Nitrogen retention and denitrification efficiency in reservoirs

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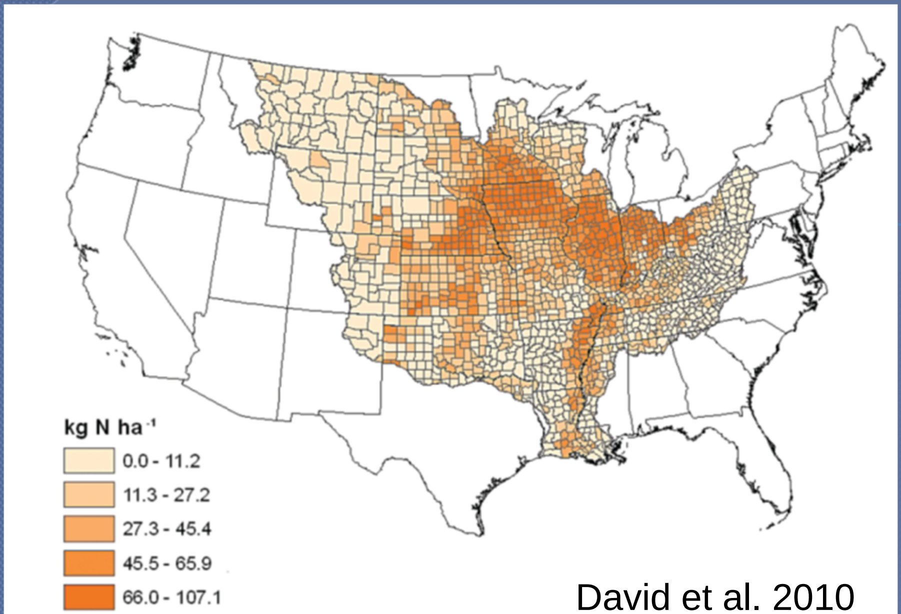
Introduction

