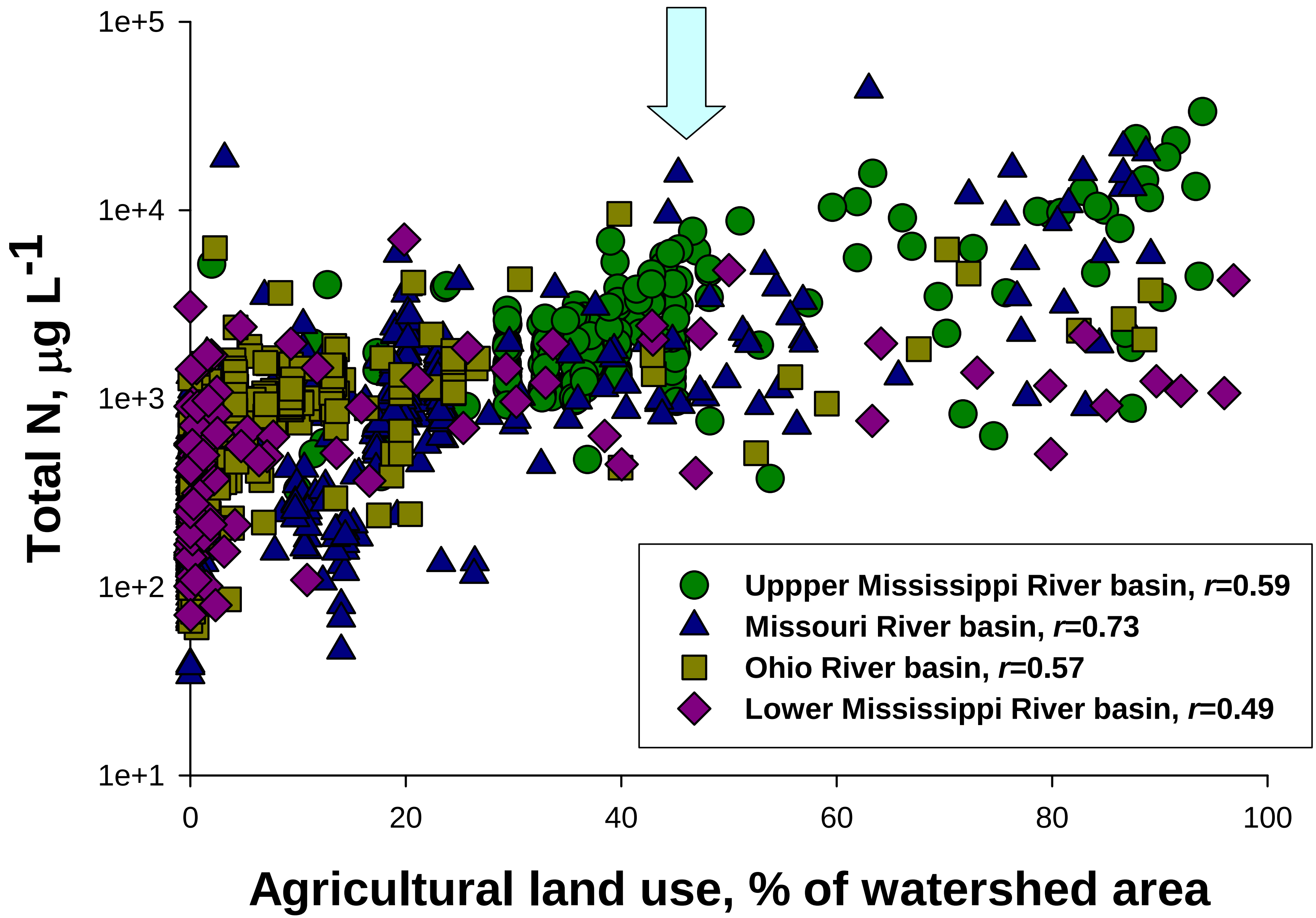
N vs. land use for small streams



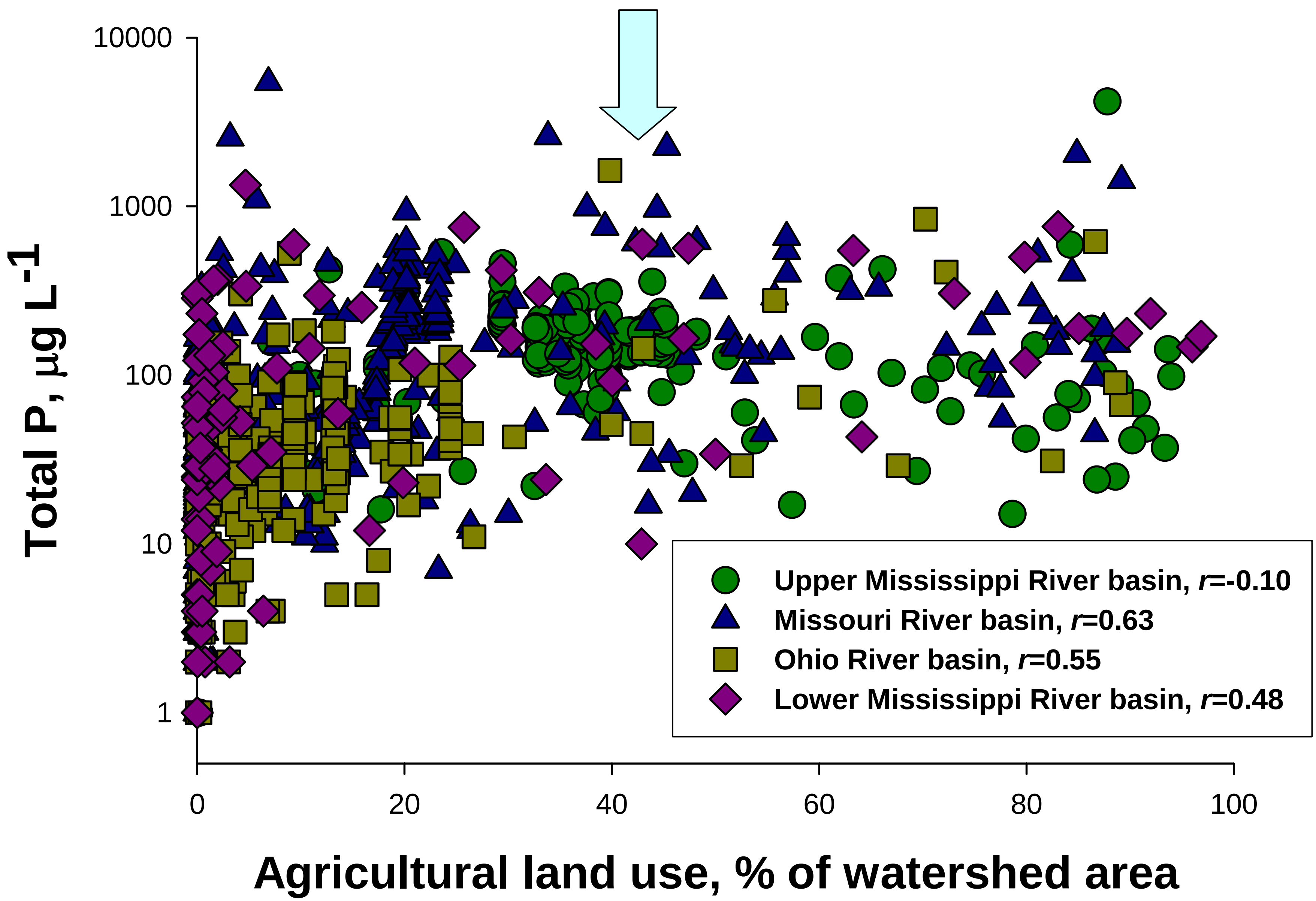
Agricultural land use in the basin



Stream N as a function of land use



Stream P as a function of land use



NHDPlus—

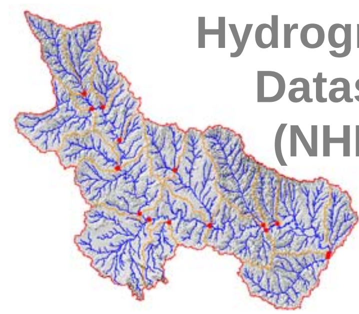
linking the stream network to the landscape

NHD

Greatly improved 1:100K National Hydrography Dataset

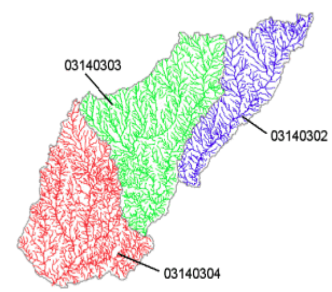
PLUS (9 more components):

