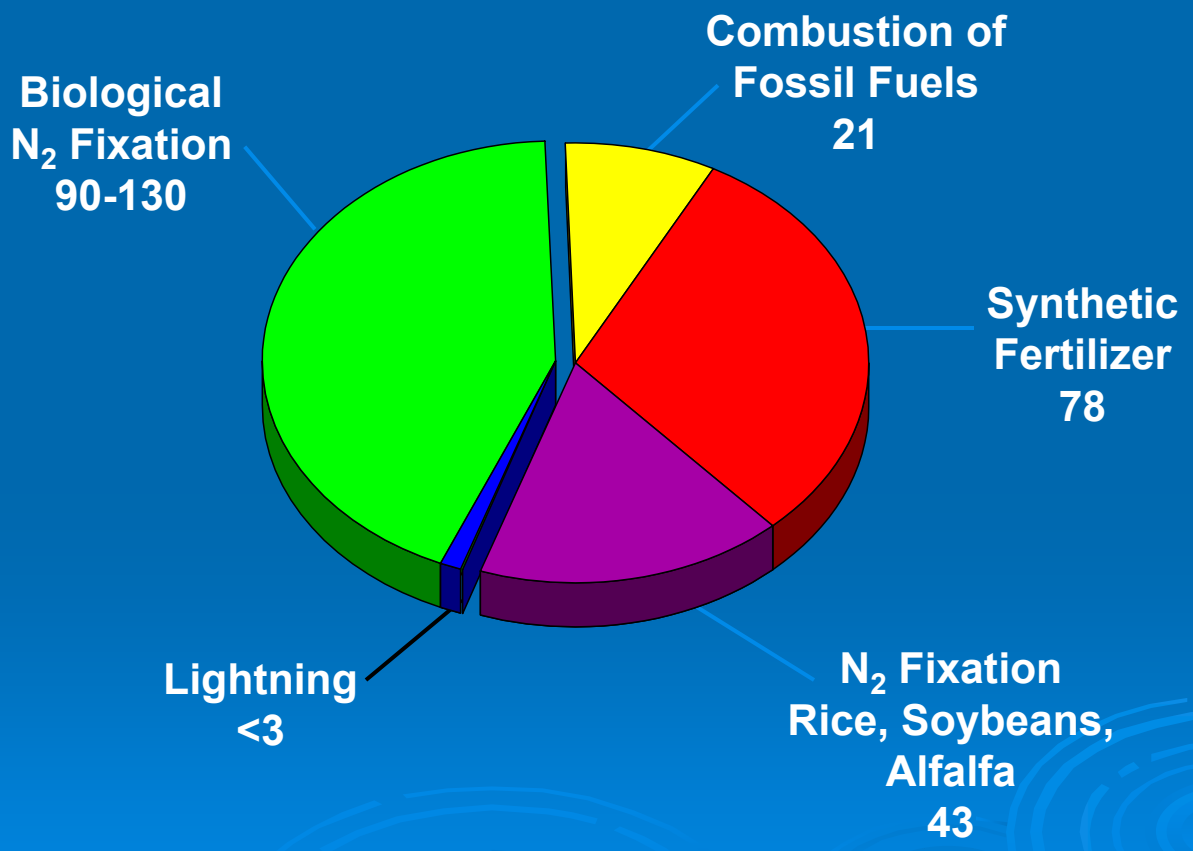
Current N Inputs to Terrestrial Systems

~250 Tg N y^{-1}



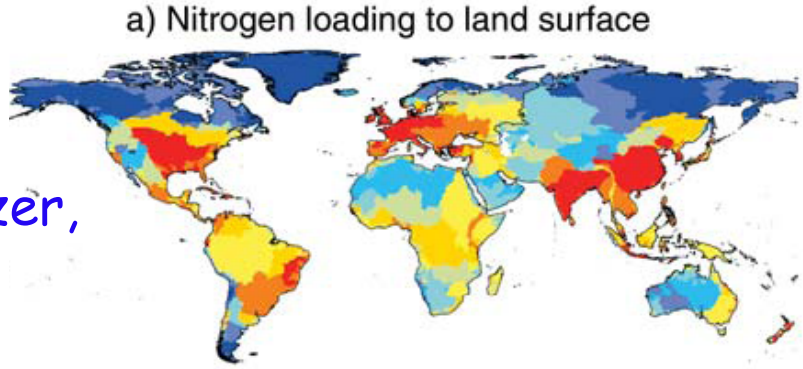
Tg = 10^{12} g

Galloway *et al*, 1995

Integrating Landscapes to Waterscapes

~250 Tg N/y

Land-based N Inputs
(BNF, synthetic fertilizer,
Atmos. Dep. N)



Terrestrial → Rivers → Estuaries → Ocean Margins → Oceanic

Global NEWS Model

Nutrient Export from WaterSheds

	Dissolved		Particulate
	Inorganic	Organic	
N	DIN	DON	PN
P	DIP	DOP	PP
C		DOC	PC
Si	(DSi soon)		

12 papers *Global Biogeochemical Cycles*, special section Dec. 2005

Overview

- Global N, P and C river transport from watersheds to coastal systems
  - Approach
  - Magnitude and spatial patterns
  - Drivers
- Effect of land-based nutrient inputs
- Fate of N input
- Atmospheric N deposition to coastal and oceanic systems
- Future directions

NEWS Model

Nutrient Sources

Natural
- N_2-Fixation
- P Weathering

Anthropogenic
- Non-Point
  - Fertilizer (by crop type)
  - N_2-fixation - crops
  - Atmos. Dep. N
  - Manure (by animal species)
- Point
  - Sewage (pop.; treatment level)

Hydrology & Physical Factors

Global Watersheds
- Water Runoff
- Precip. Intensity
- Land-use
- Slope

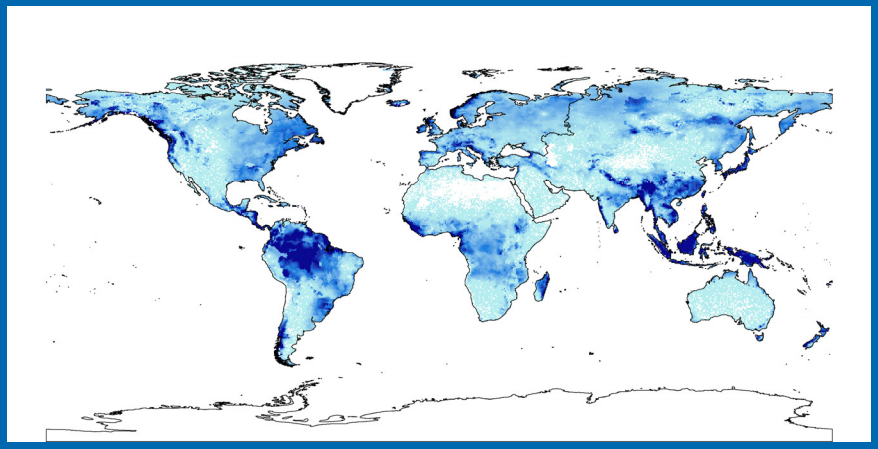
In-River N & P Removal

Rivers & Reservoir
- Consumptive Water Use

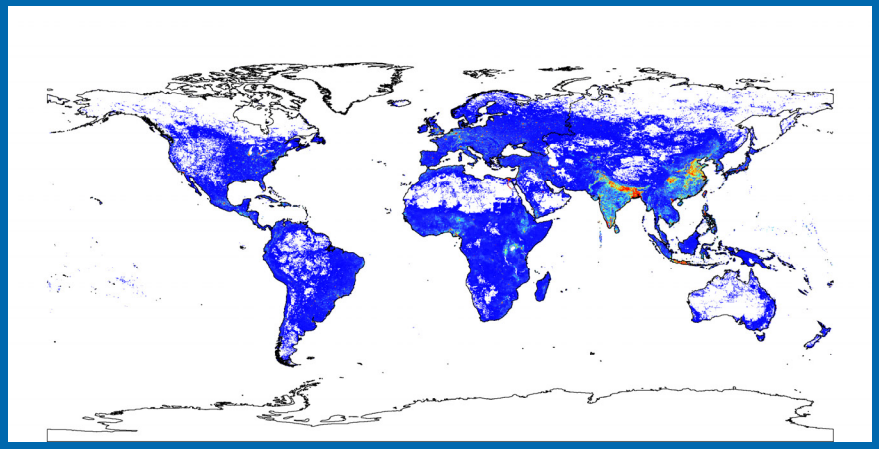
>4500 watersheds globally

A Few Model Input Datasets

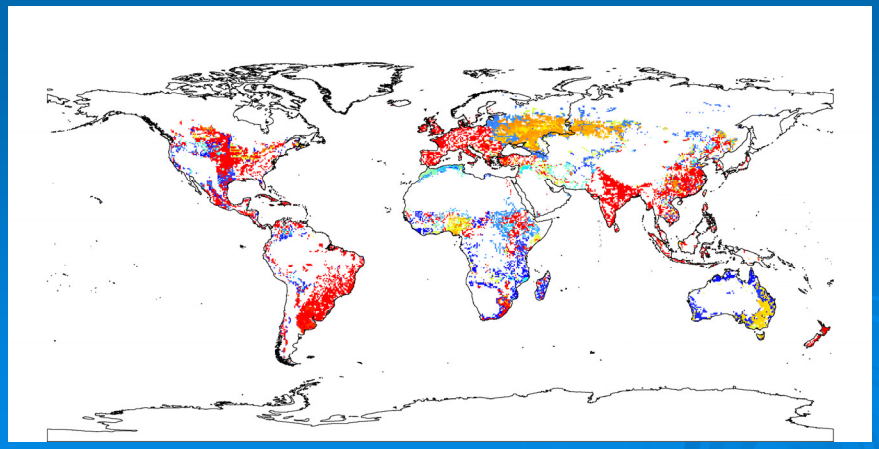
Runoff



Population Density



Fertilizer P input



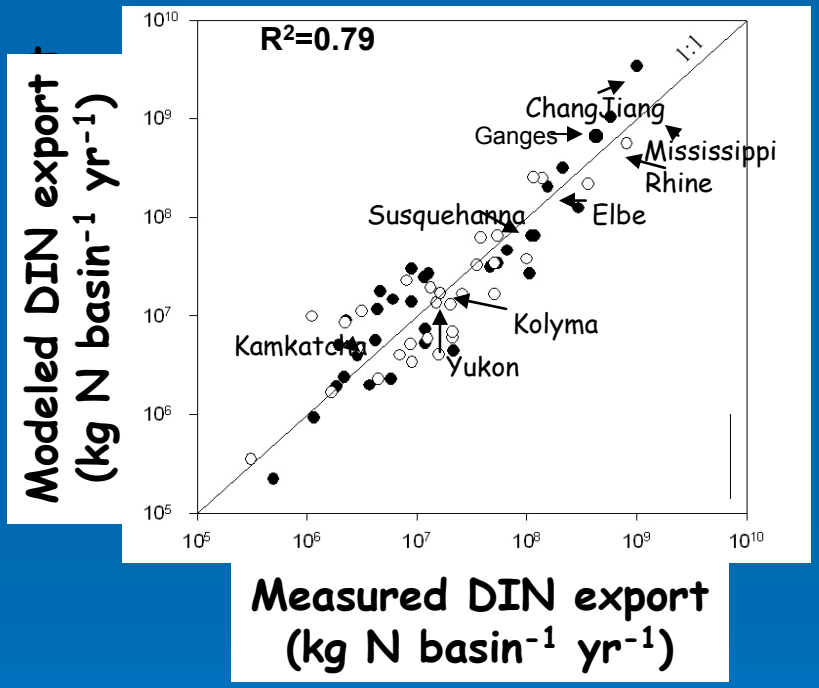
Annual
0.5 x 0.5 degree
>4500 watersheds

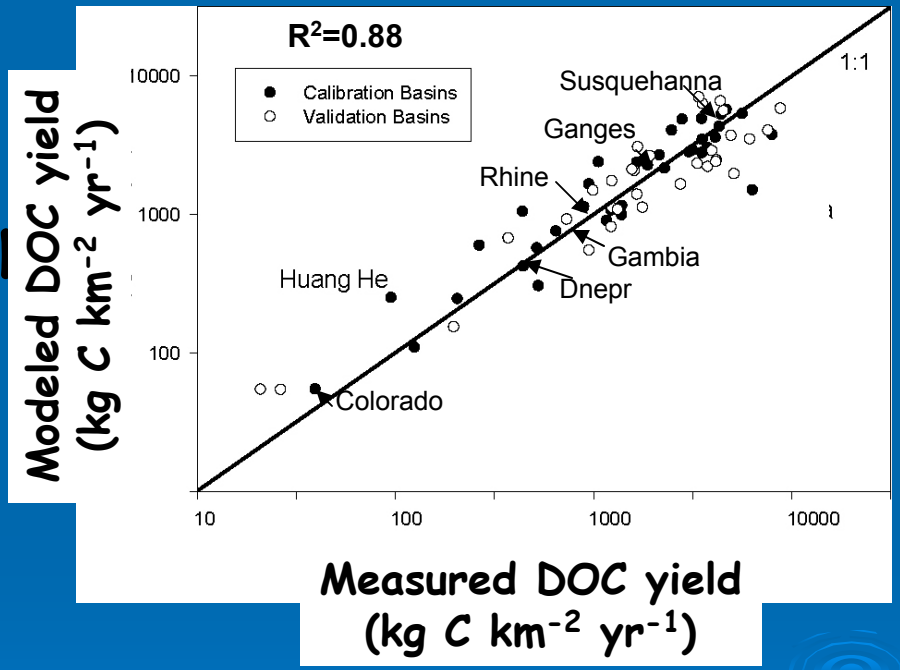
River Export

	Dissolved		Particulate
	Inorganic	Organic	
N	DIN	DON	PN
P	DIP	DOP	PP
C		DOC	PC
Si	(DSi soon)		