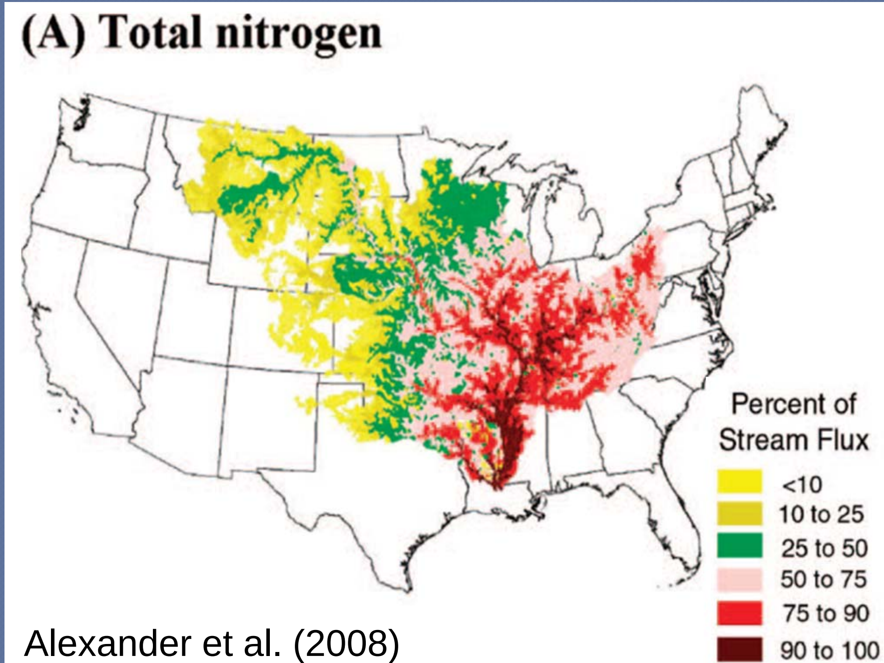


David et al. 2010

- Anthropogenic activities increase terrestrial reactive nitrogen (N) pool

- Adjacent stream networks transport N

- Not all terrestrial nutrient inputs arrive downstream



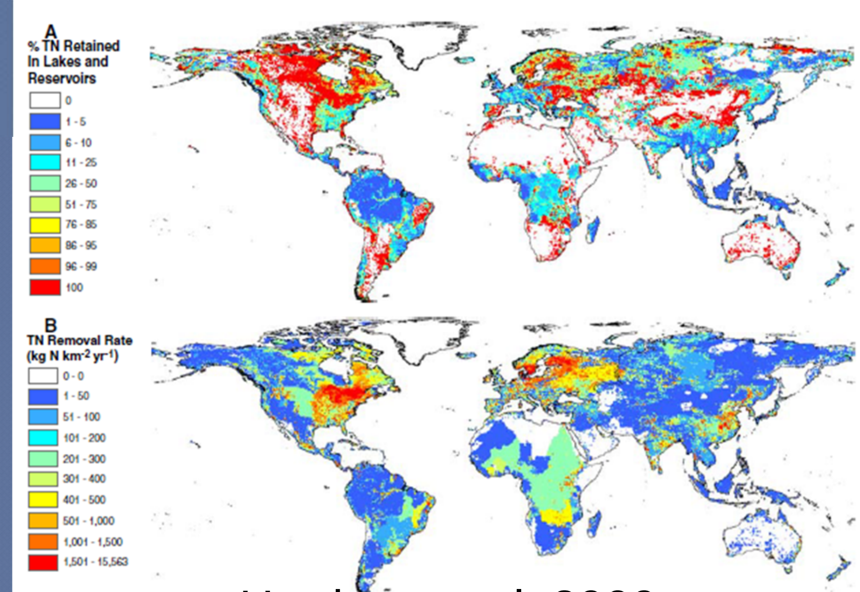
Alexander et al. (2008)

Introduction

- Natural & man-made lakes are nutrient sinks in the landscape

- Stream networks also transform & store N

- Temporally and spatially variable

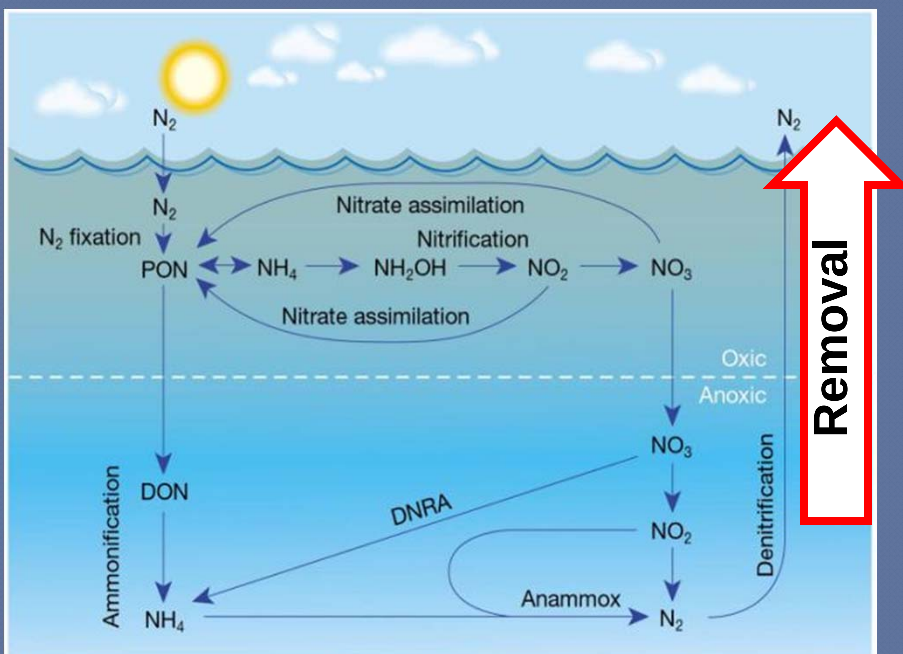


Harrison et al. 2009

Fig. 2 NiRReLa-modeled global distribution of percent N removal by lakes and reservoirs (a). N removal by lakes and reservoirs kg N km^{-2} $year^{-1}$ (**b**)