- Value Added Attributes
- Elevation-based Catchments
- Catchment Characteristics (NLCD)
- Headwater Node Areas
- Cumulative Drainage Area Characteristics
- Flow Direction, Flow Accumulation, and Elevation Grids
- Min/Max Elevations and Slopes
- Flow Volume & Velocity Estimates
- Flow Gages with Network Locations



National Hydrography Dataset (NHD)

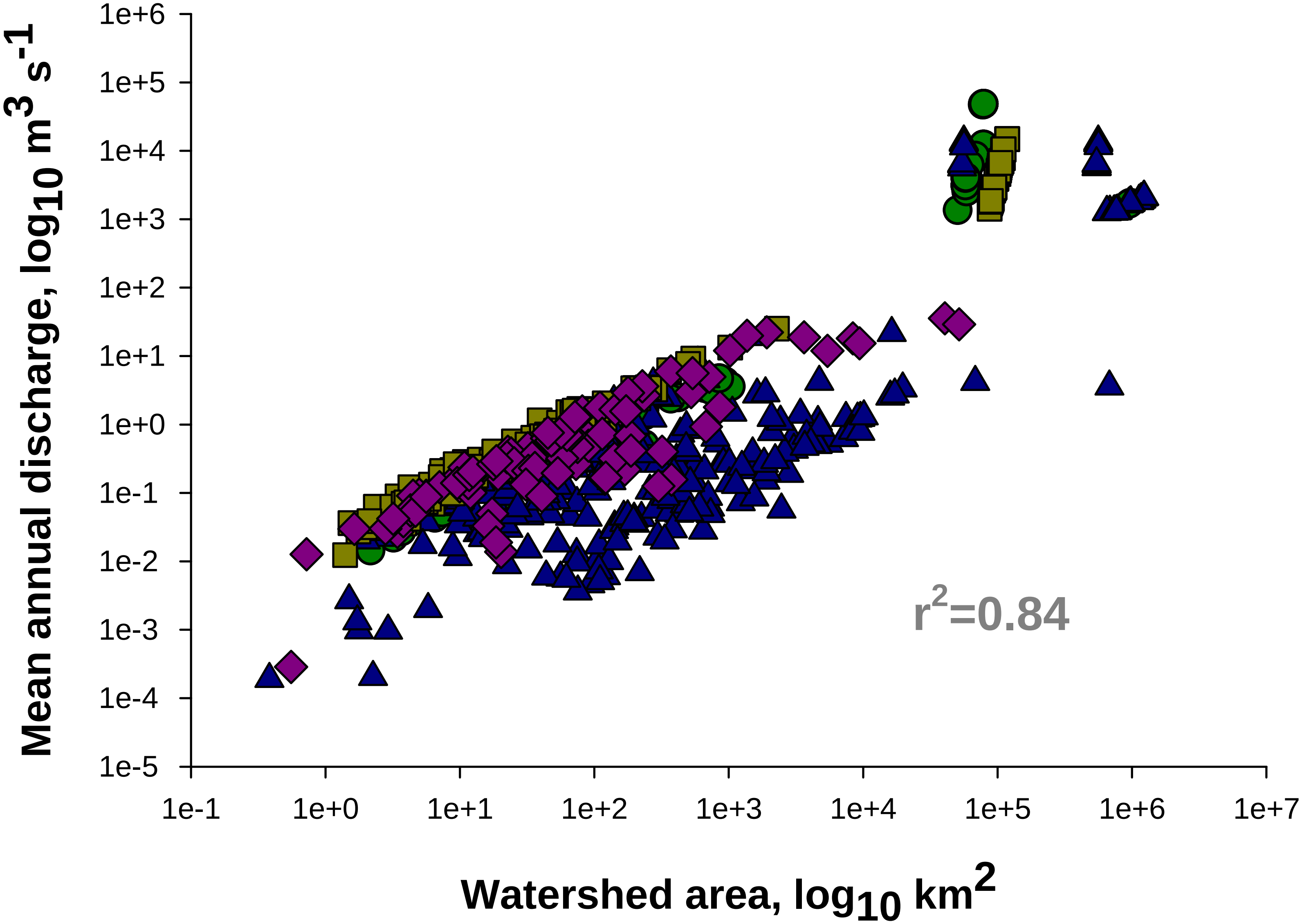
National Elevation Dataset (NED)

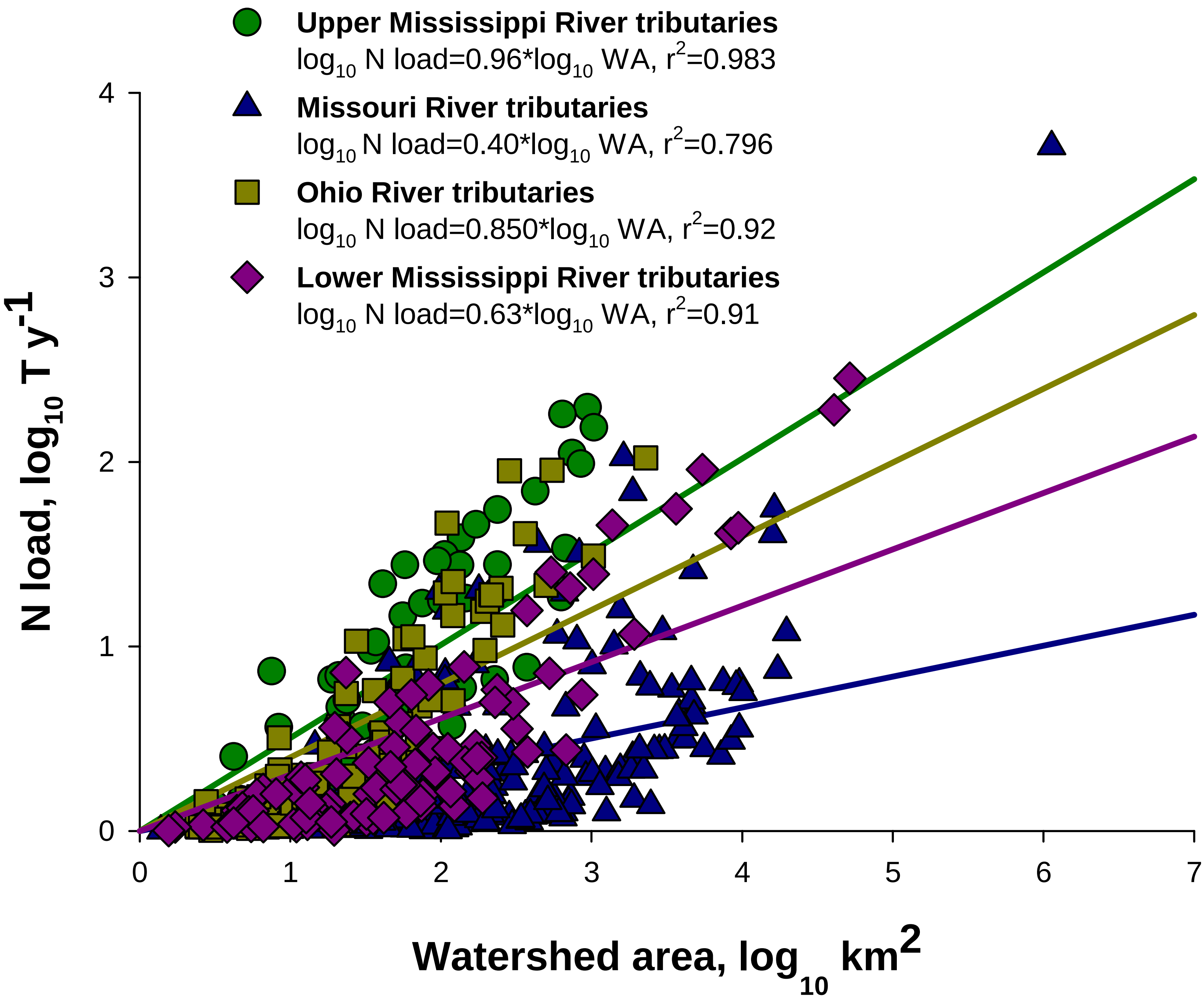


Watershed Boundary Dataset (WBD)