12 papers *Global Biogeochemical Cycles*, special section Dec. 2005

Comparison of Model Predicted vs Measured River Transport

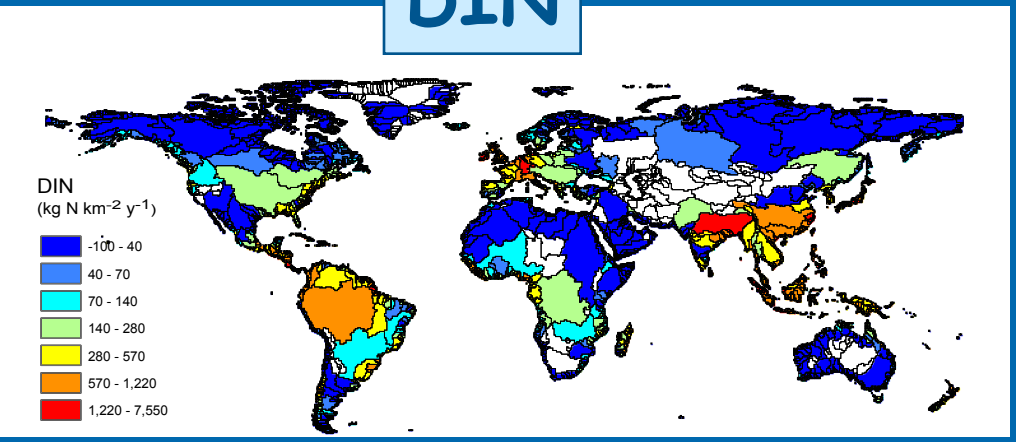




Global Patterns of Export

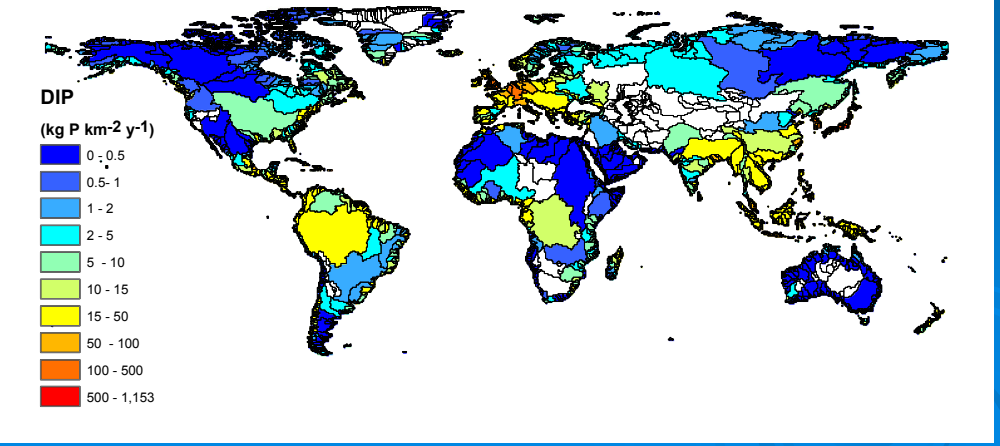
Yield – kg N or P km^{-2} y^{-1}

DIN



Dumont, Harrison, Kroeze, Bakker & Seitzinger GBC 2005

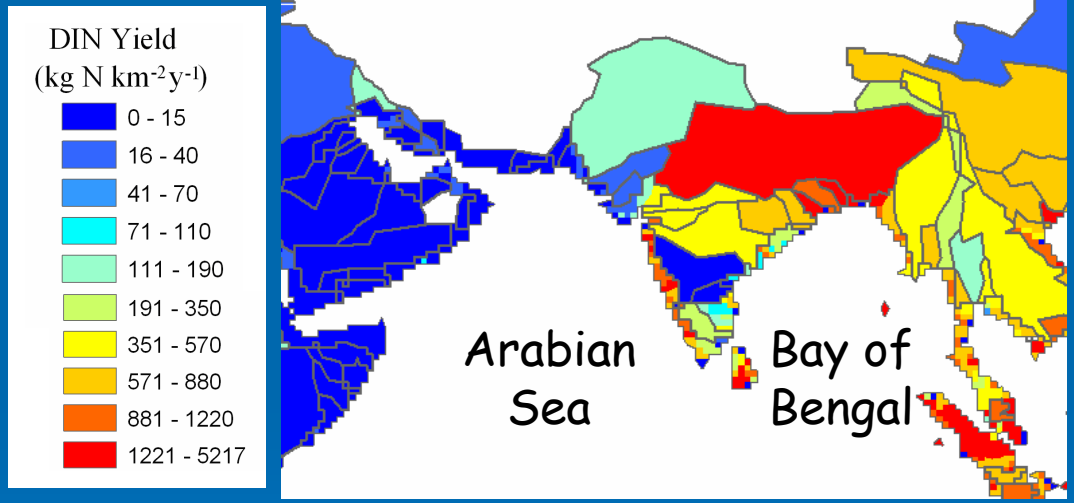
DIP



Harrison, Seitzinger, Bouwman, Caraco, Beusen & Vörösmarty GBC 2005

Regional Analysis
DIN Export by Rivers

(kg N/km2 watershed/yr)

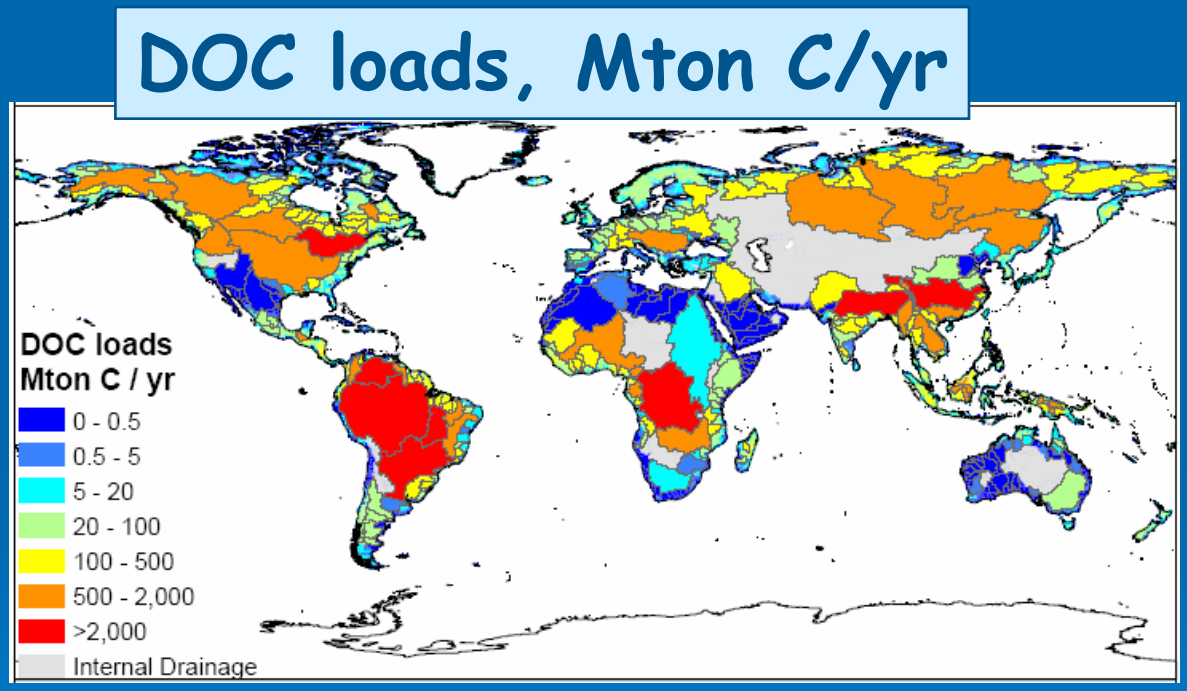


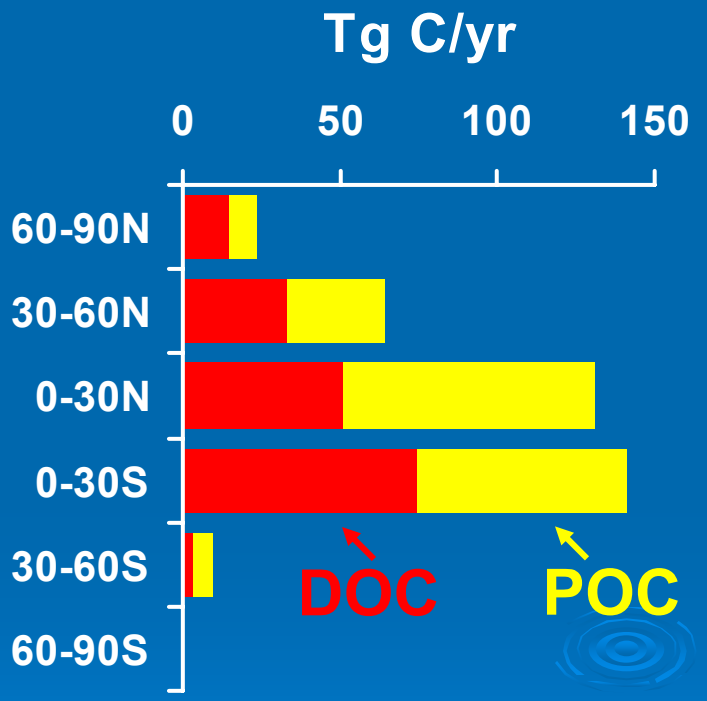
494 3,600

Total Export – 10^9 g DIN/yr

- Ganges/Brahmaputra accounts for 60% of river DIN load to BB
- DIN load to BB+AS accounts for 20% of total global DIN export