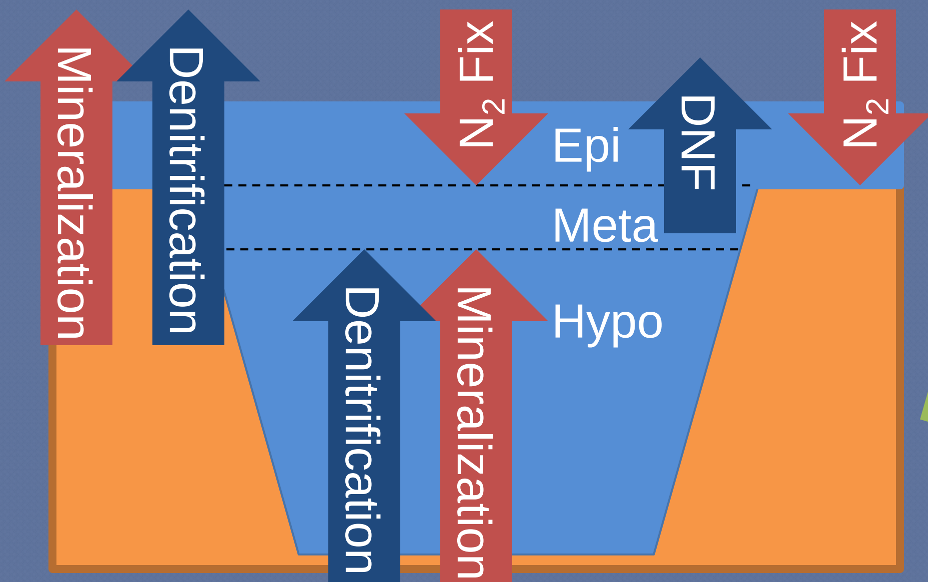
Clean Lakes & N Retention

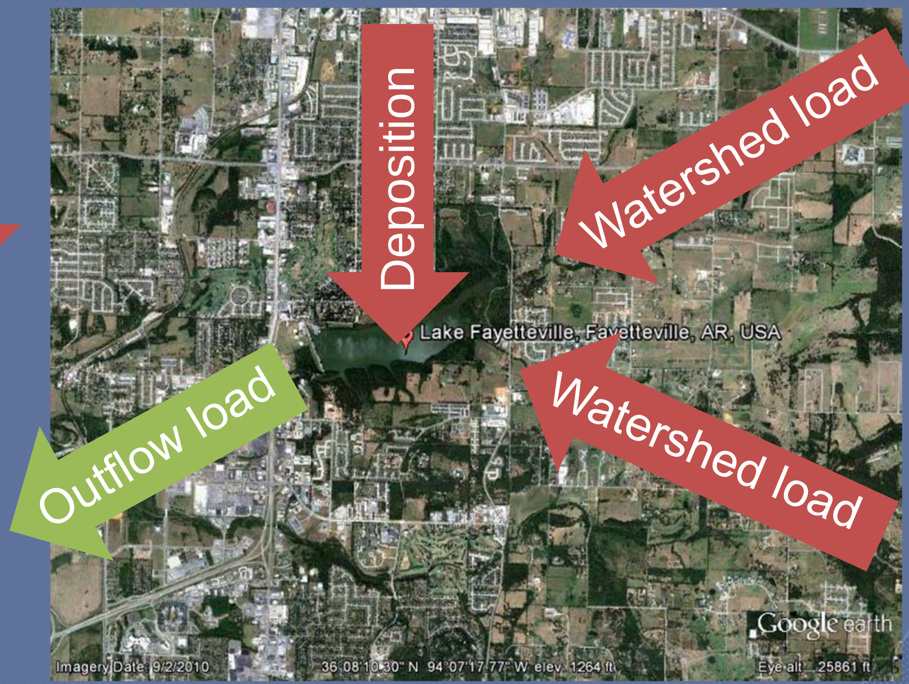
- Retention = Eutrophication?
- What are mechanisms of retention?