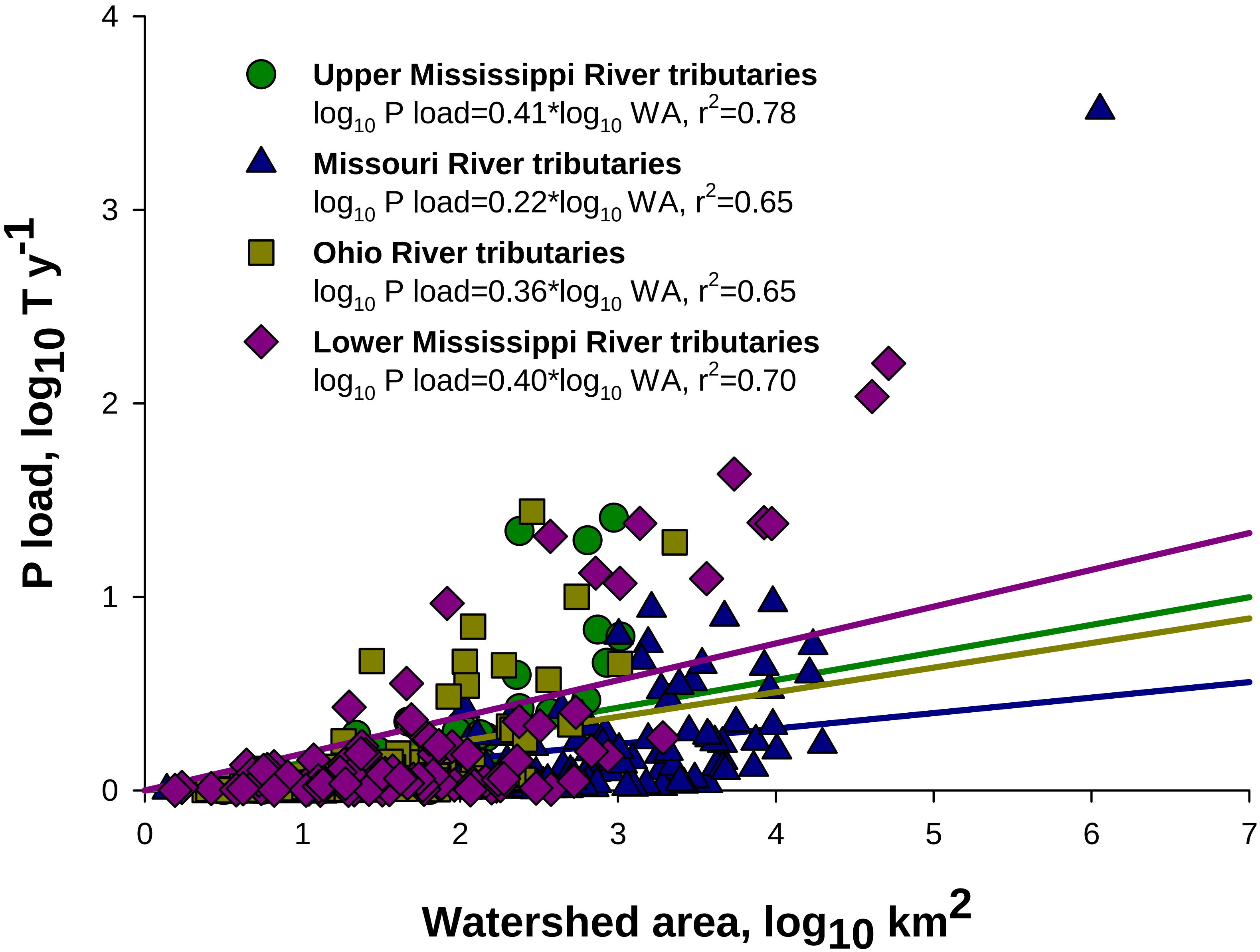
A joint USGS-USEPA venture

Runoff as a function of watershed area

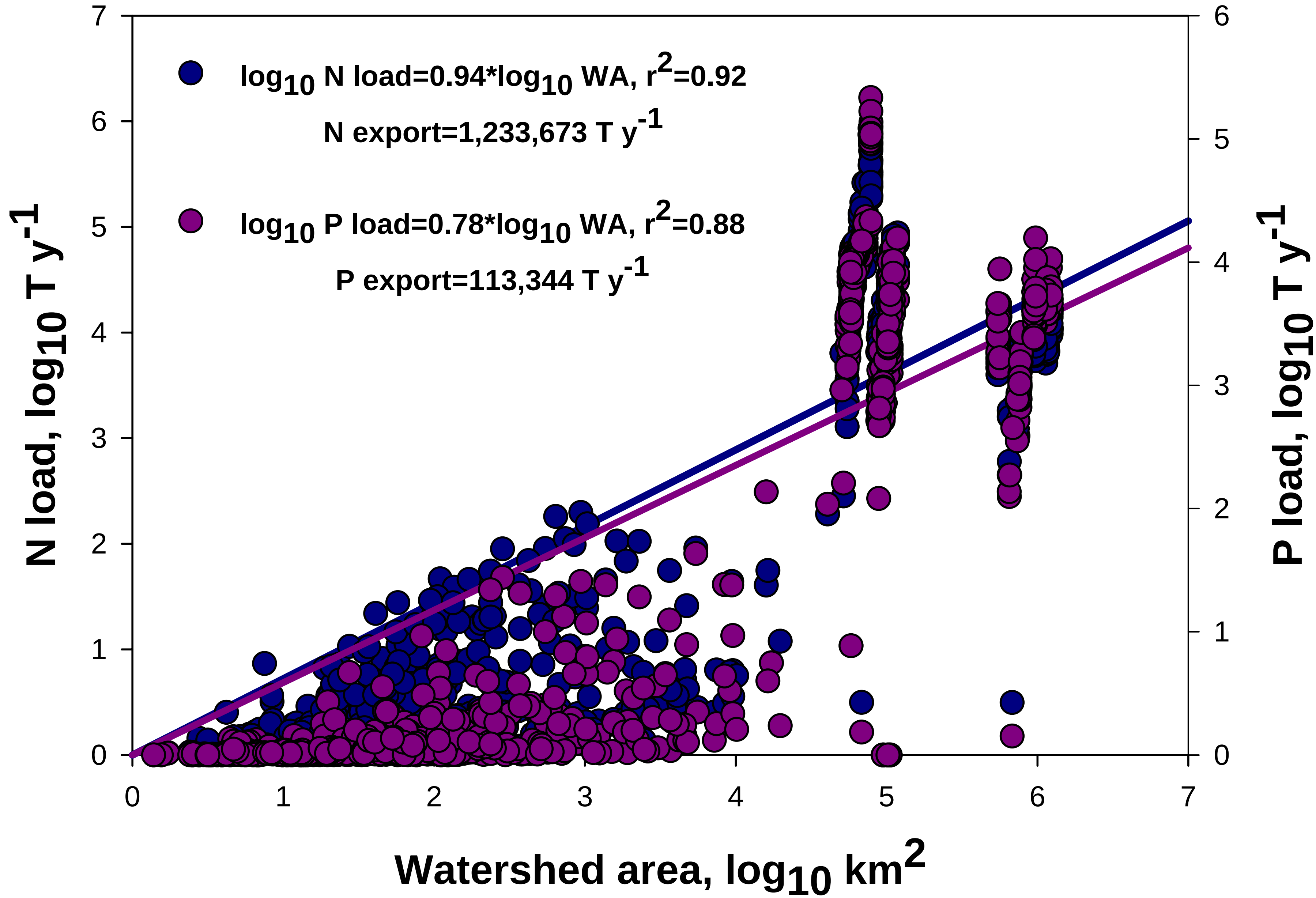




Load=mean annual discharge x mean nutrient concentration

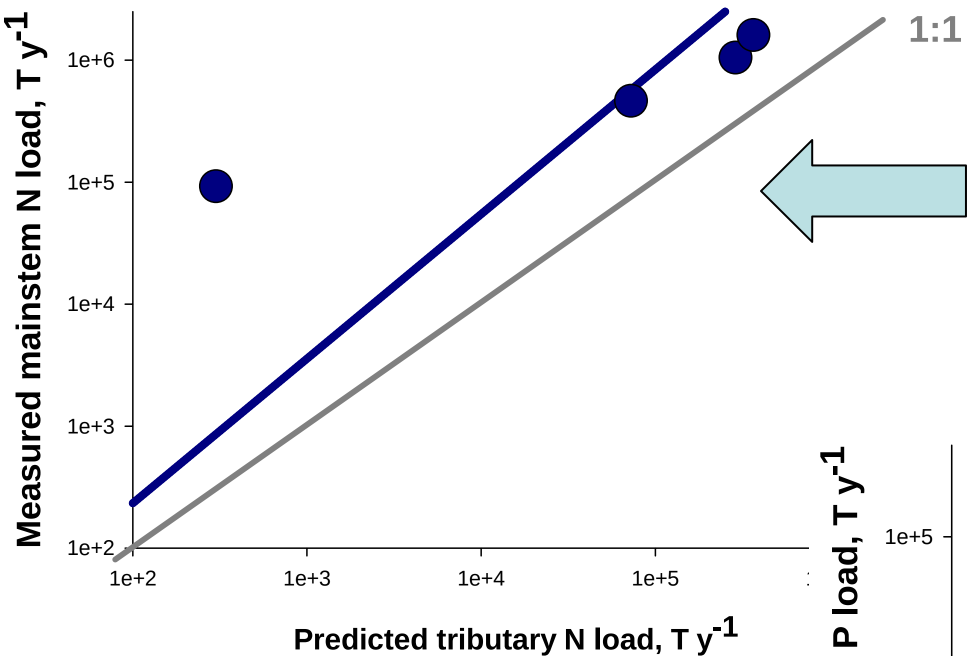


Load=mean annual discharge x mean nutrient concentration