DOC and POC Loads by Latitude



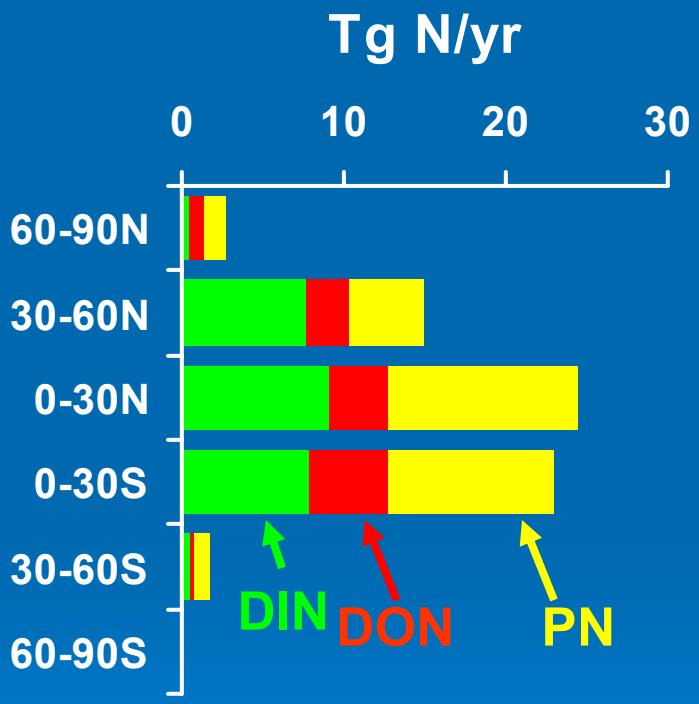


75% of TOC enters in tropical latitudes

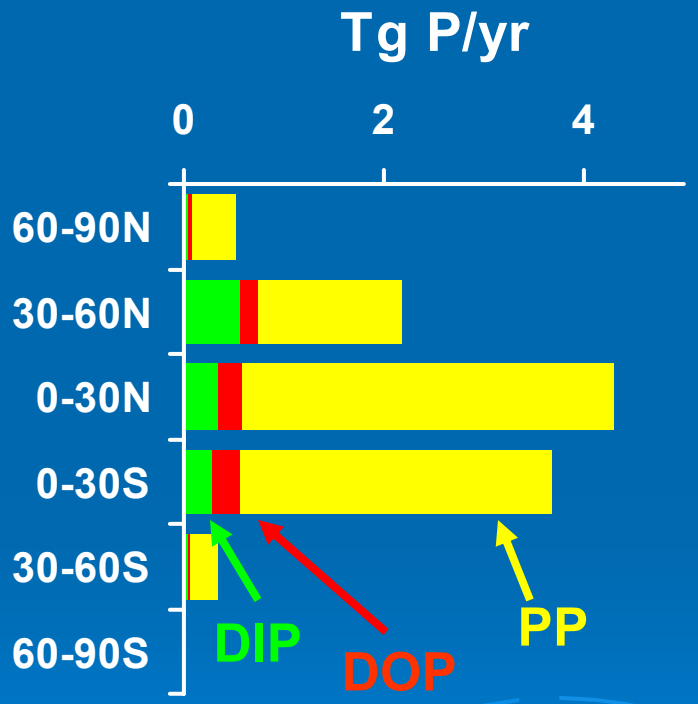
Totals DOC 170 Tg

POC 197 Tg

N and P River Export by Form by Latitude

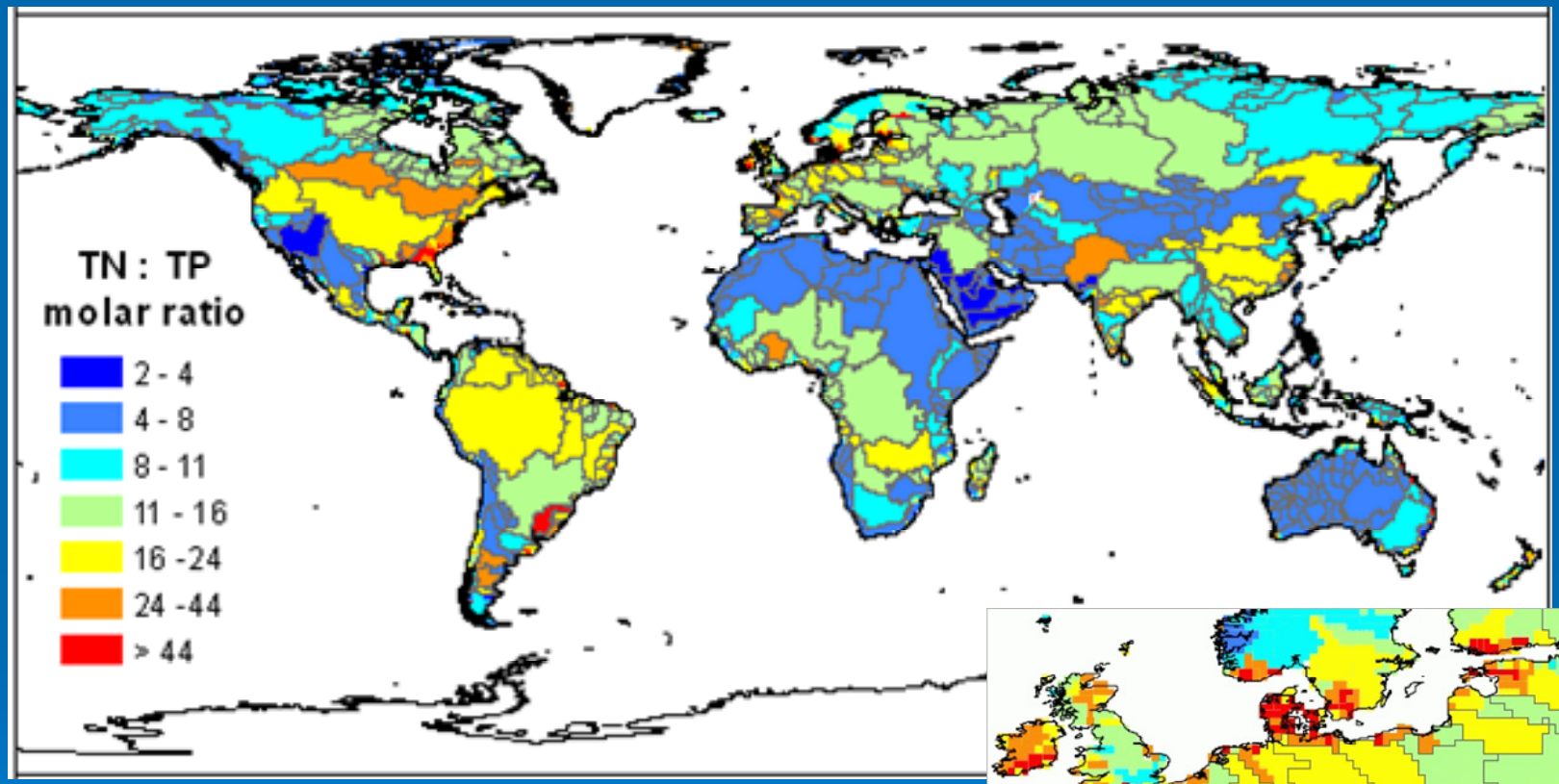


71% tropics



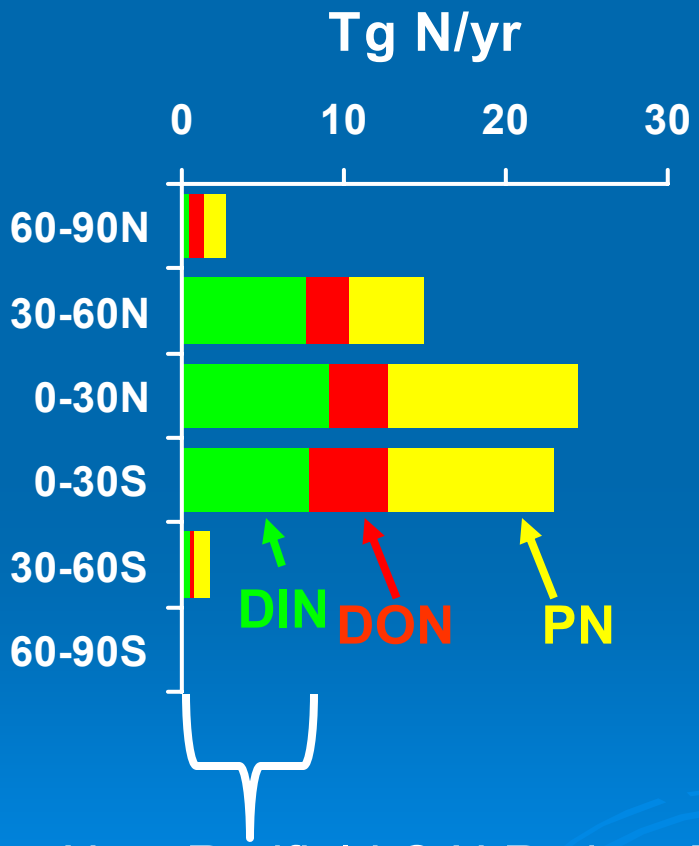
83% tropics

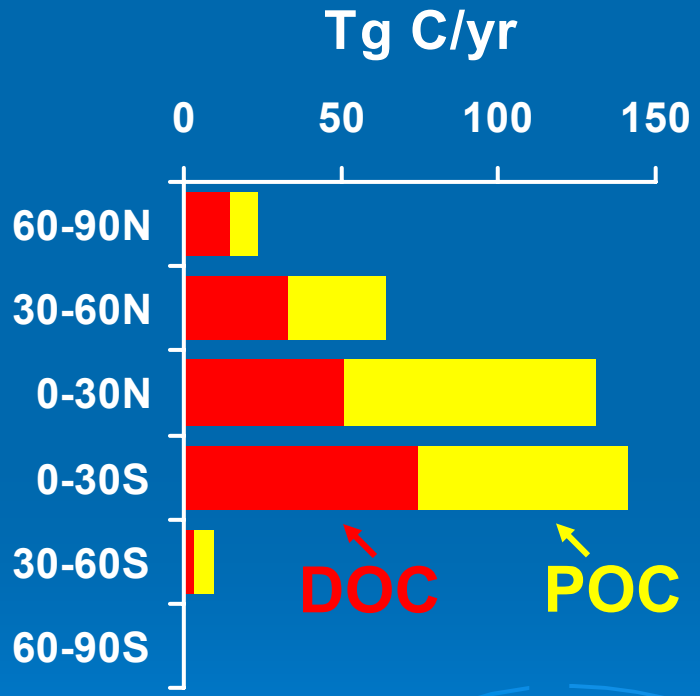
TN:TP River Export



Mayorga et al. in prep.

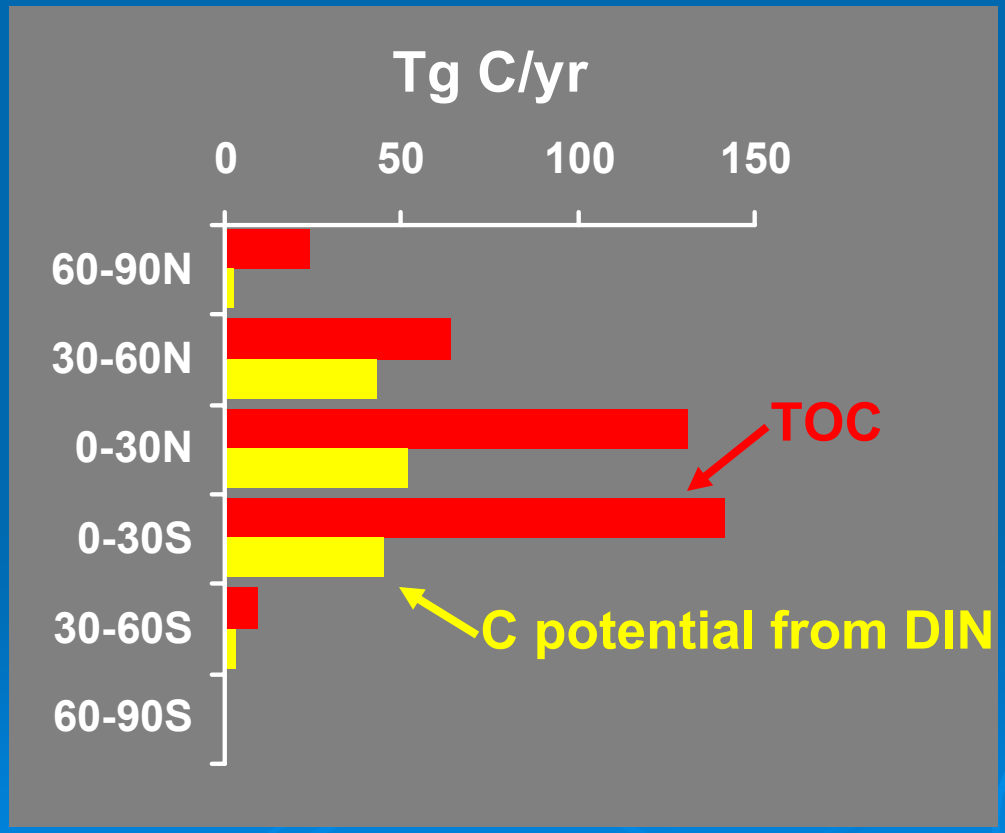
N and C River Export by Form by Latitude





N x Redfield C:N Ratio = Potential C Production

Amount of OC Delivered Rivers = 2-3x Amount of OC that Could be Produced from DIN Delivered by Rivers