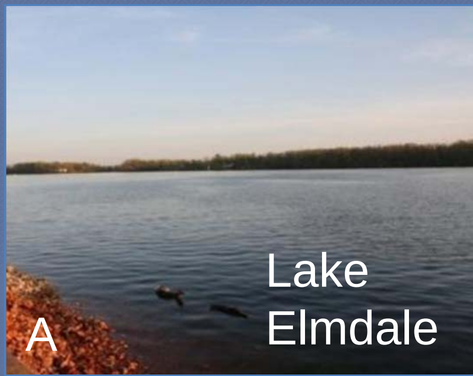
Study Objectives

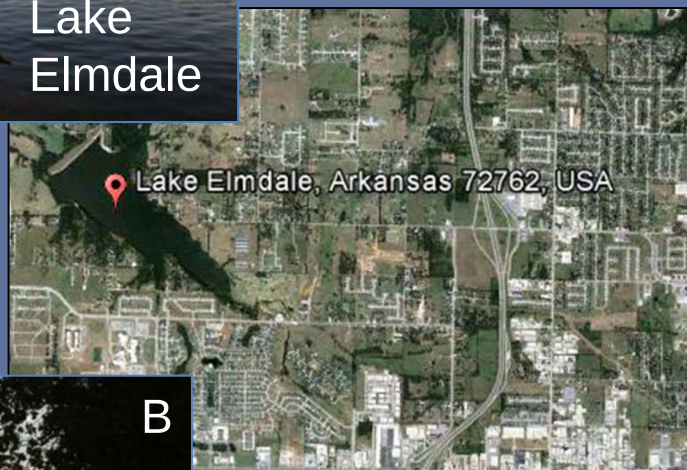
- Mass balance of annual, whole-lake N fluxes in 2010
  - Inputs
  - Outputs
  - Denitrification (DNF)
- Reservoir N retention rates/efficiency
- DNF efficiency