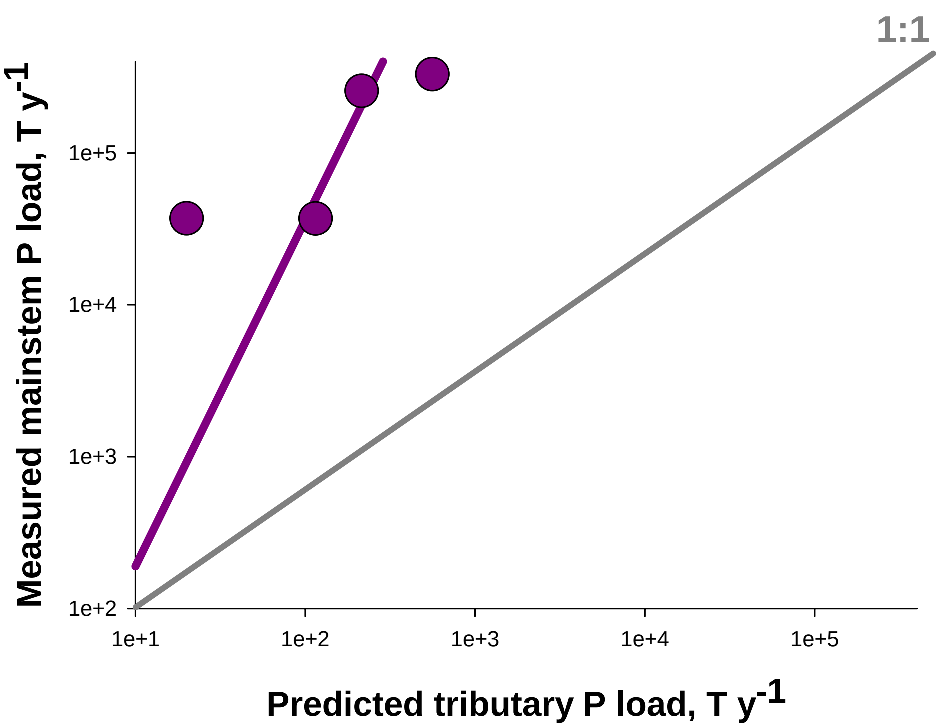
Load=mean annual discharge x mean nutrient concentration

Observed vs. predicted N & P loads

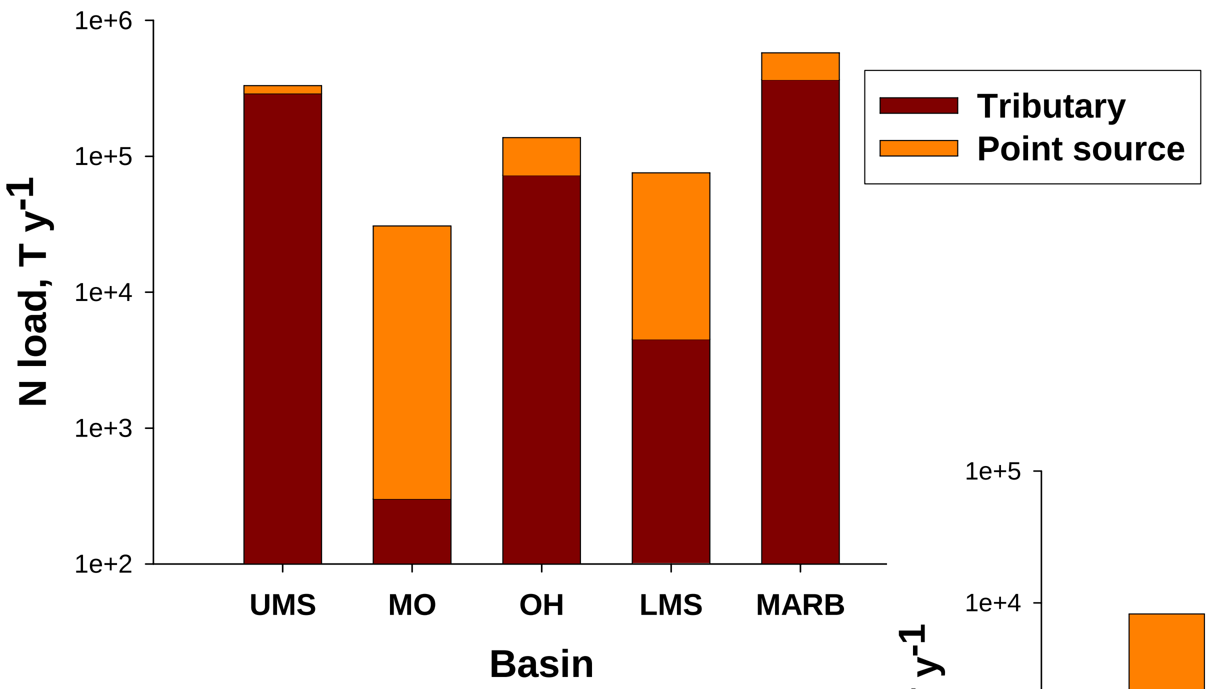


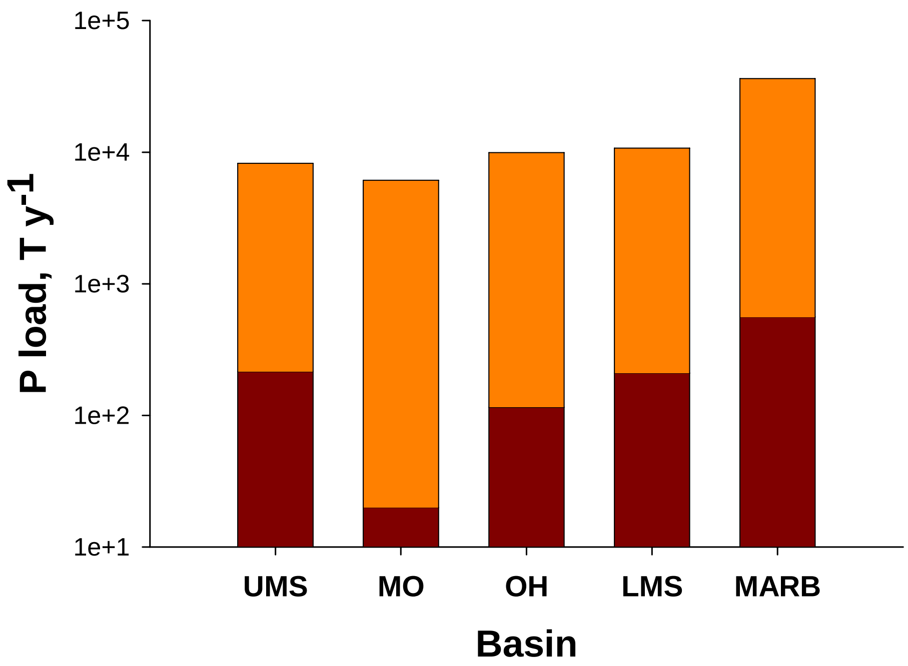
Measured N load is less than predicted, but within the same order of magnitude