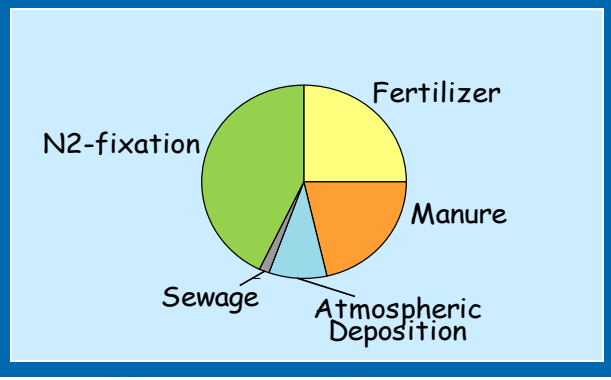
Nutrient Sources and Hydrology

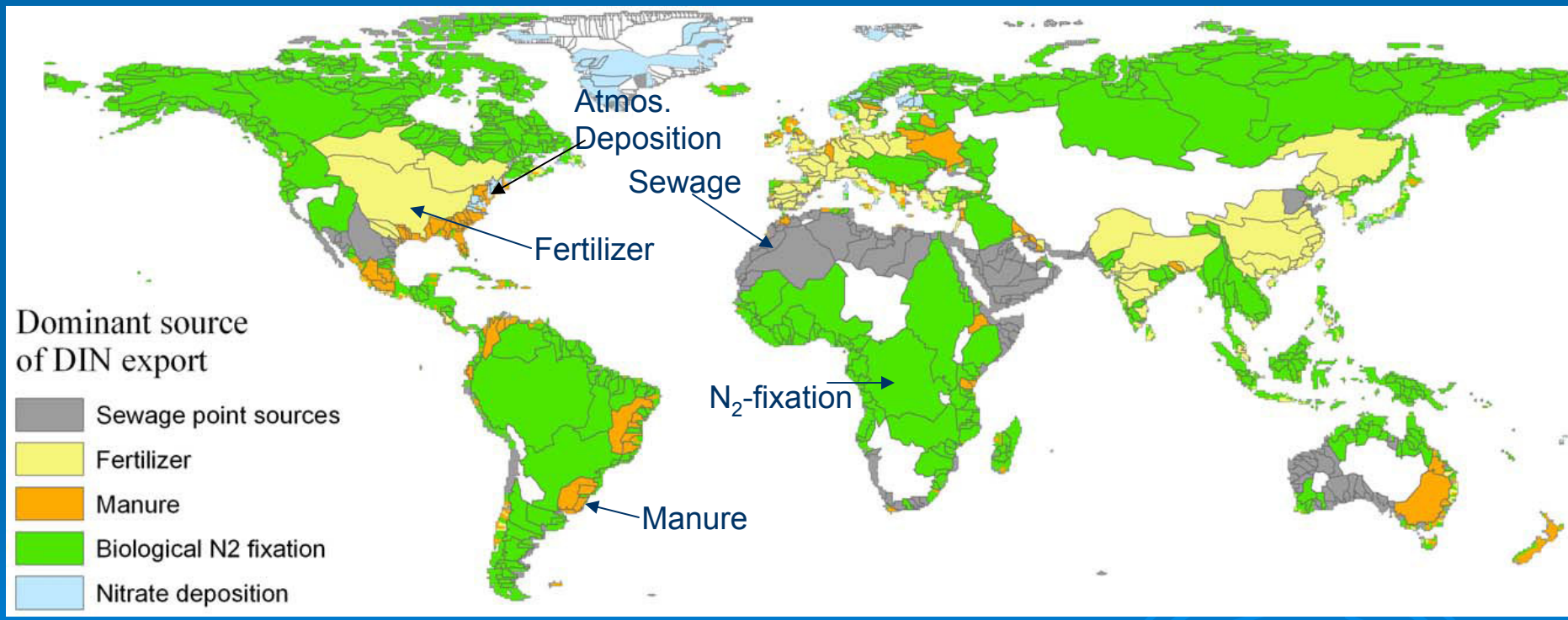
Why might you care about nutrient sources in watersheds and watershed hydrology?

Scenarios for future conditions –

- climate change hydrology
- development scenarios

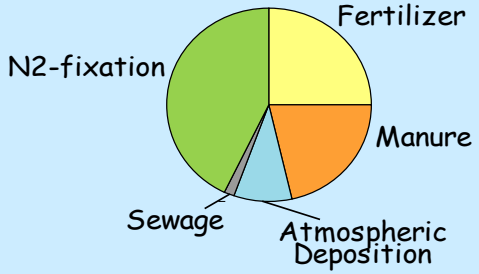
DIN Export Variation in Dominant Source

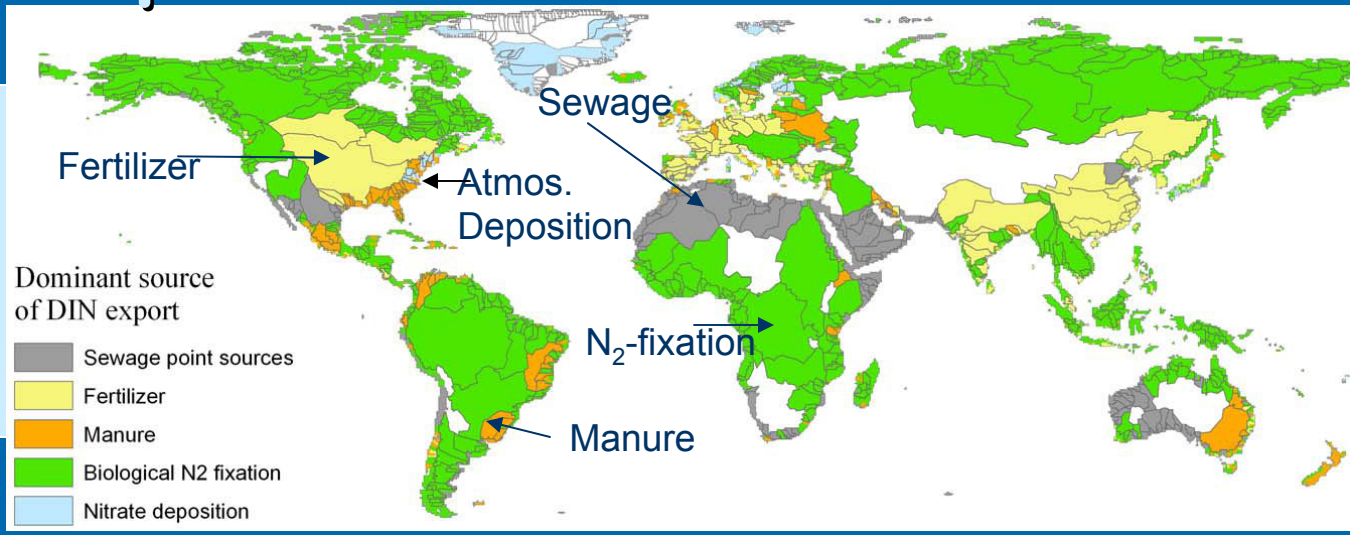




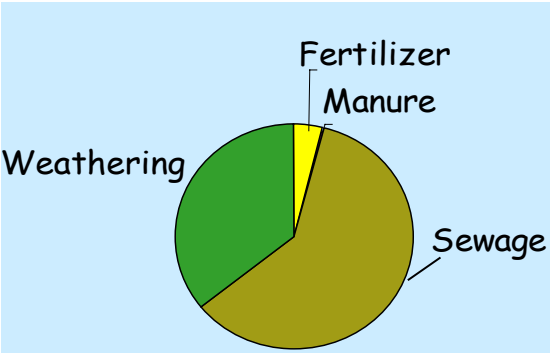
From: Dumont, Harrison, Kroeze, Bakker & Seitzinger GBC 2005

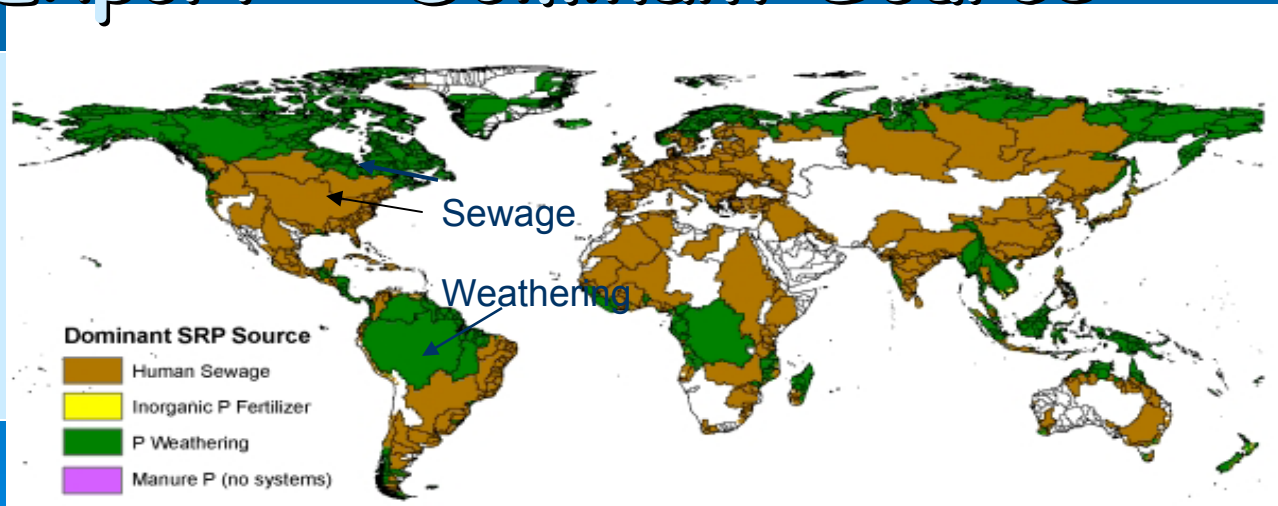
DIN Export --Dominant Source





DIP Export --Dominant Source

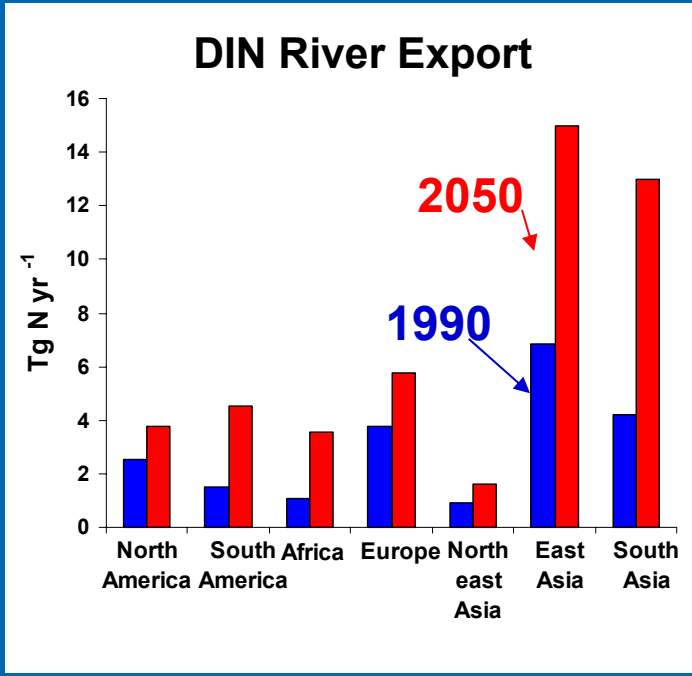




From: Dumont et al. 2005 and Harrison et al. GBC 2005

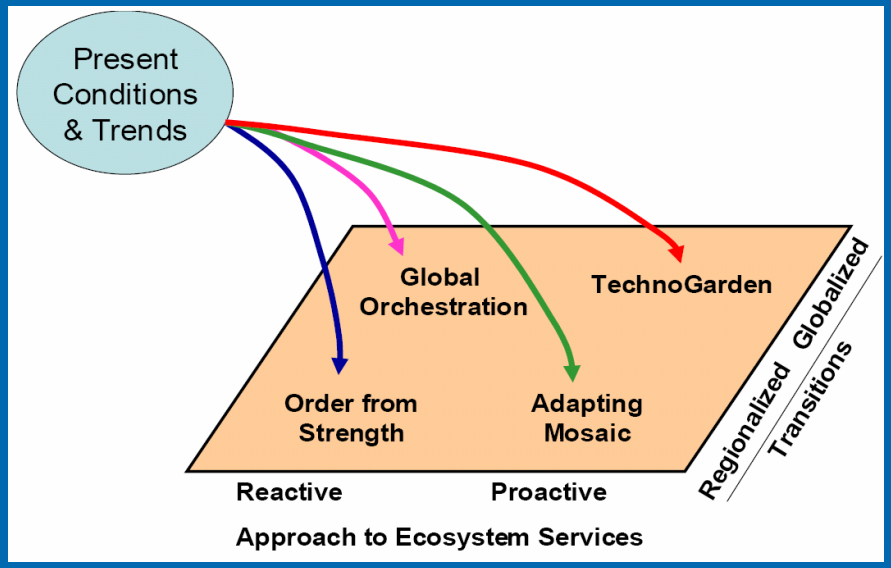
Scenarios

Business-as-Usual



Kroeze & Seitzinger 1998
Seitzinger et al. 2002

Millennium Assessment Scenarios (2025 and 2050)



include social, economic, policy, and ecological considerations

Climate Change

effects on water runoff ⬆⬇

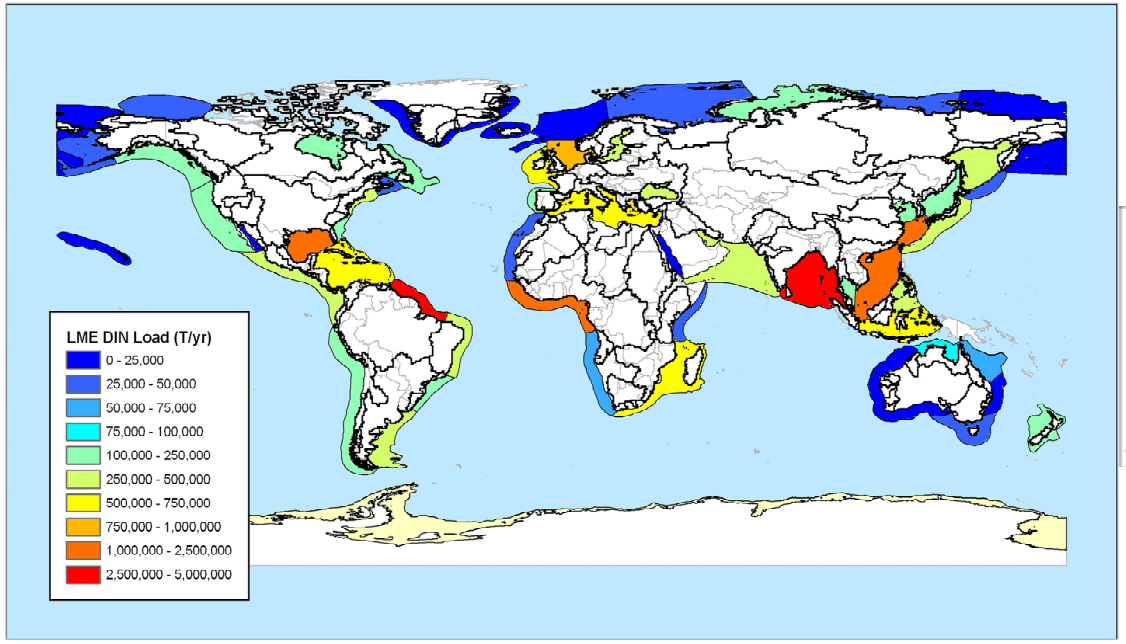
consumptive water use (irrigation)

Biofuels

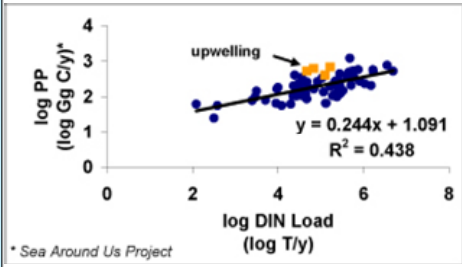
What is the Effect on Continental Shelf Primary Production of:

- N inputs from rivers?
- N removal by denitrification?