Study sites

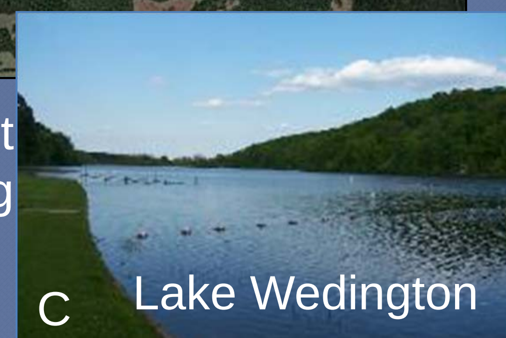




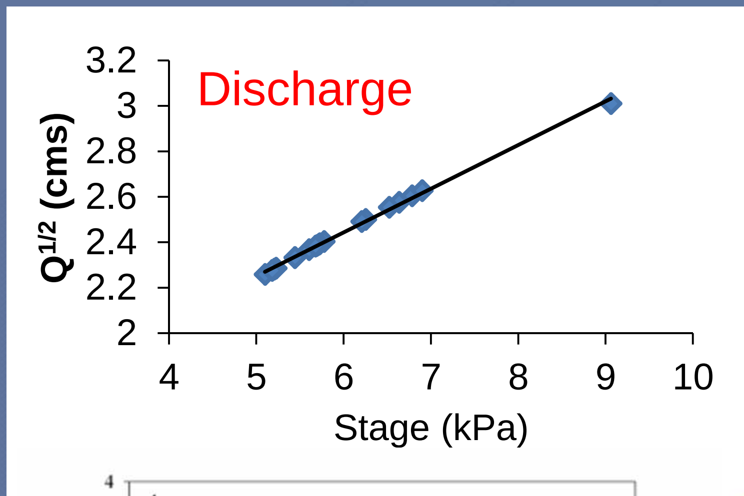
60% urban
40% ag

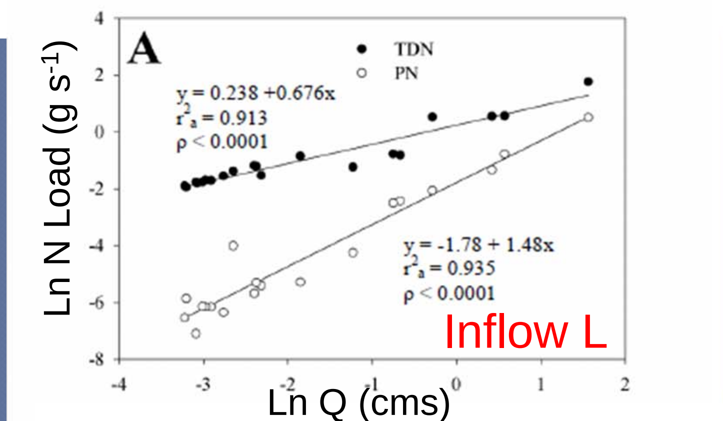
40% urban
40% ag

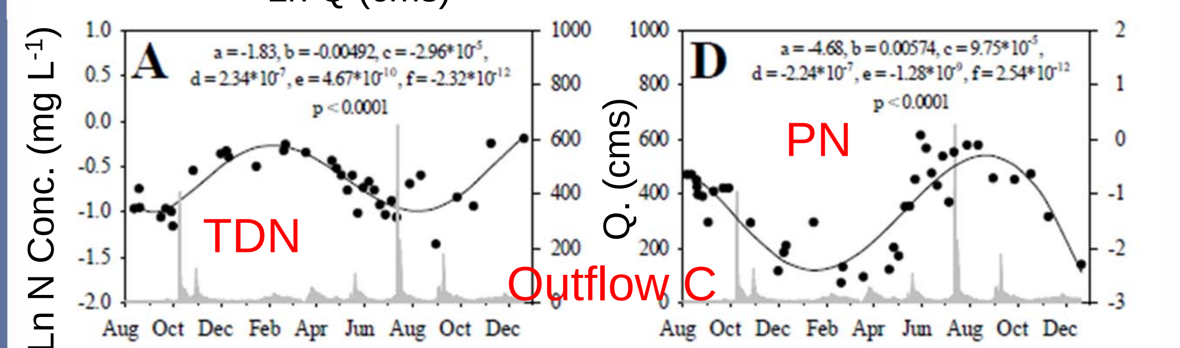
80% forest
10% ag



Modeling Watershed Inflow & Outflow Loads



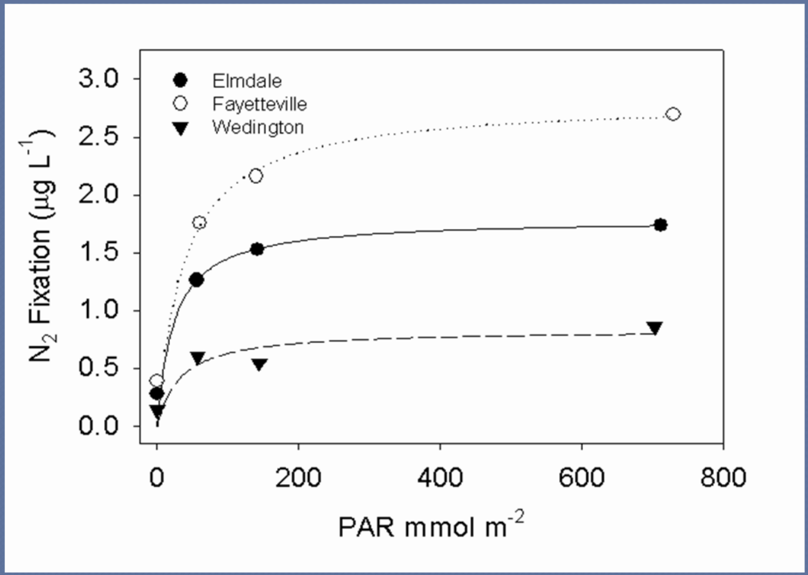