Measured P load is significantly less than predicted

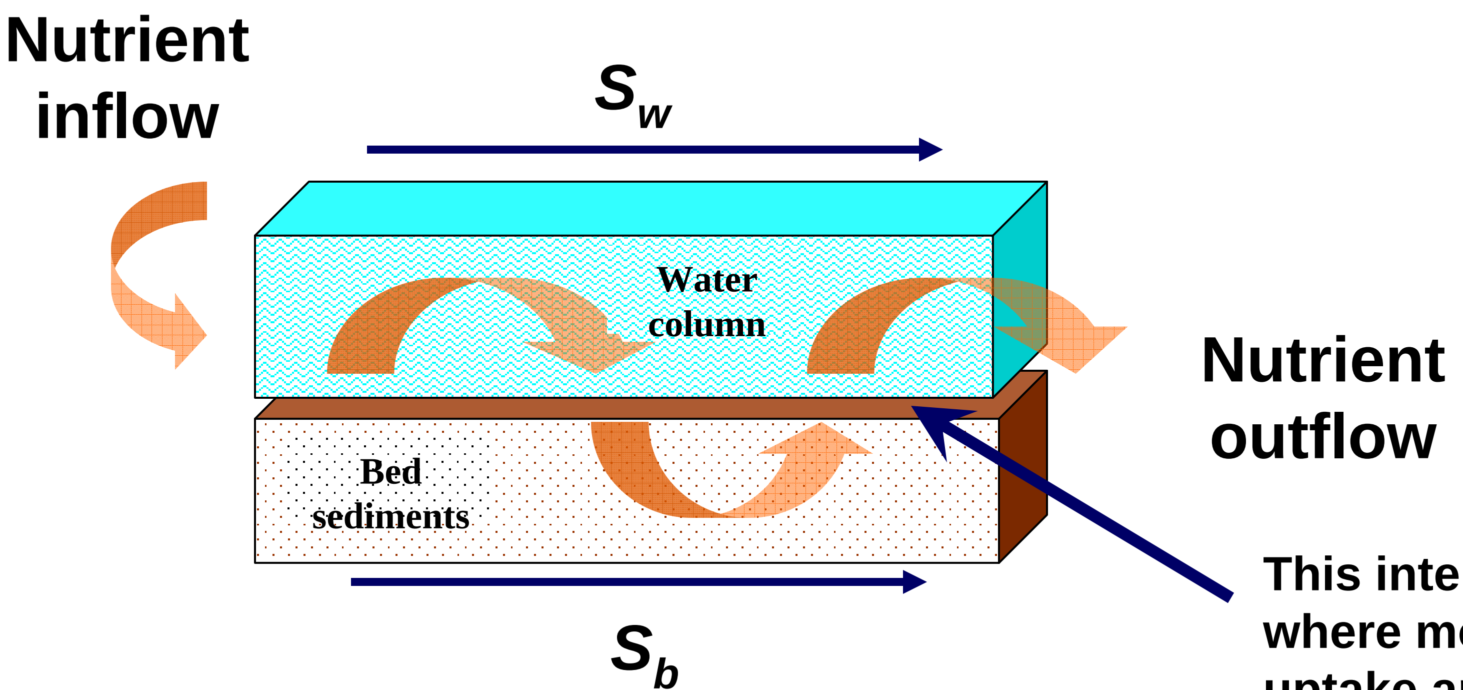


Tributary (non-point source) vs. point source N & P contributions





Nutrient spiraling



This interface is where most of the uptake and release occurs…

$$\textit{Spiral length } (S) = S_w + S_b$$

S_w is distance transported before uptake by the stream bed
S_b is the distance transported while in the stream bed

The more time an atom of nutrient spends in the water column, the slower the uptake rate and the longer the spiral length, the less likely it will be metabolized and/or lost from the system.

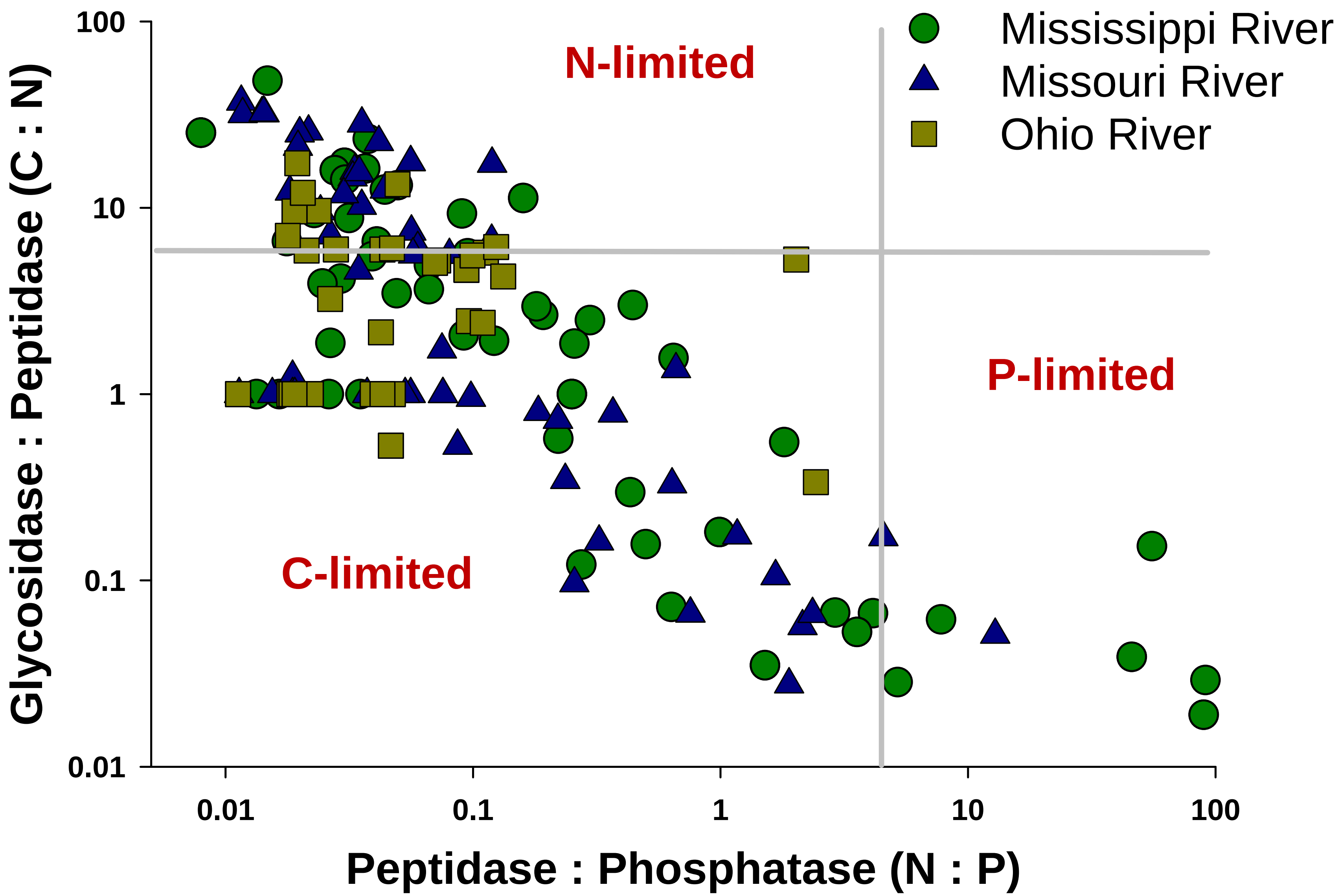
Upstream serial autocorrelation

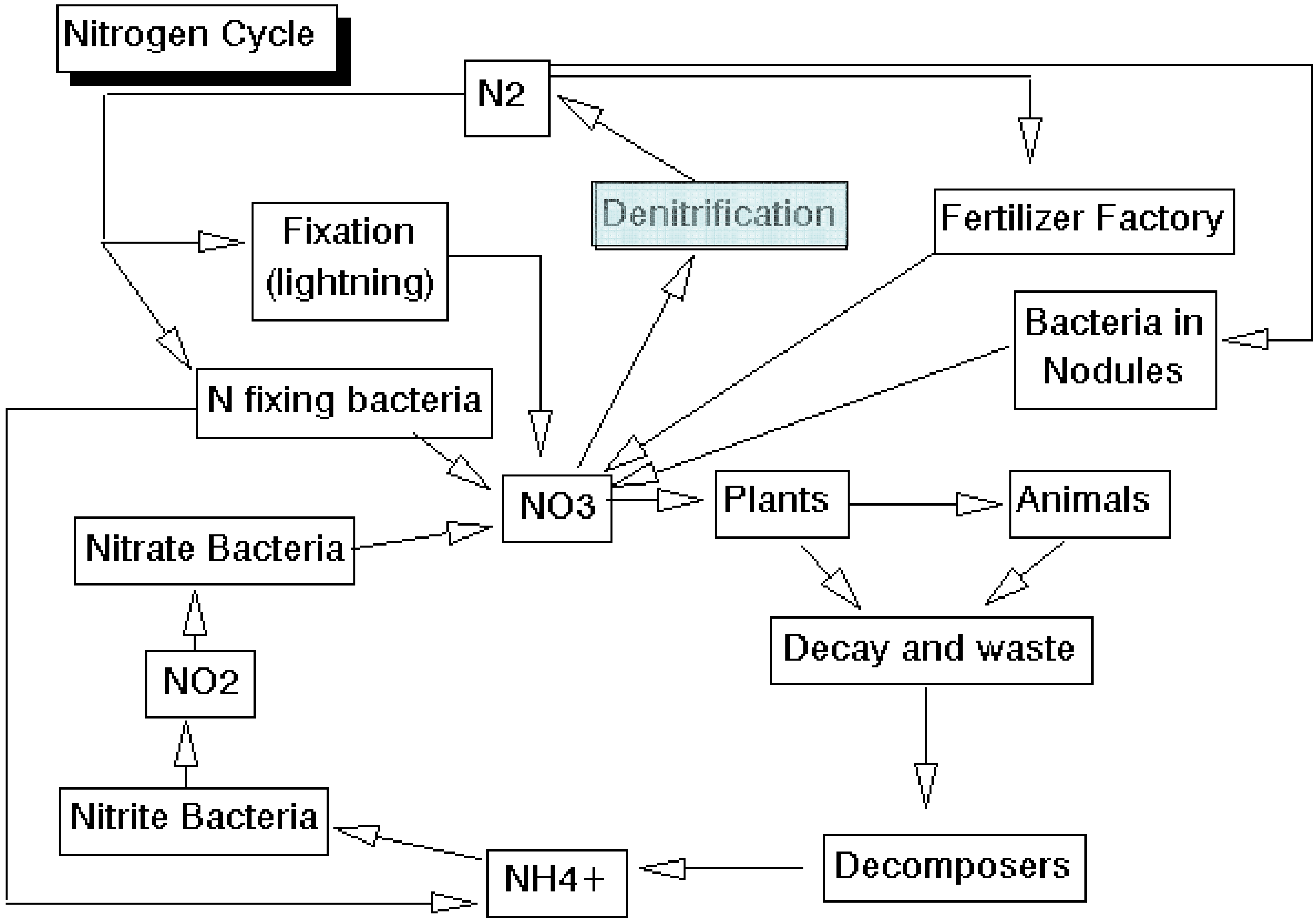
How far upstream can we track nutrient influences?