Modeled DIN load to Large Marine Ecosystems and Relationship with Primary Production

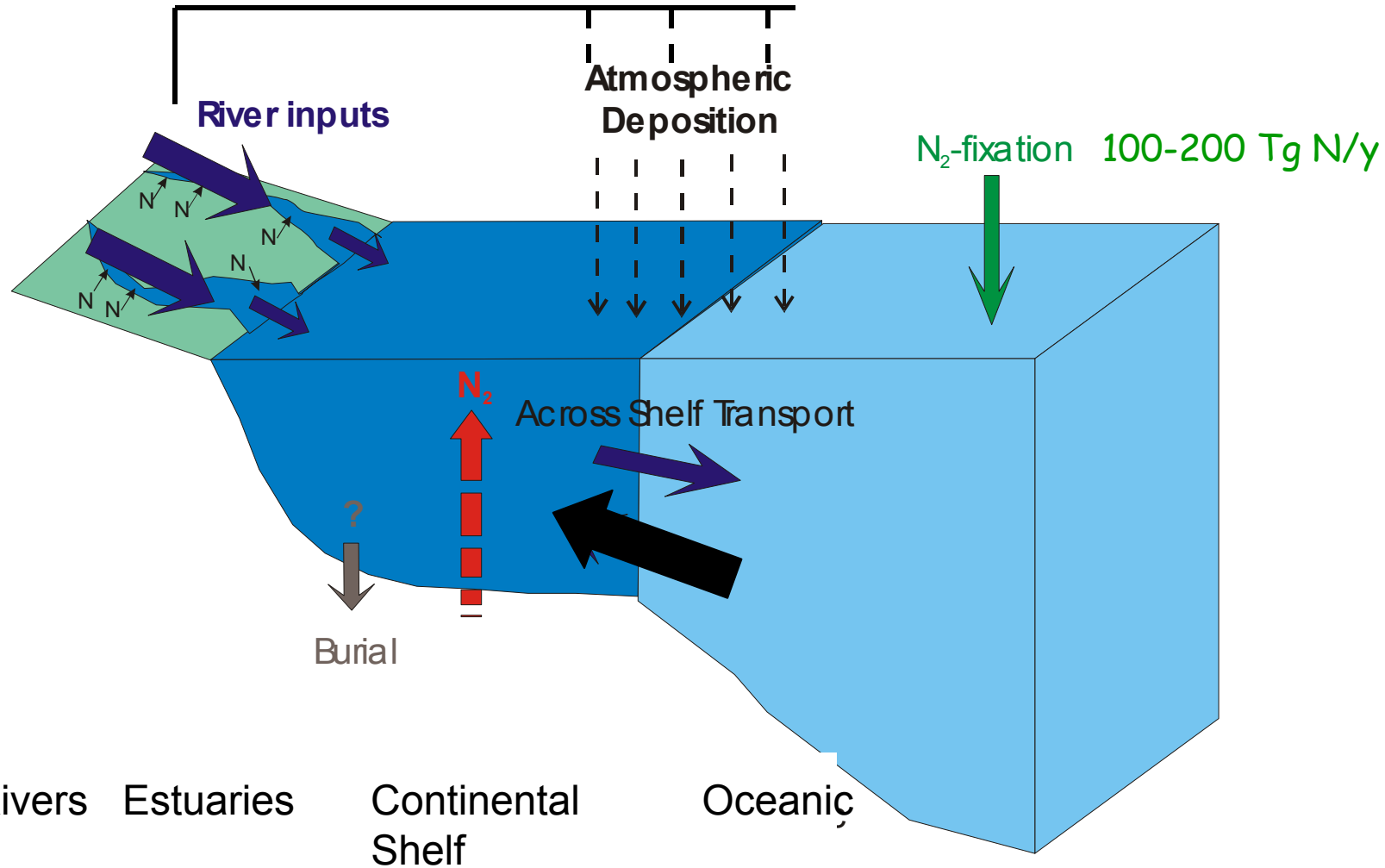


Primary production is related to DIN load across the 64 LMEs

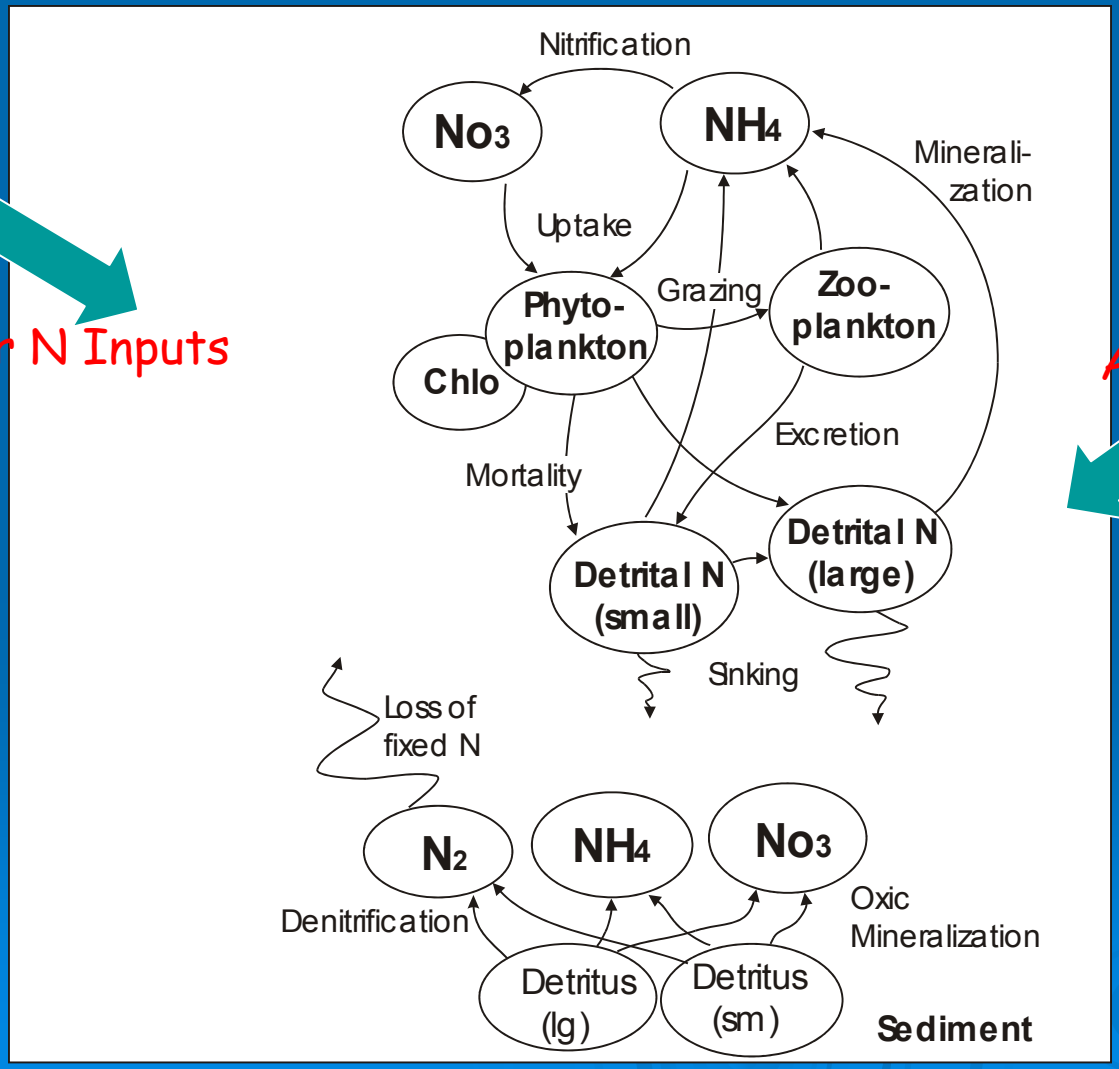


Rosalynn Lee and Seitzinger in prep.