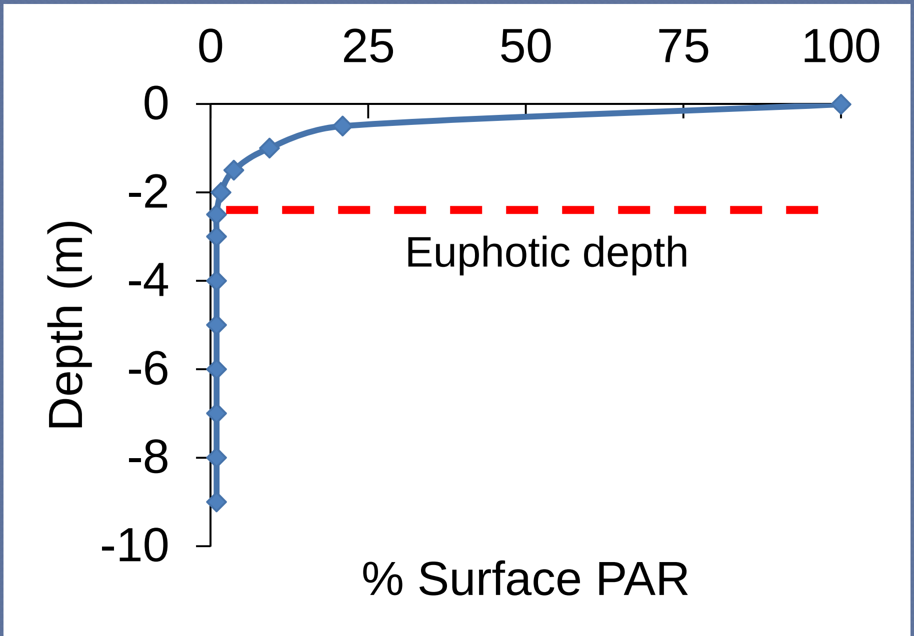


- Primary impounded stream gauged at inlet & outlet
- Discharge (Q) & water samples at base & storm flow
- Q modeled by stage all sites
- Inflow dissolved (TDN) & particulate (PN) load (L) modeled by Q
- Outflow TDN & PN conc. (C) modeled by season
- C x Q = L