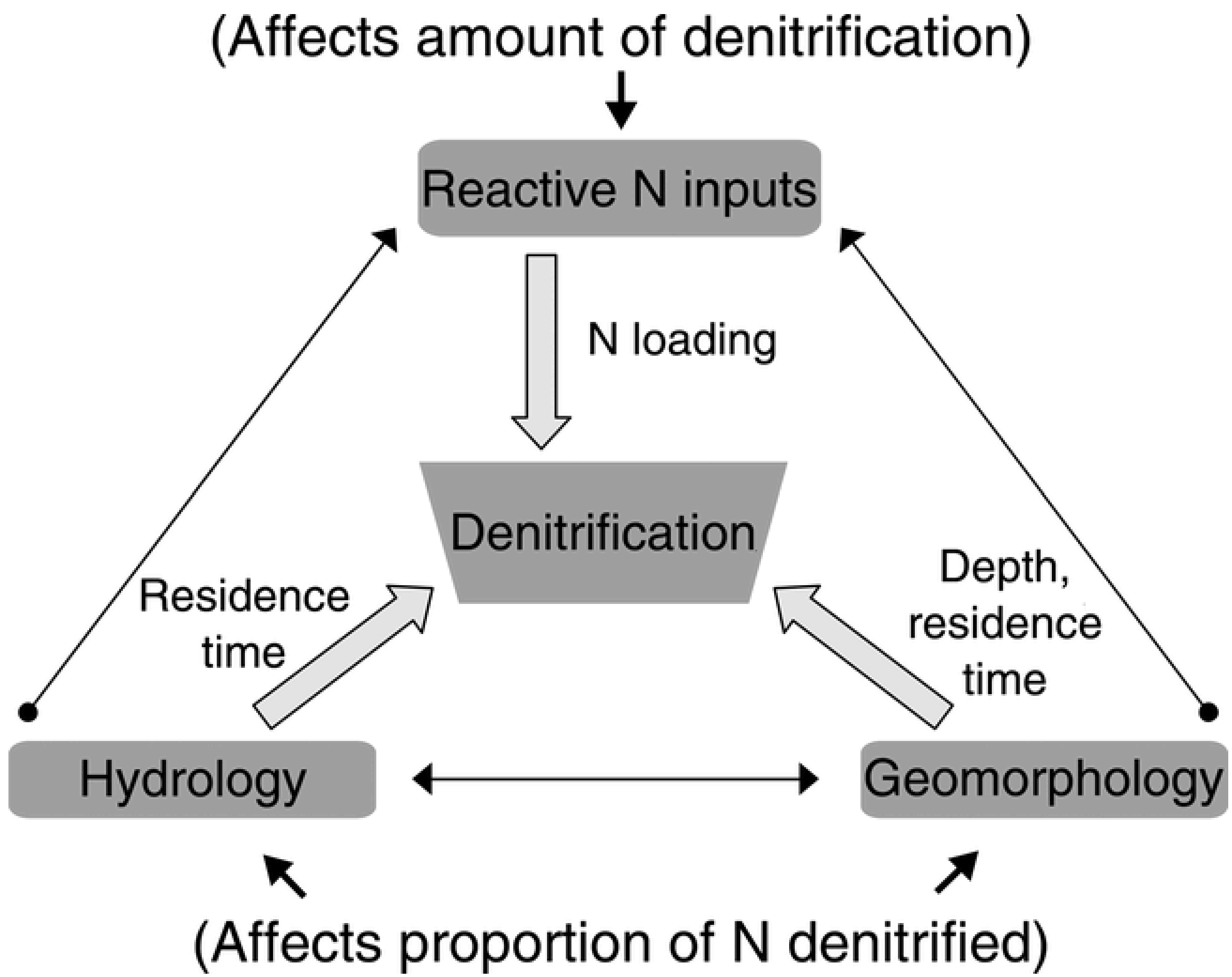
Interval (km)	Critical D-W	D-W NOx	D-W NH_3	D-W Ln_N	D-W SRP	D-W Ln_P
0-40	1.36	***1.16***	1.40	***1.16***	***1.16***	***1.17***
0-57	1.36	***1.16***	1.40	***1.16***	***1.16***	***1.17***
0-65	1.36	***1.23***	***1.24***	***1.24***	***1.24***	***1.24***
0-73	1.36	1.83	2.16	1.95	2.89	2.79
0-81	1.36	1.83	2.16	1.95	2.79	2.79
0-162	1.54	1.68	***1.19***	1.83	1.84	1.90
0-400	1.49	1.86	1.89	2.35	1.55	2.03
0-800	1.62	1.80	2.02	1.84	***1.52***	1.86
Entire (1300-1500)	1.69	2.14	***1.54***	***1.23***	1.84	2.07

Based on Durbin-Watson test for 1^{st} order autocorrelation

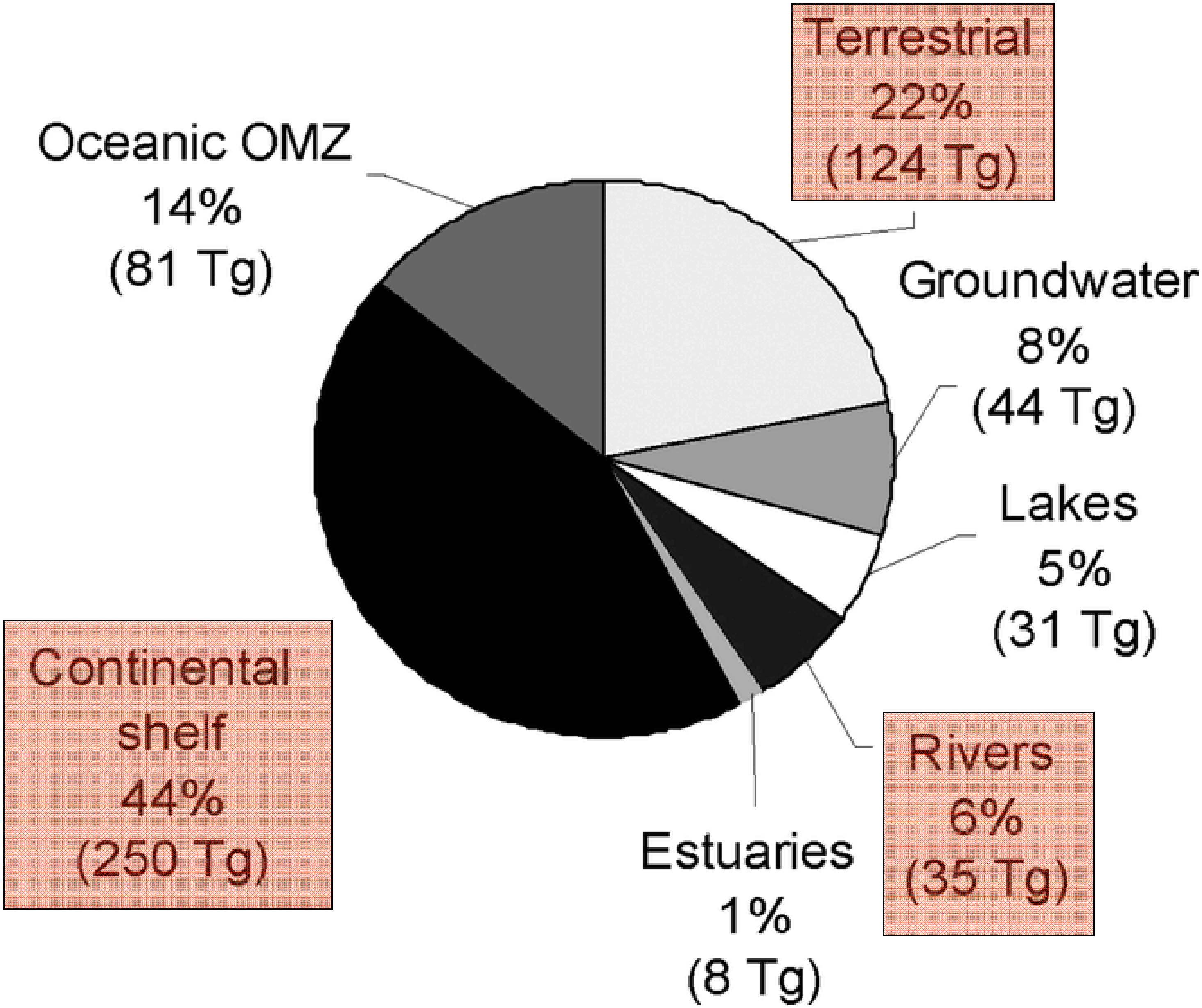
Microbial Enzyme Stoichiometry




Nitrogen Cycle
N2
Fixation (lightning)
Denitrification
Fertilizer Factory
Bacteria in Nodules
N fixing bacteria
NO3
Plants
Animals
Nitrate Bacteria
Decay and waste
NO2
Nitrite Bacteria
NH4+
Decomposers