N Inputs to Continental Shelf From Land and Marine Sources



Dynamic Biogeochemical/Hydrodynamic Model of the MAB
K. Fennel et al. 2006 GBC



River N Inputs

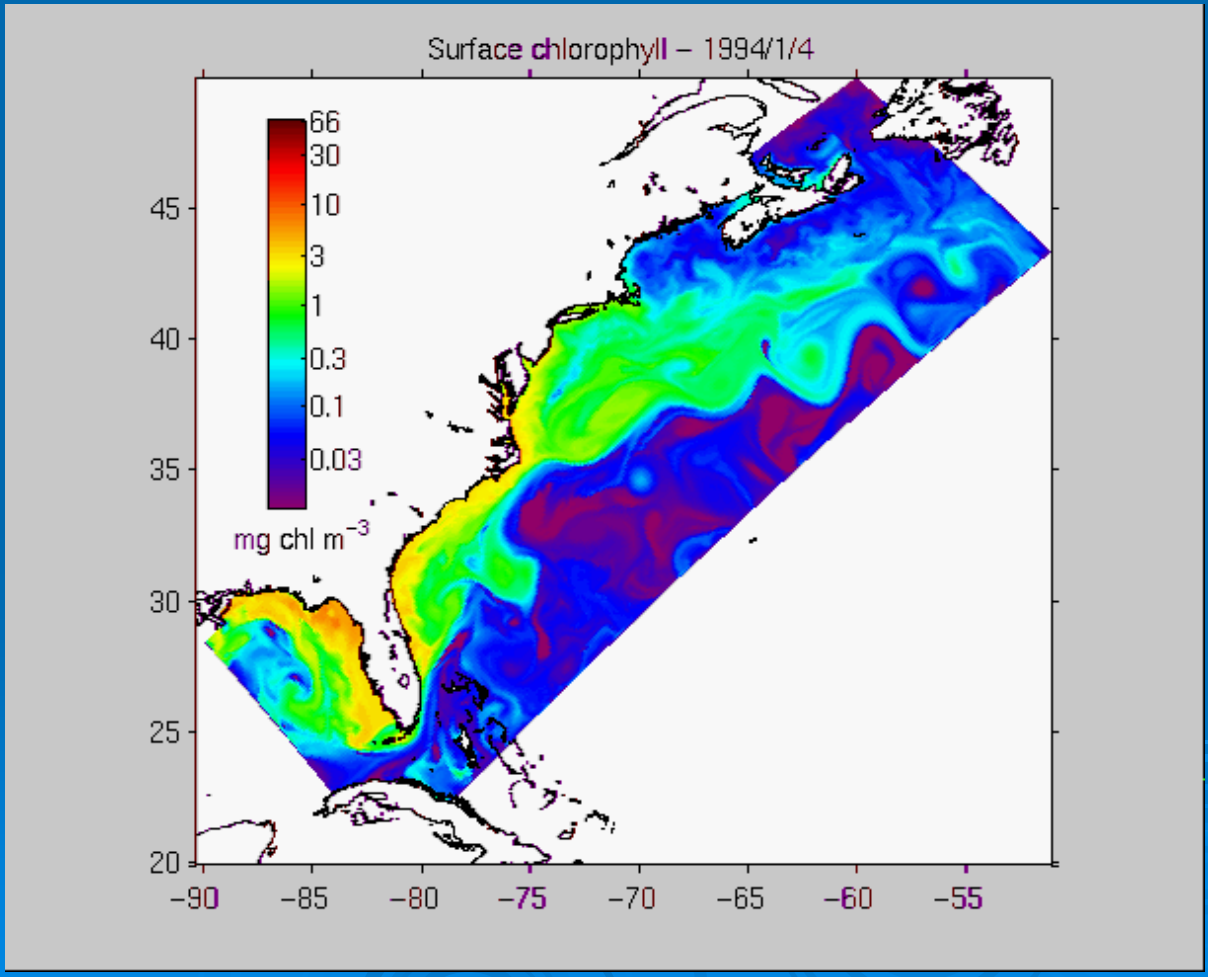
Across Shelf Transport

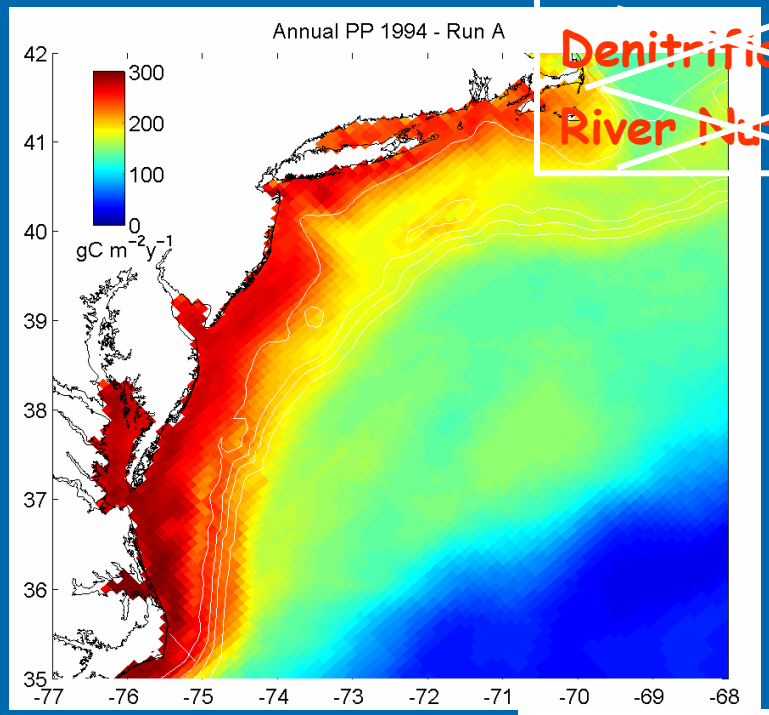
- N Based Plankton Model
  Fasham et al. 1990

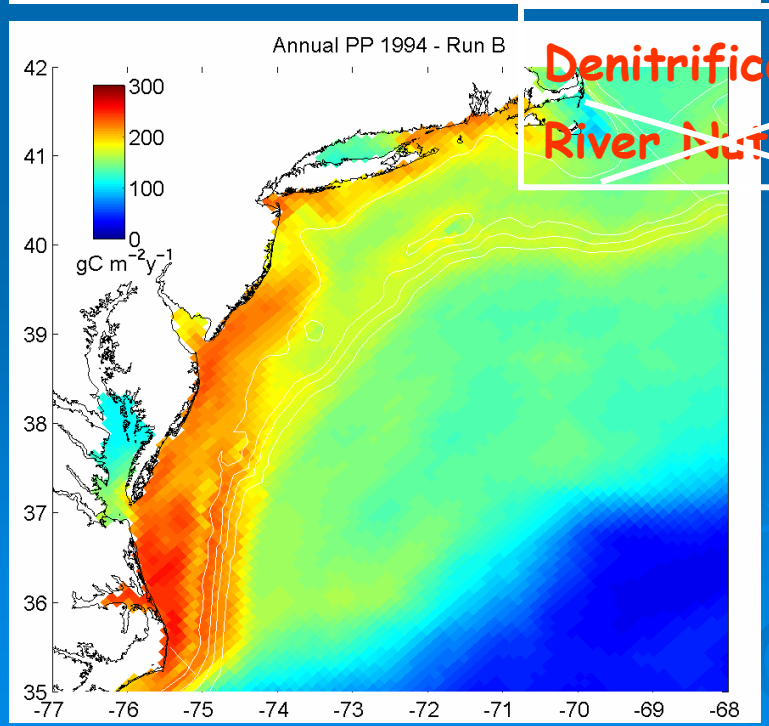
- Sediment Denitrification
  Seitzinger & Giblin 1996