Seitzinger et al. 2006. *Ecological Applications 16(6):2064-2090*



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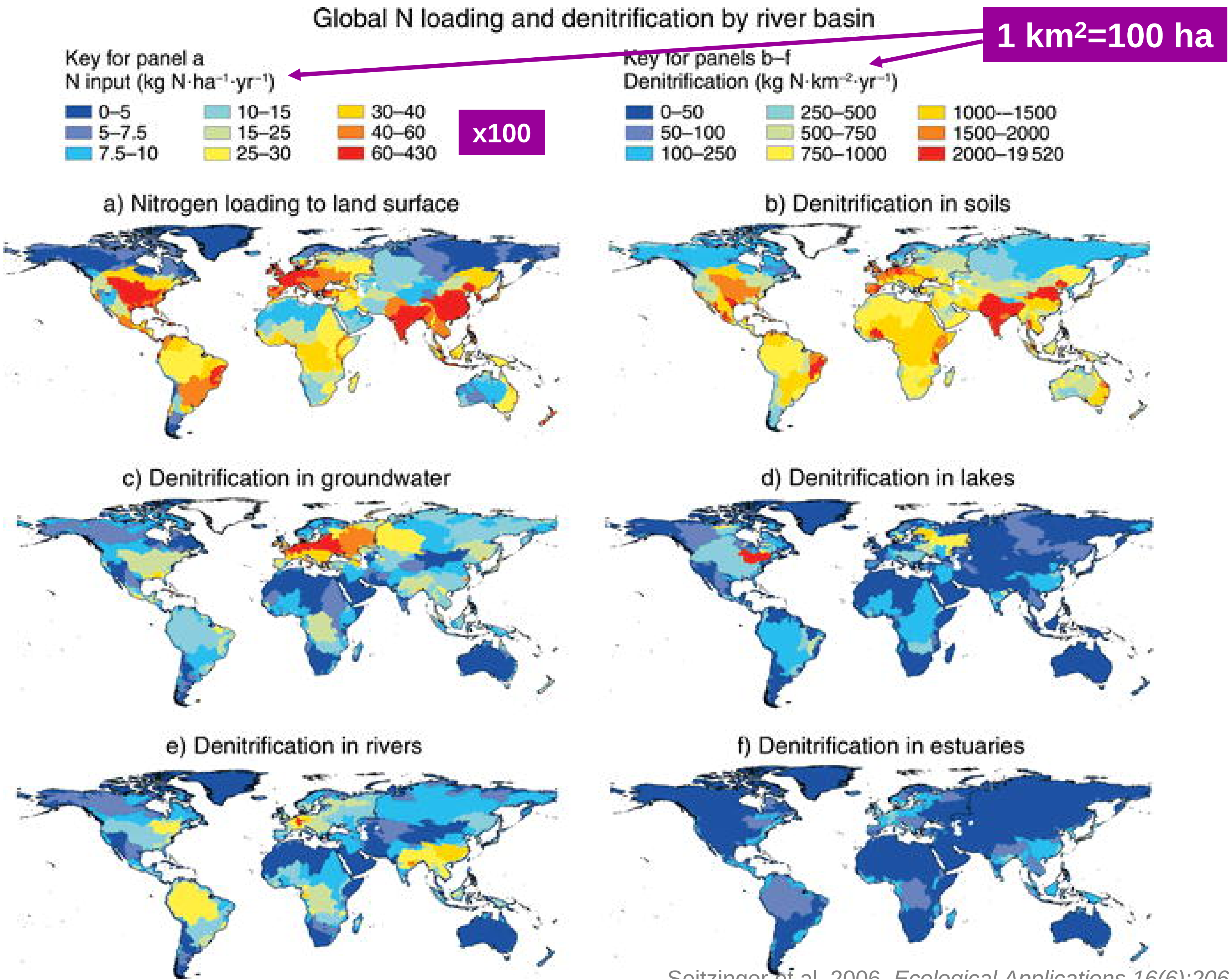

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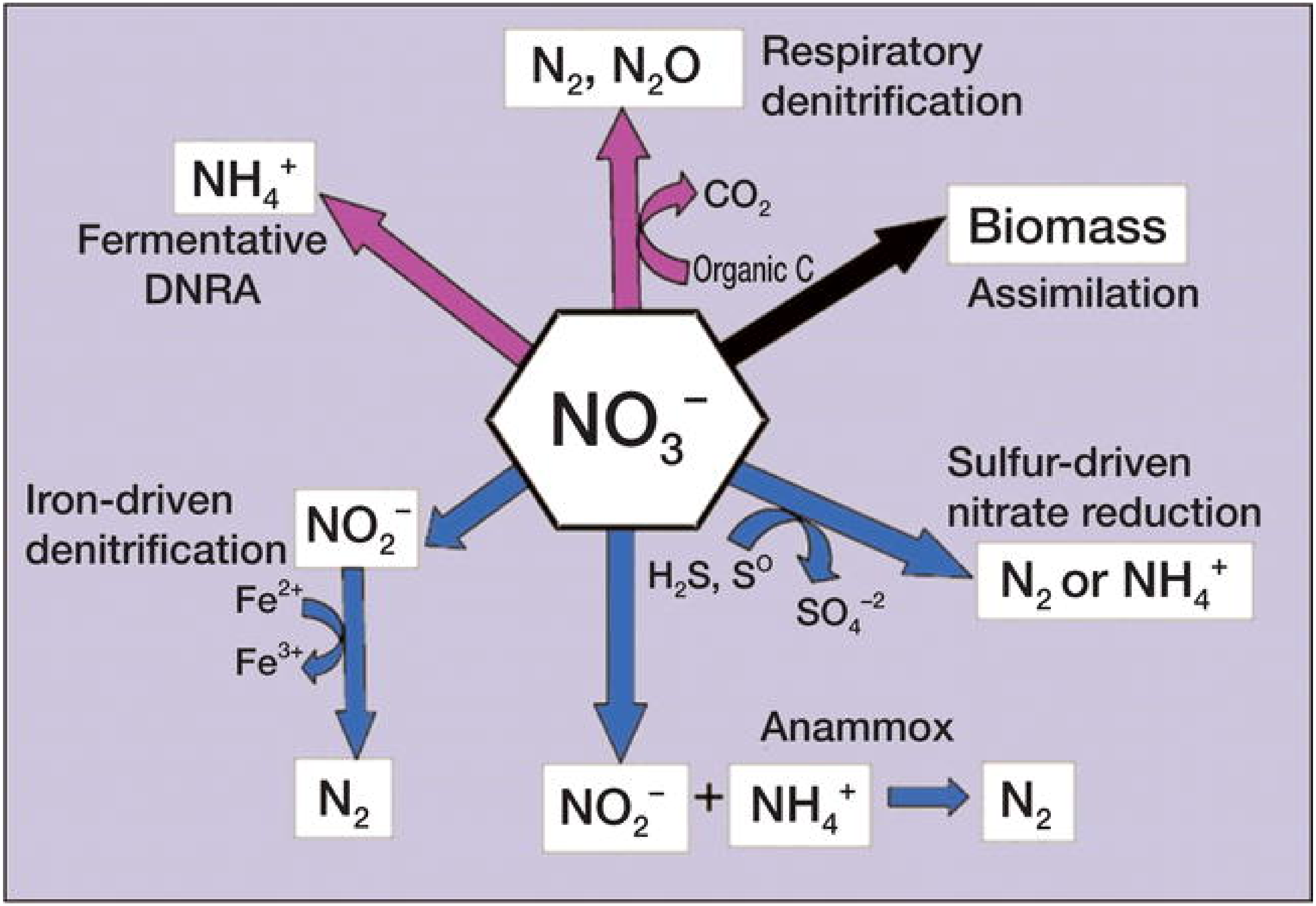
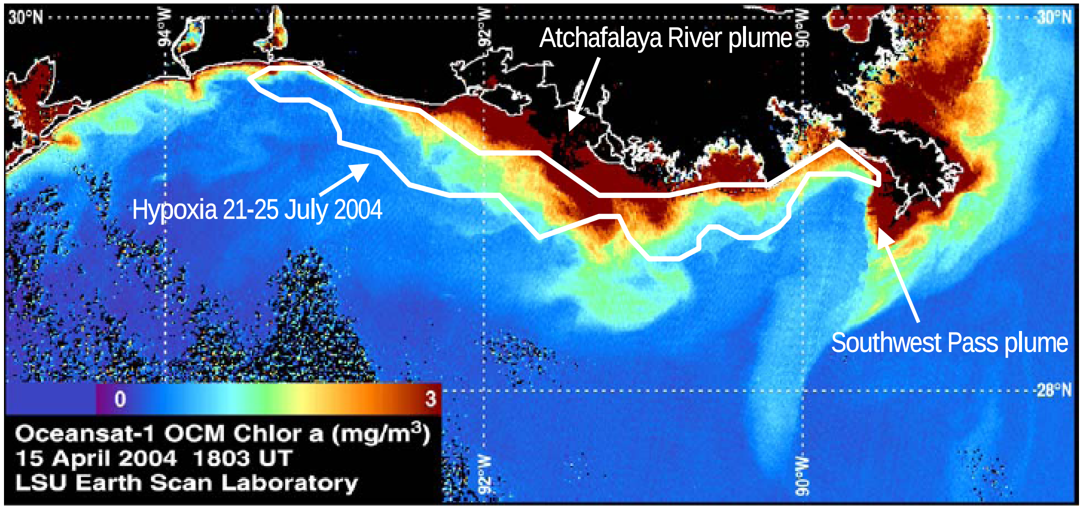
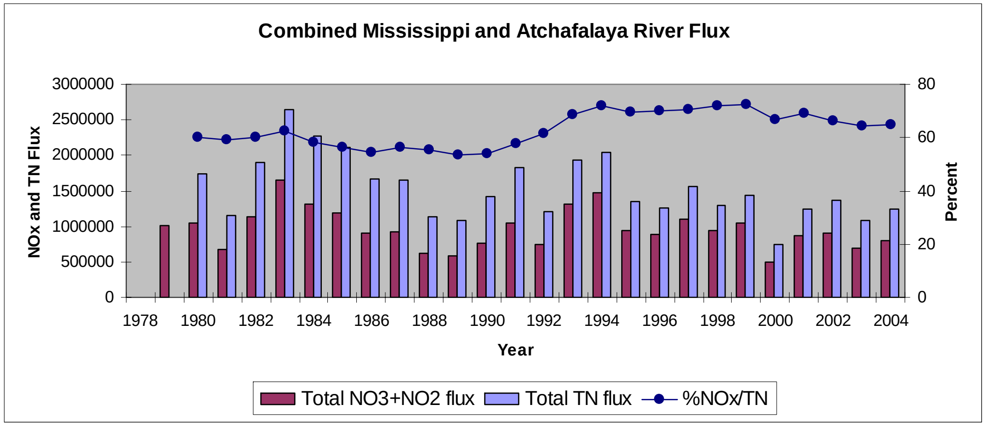