Coupled Hydrodynamic/NPZ Model

K. Fennel et al., 2006





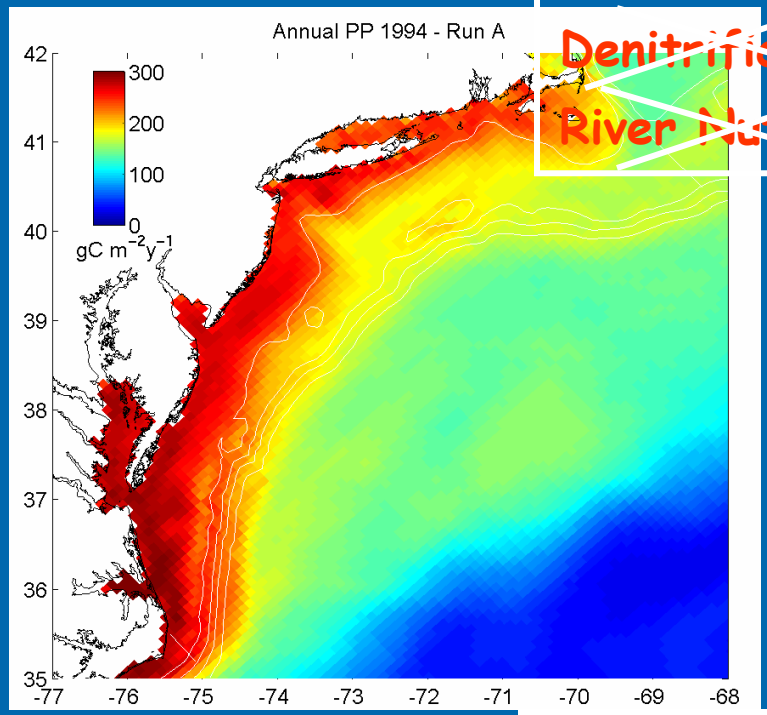


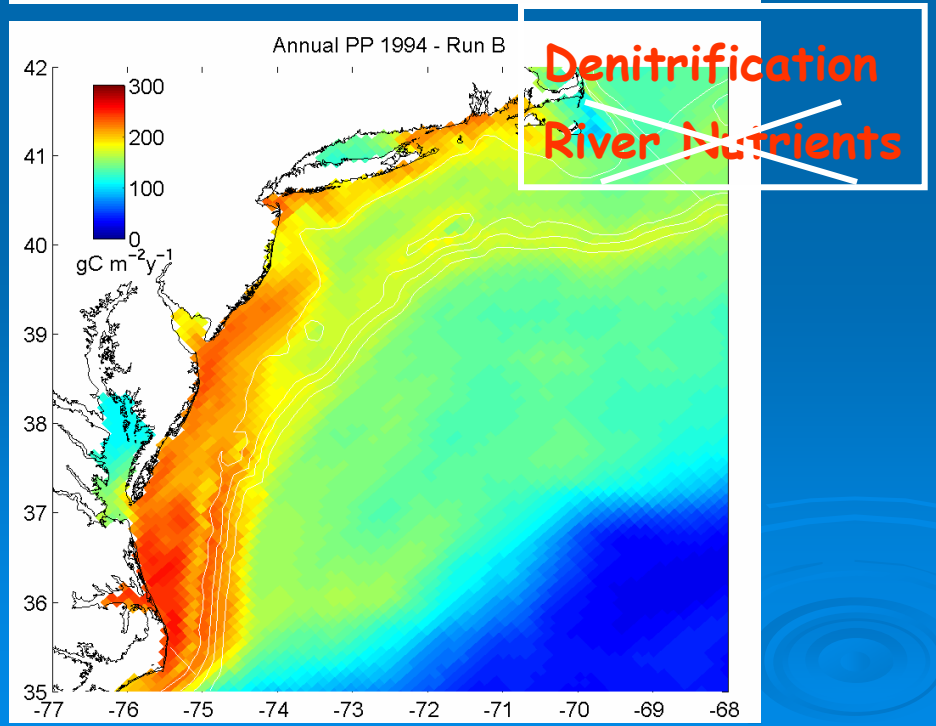
Annual Primary Production

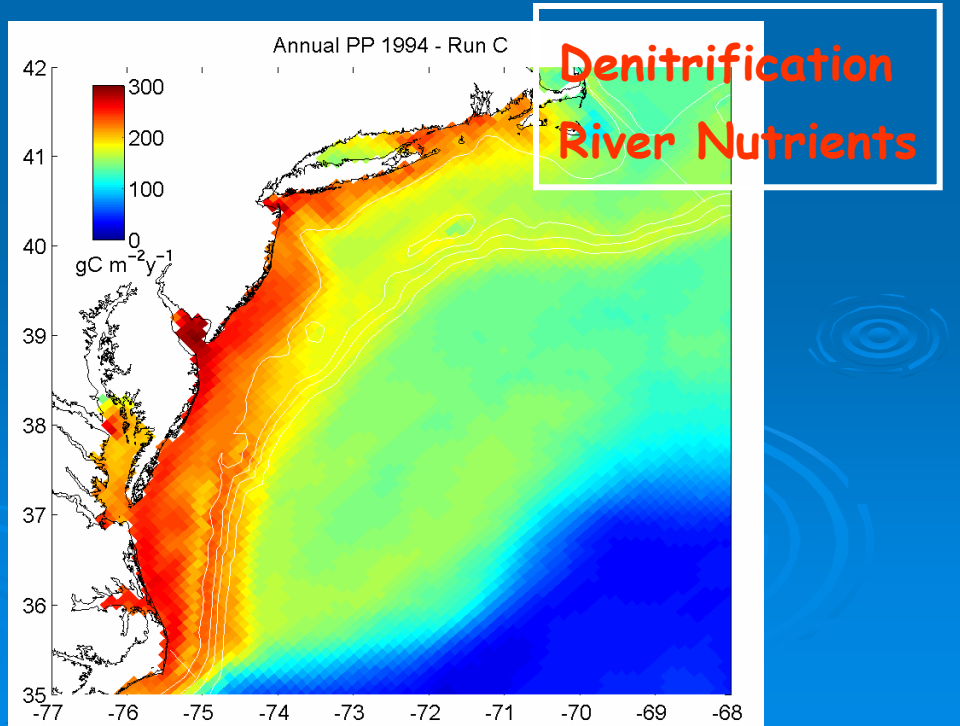
K. Fennel et al., 2006

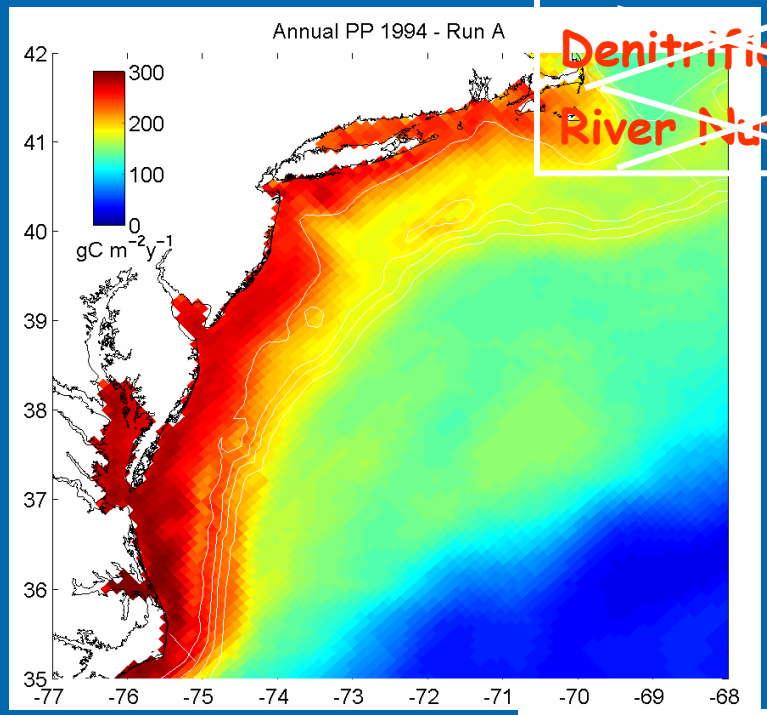
K. Fennel et al. GBC 2006

Annual Primary Production





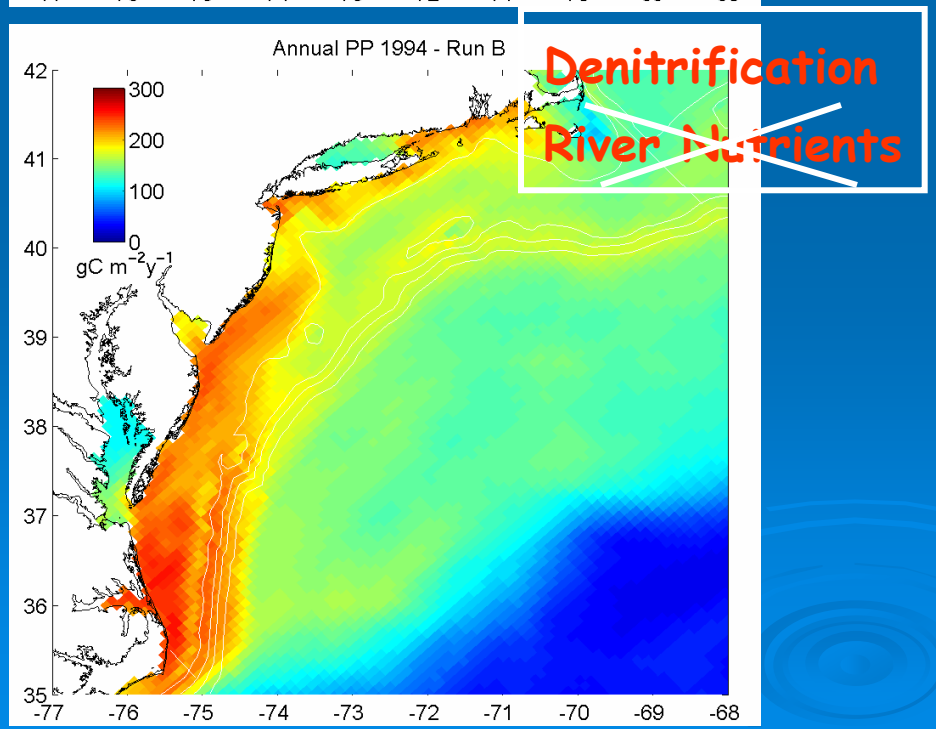


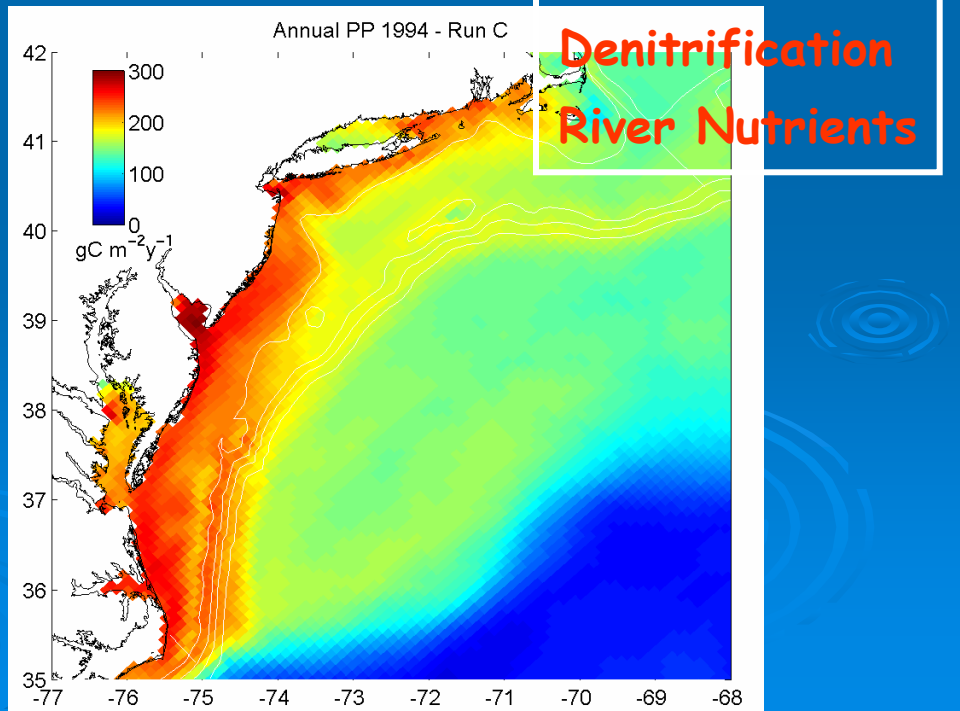


K. Fennel et al. GBC 2006

10^{10} mol N/y

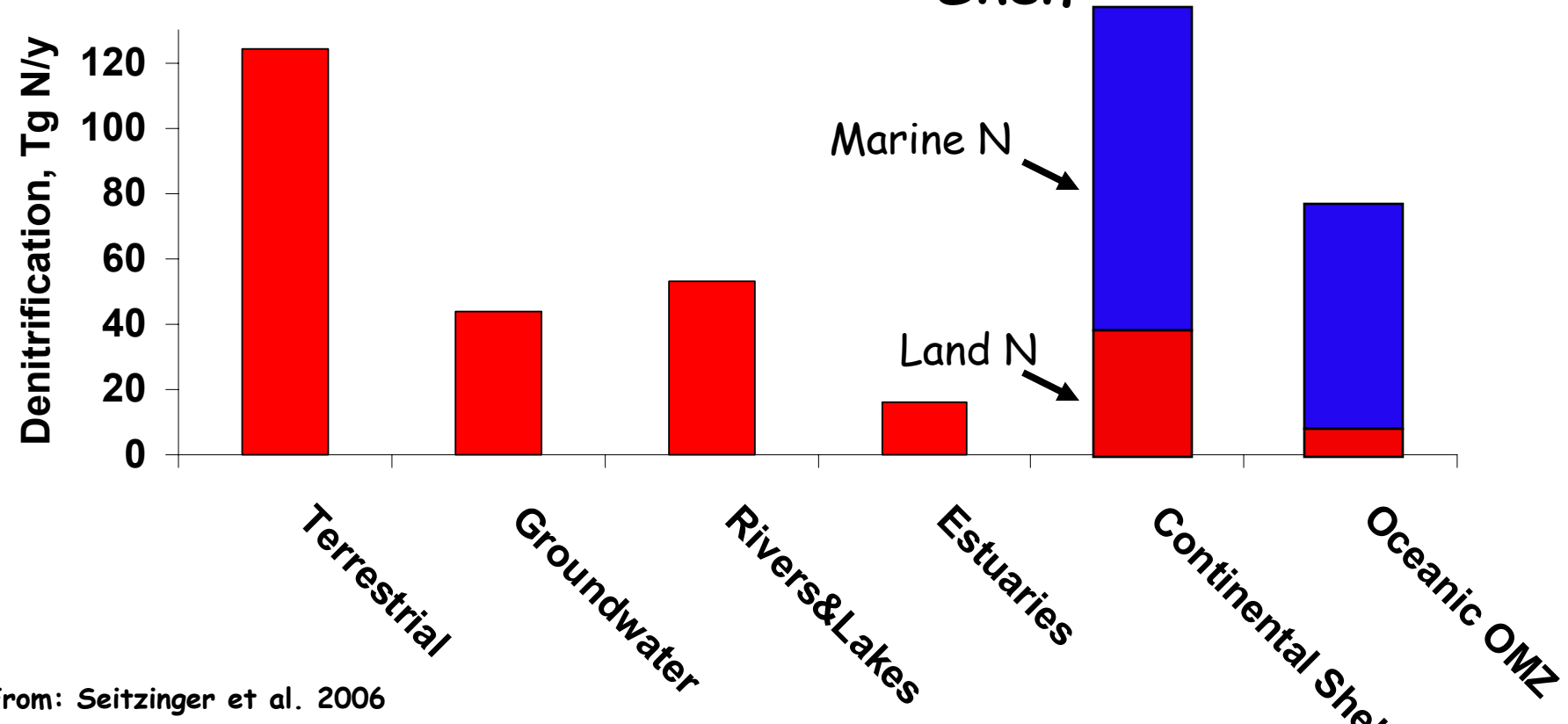
River N	Denitrification
1.8	5.3





Denitrification of Land plus Marine Sources of N

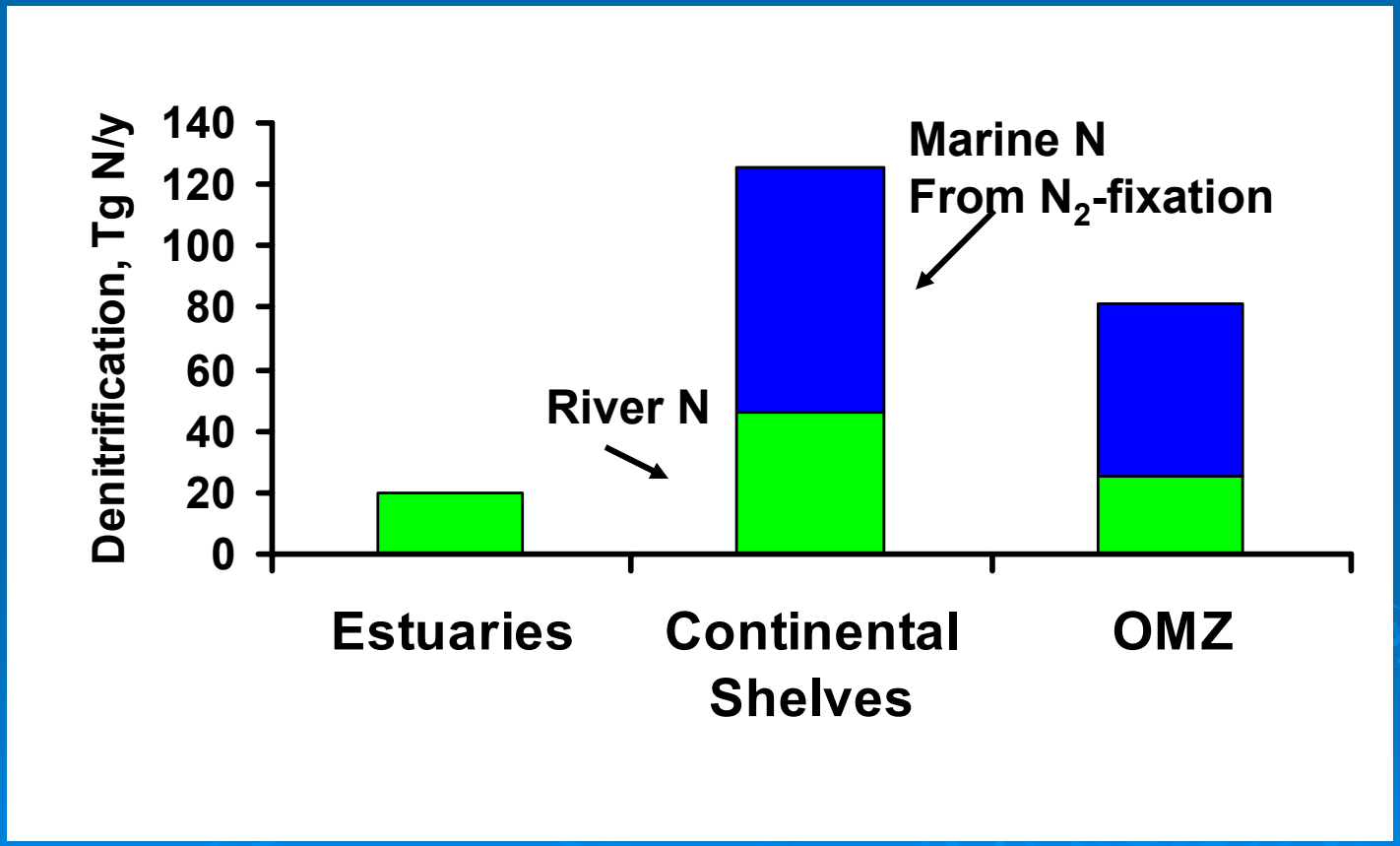
Terrestrial → Rivers → Estuaries ⟷ Continental Shelf ⟷ Oceanic



From: Seitzinger et al. 2006

Denitrification of N from Land-based & Marine Sources

River Export
67 Tg N/y



Modified from Seitzinger et al. 2006

NSF Research Coordination Network
Denitrification - Integration Across Landscapes and Waterscapes

www.denitrification.org

Bring together denitrification scientists across a broad range of disciplines to advance:

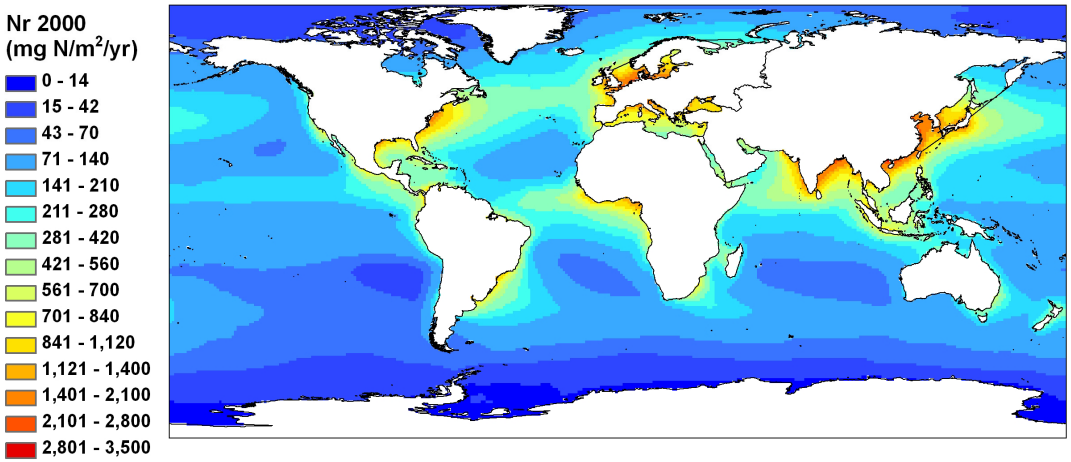
- quantification of denitrification rates
- quantitative relationships between denitrification rates and controlling factors
- process-based models that can be used to scale-up site specific measurements to ecosystem, regional and global scales.