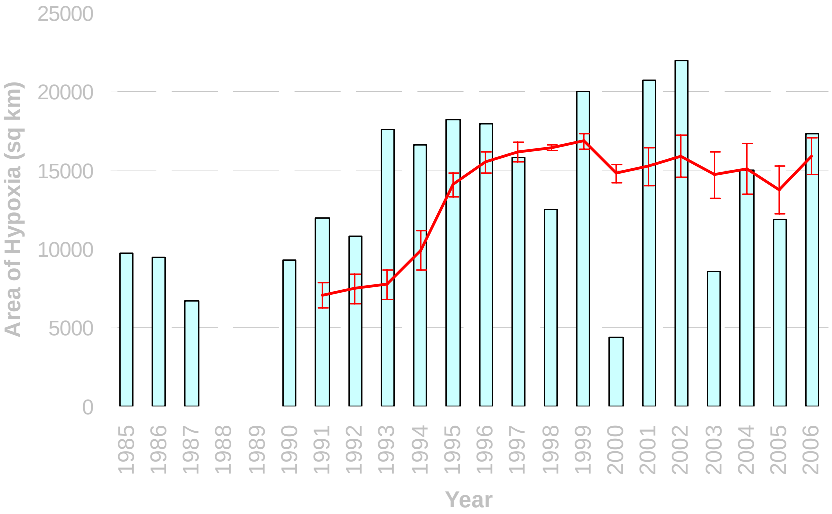
Burgin & Hamilton 2007, *Frontiers in Ecology and Environment 5 (2):89-96*

Hypoxia in the Gulf of Mexico—

Linking watersheds, drainage networks and receiving waters

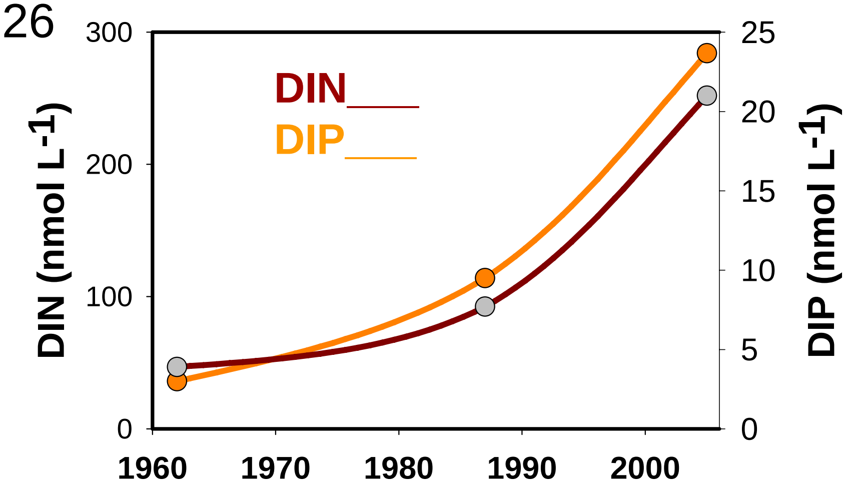


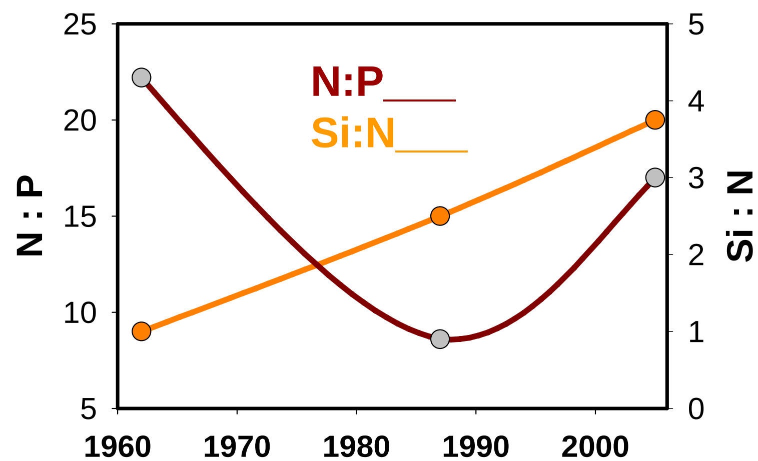




Compared to prior study

		MS	*MO*	*OH*
This study	DIN	**287**	155	157
	DIP	**21**	17	4
	DSi	205	188	39
	N:P	**20**	11	76
	Si:N	3	14	0.4
	Si:P	14	80	26
Justic et al. (1995)				
1981-87 data		DIN	**114**	
	DIP	**8**		
	DSi	108		
	N:P	**15**		
	Si:N	1		
	Si:P	14		
1960-62 data	DIN	**36**		
	DIP	**4**		
	DSi	160		
	N:P	**9**		
	Si:N	4		
	Si:P	40		





Conclusions

- N & P were positively correlated with % of watershed in agriculture
- N & P loads fit a simple regression model based on cumulative watershed area
- Disparity between basin-wide projections of N & P and the sum of sub-basin models—suggesting other sources (e.g., point sources) & losses (e.g., N & P sequestration, denitrification)
- Serial correlation of N & P with river distance suggests that spiral lengths (sum of transport in water and bed phases) may be > 65km
- N:P in the tributaries and in the Great Rivers suggest N-limitations relative to available P concentrations
- Microbial enzyme activity associated with the acquisition of C, N & P also suggests N-limitation, along with C-limitation (indicative of nutrient enrichment)