Steering Committee:

S. Seitzinger and E. Davidson (Co-Chairs), R. Lee (Post-doc)
M. Altabet, E. Boyer, M. Firestone, A. Giblin, W. Gilliam, P. Groffman, L.P. Nielsen (Denmark), M. Scholes (S. Africa), L. Schipper (NZ).

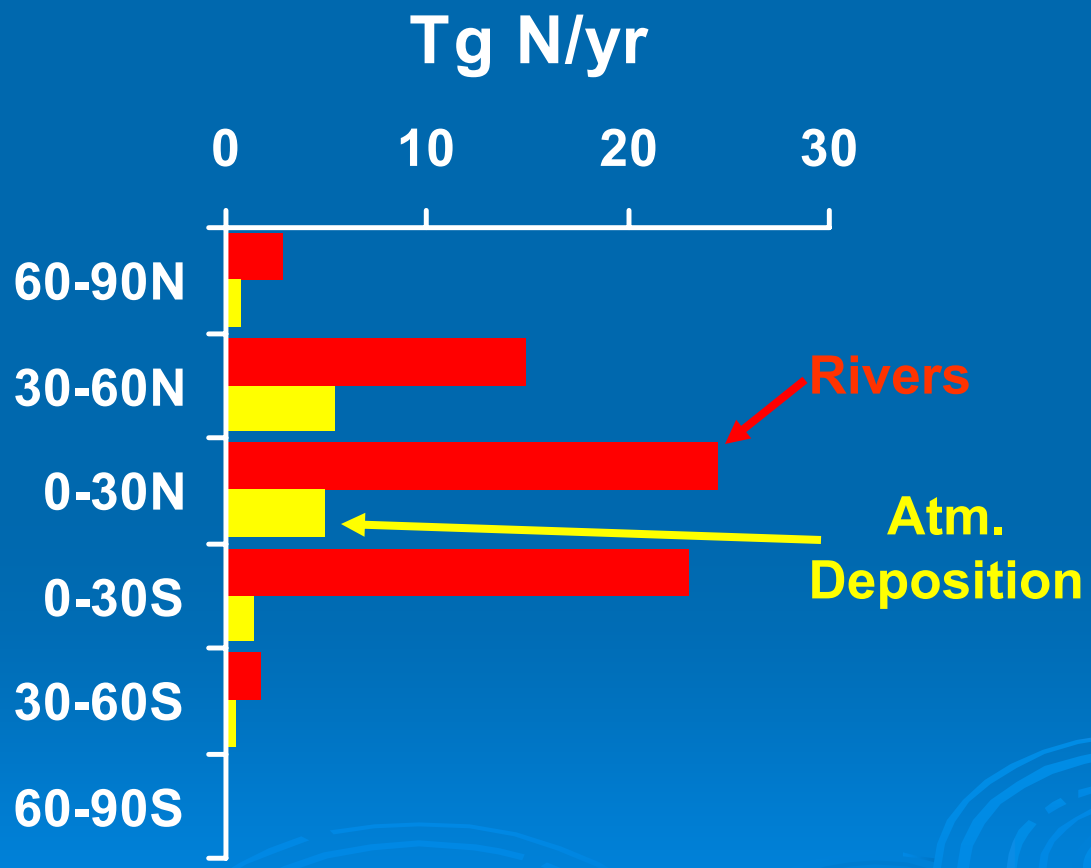
Atmospheric N Deposition to Coastal Ocean vs River Inputs

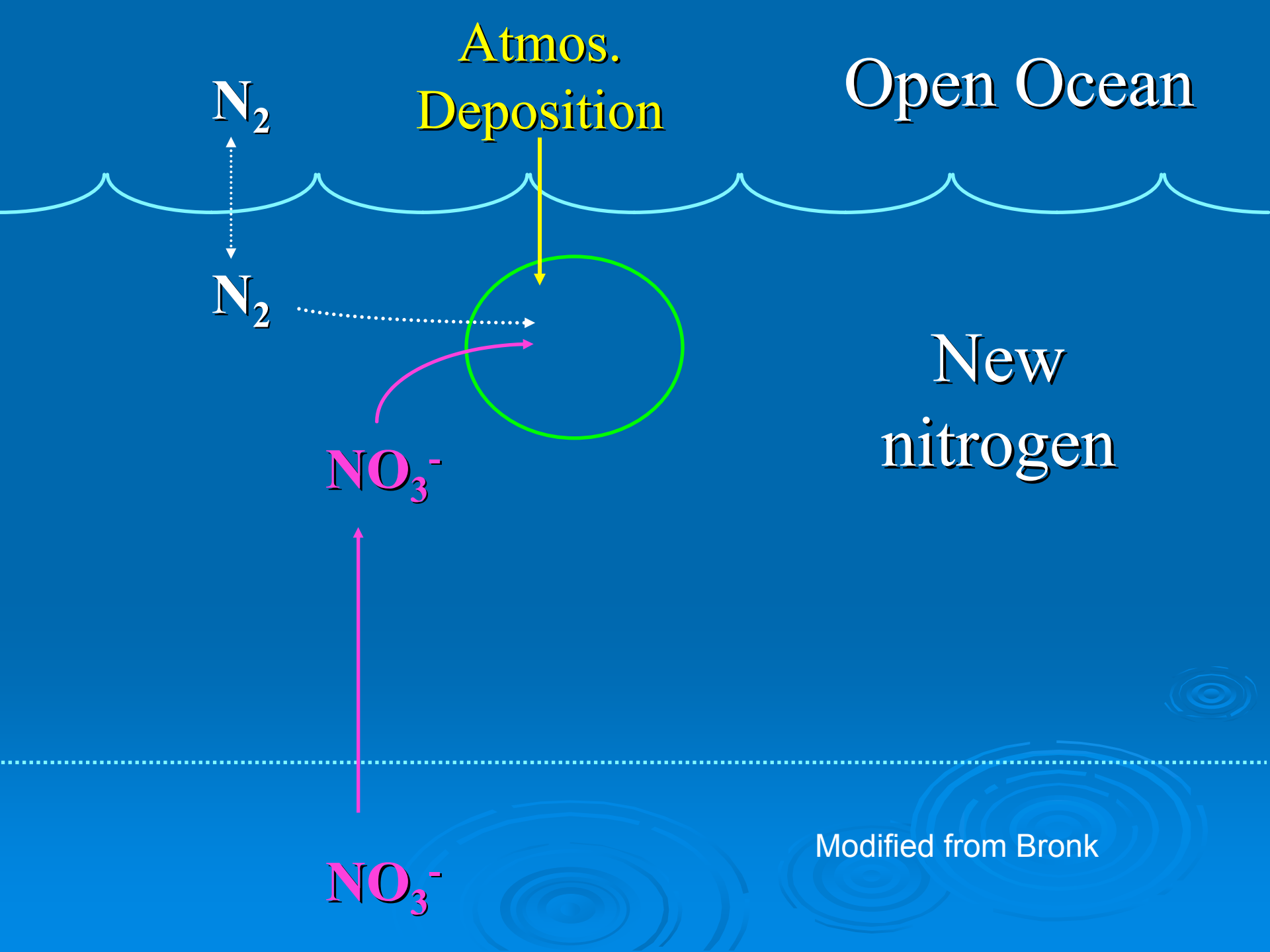
Atmos. Dep. 2000



From Katye Altieri using data from Dentener et al. 2006

N Loads from rivers vs. Atmospheric Deposition on Shelf by Latitude




Atmos.
Deposition
Open Ocean
N_2
N_2
New
nitrogen
NO_3^-
NO_3^-
Modified from Bronk

Atmospheric N Deposition to Ocean

1860 **20 Tg N/y**

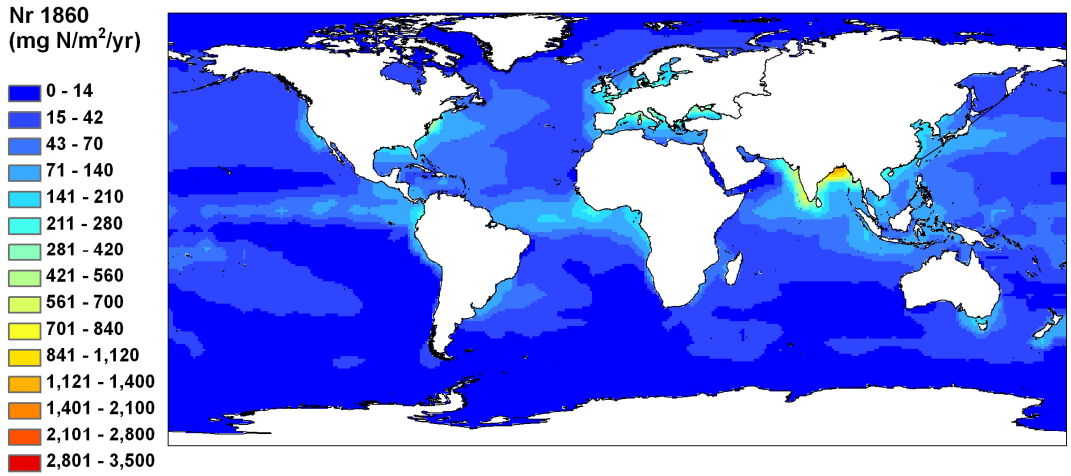
***More than tripled*

2000 **67 Tg N/y**

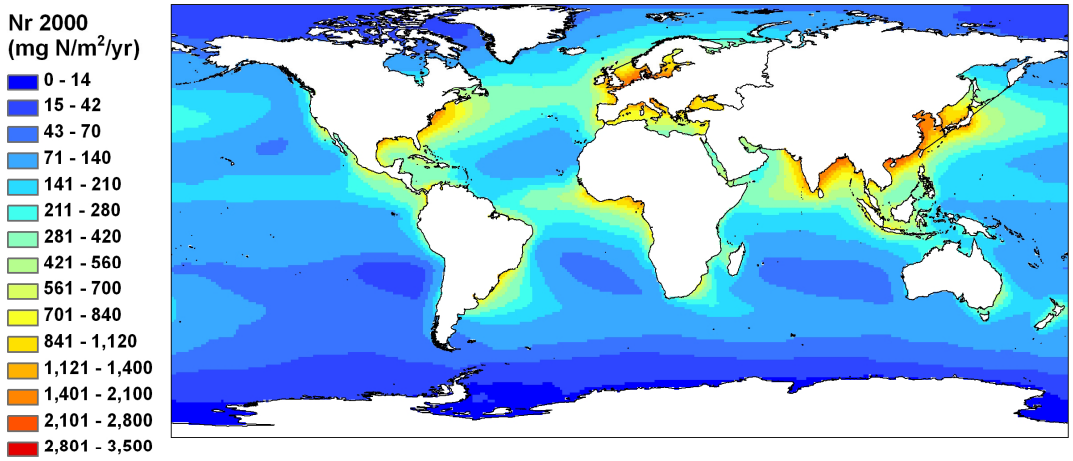
***Currently similar magnitude to N_2-fixation*

N_2-fixation ~100 Tg N/y

1860



2000



From Katye Altieri using data from Dentener et al. 2006

Krishnamurthy et al. 2007; Duce et al. in prep.

Acknowlegments

- Global NEWS workgroup
- UNESCO- IOC
- UNEP
- GEF
- NSF
- NOAA
- NASA

- Global N, P and C river transport from watersheds to coastal systems
  - Approach
  - Magnitude and spatial patterns
  - Drivers
- Effect of land-based nutrient inputs
- Fate of N input
- Atmospheric N deposition to coastal and oceanic systems
- Future directions

Questions

- How can we best link past and current N, P and C land-based inputs to coastal ecosystem effects at regional to global scales?
- How might nutrient inputs change under a range of future scenarios (development, climate, biofuels) and what are the consequences for marine ecosystems?