Modeling Lacustrine N_2 Fixation

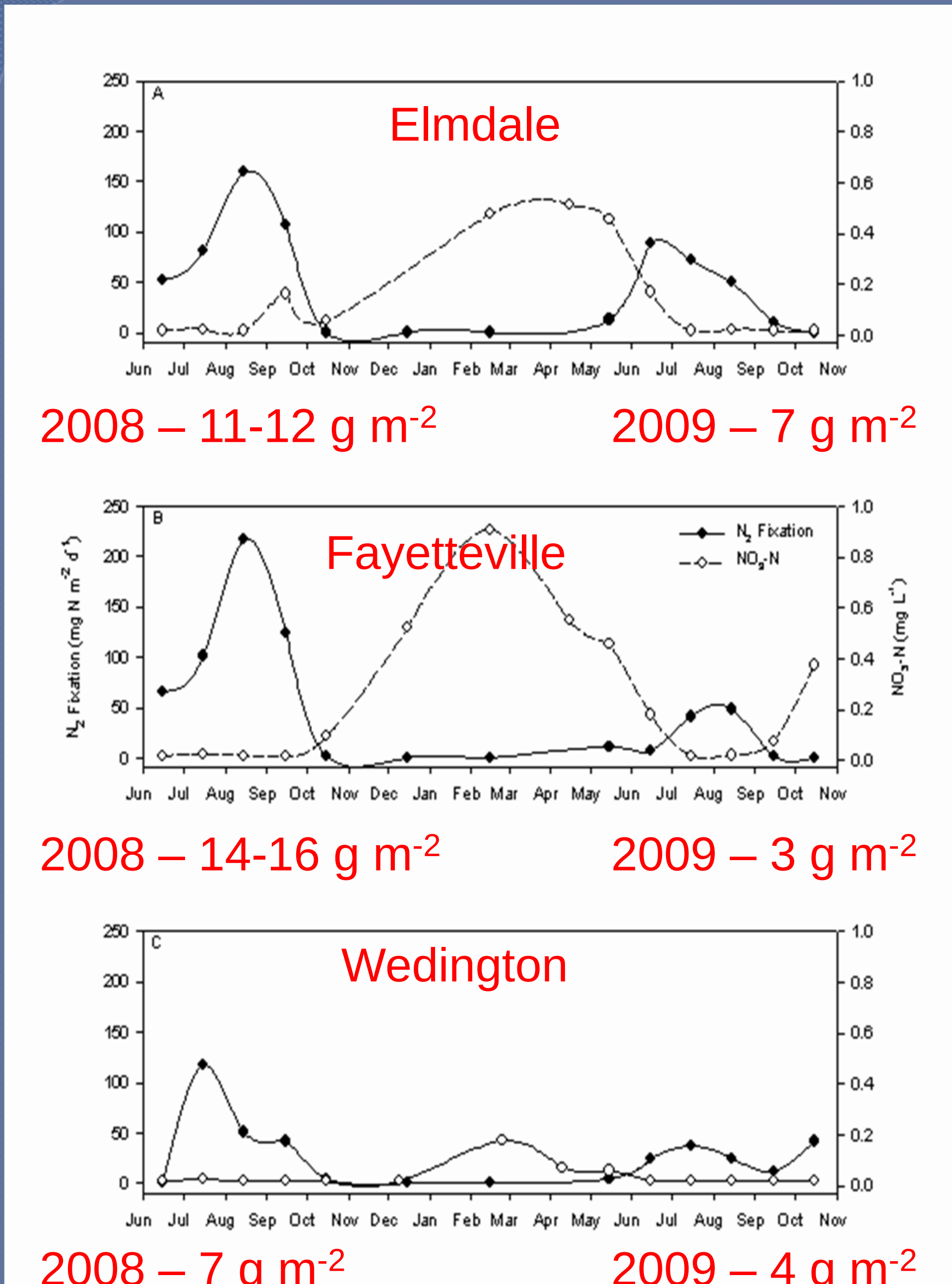
- 2008-2009 acetylene reduction incubations
- Light (PAR) gradient





- Monthly models May-Oct
- Scaled spatially across euphotic zone

Lacustrine N_2 Fixation



- No cool season N_2 fix
- Sustained N_2 fix only with low NO_3-N
- 2008-2009 models + 2010 PAR:

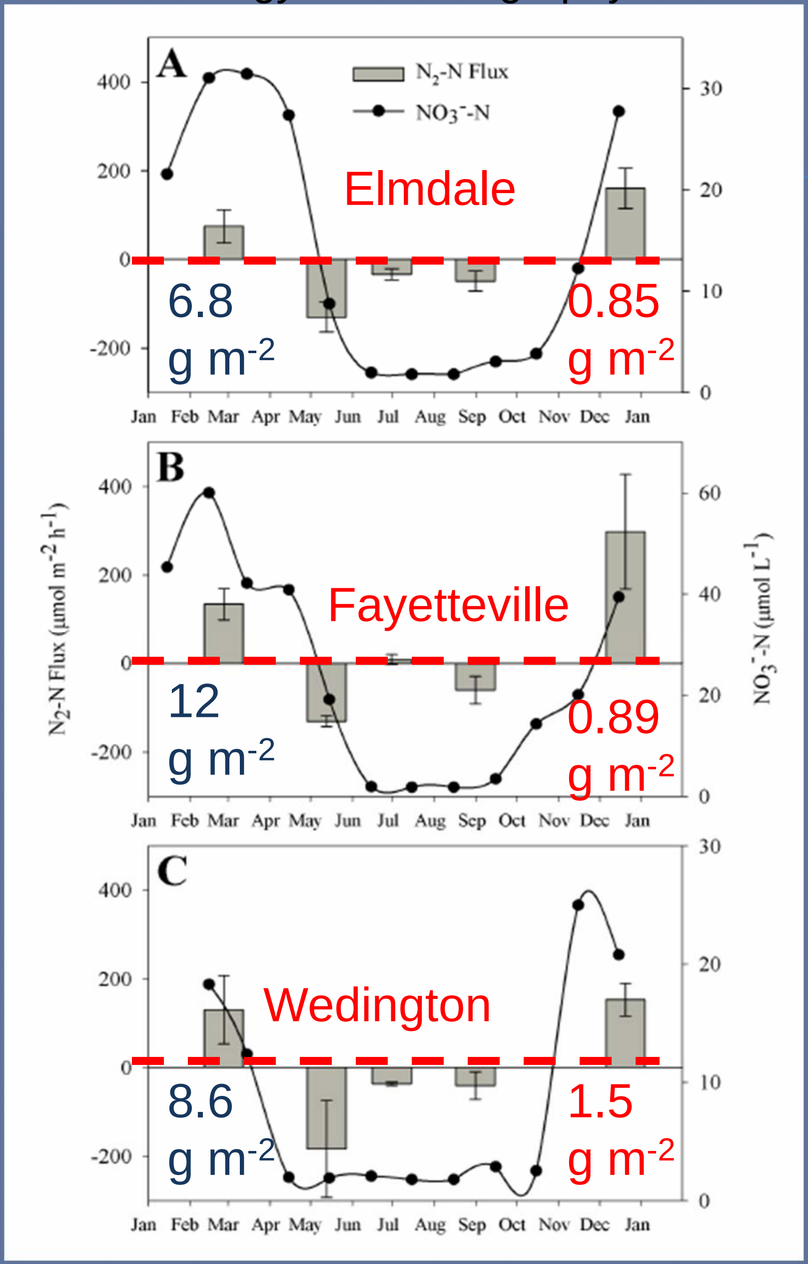
Reservoir	2010 N_2 Fix (g N m^{-2})
Elmdale	12
Fayetteville	12
Wedington	6.7

Epilimnion Sediment Core Incubations

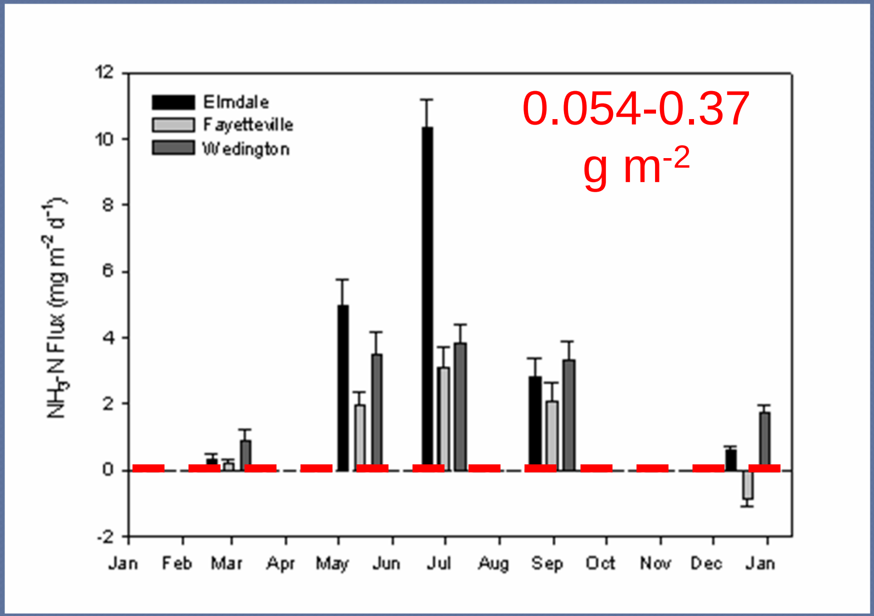
- 5 experiments, Feb., May, June, Aug., & Dec. 2010
- Measured fluxes:
  - NH_3-N for mineralization
  - N_2-N (MIMS N_2:Ar) for denitrification
- Flux = output – input

Grantz et al. *Accepted*. Limnology & Oceanography

N Fluxes at the Sediment Interface



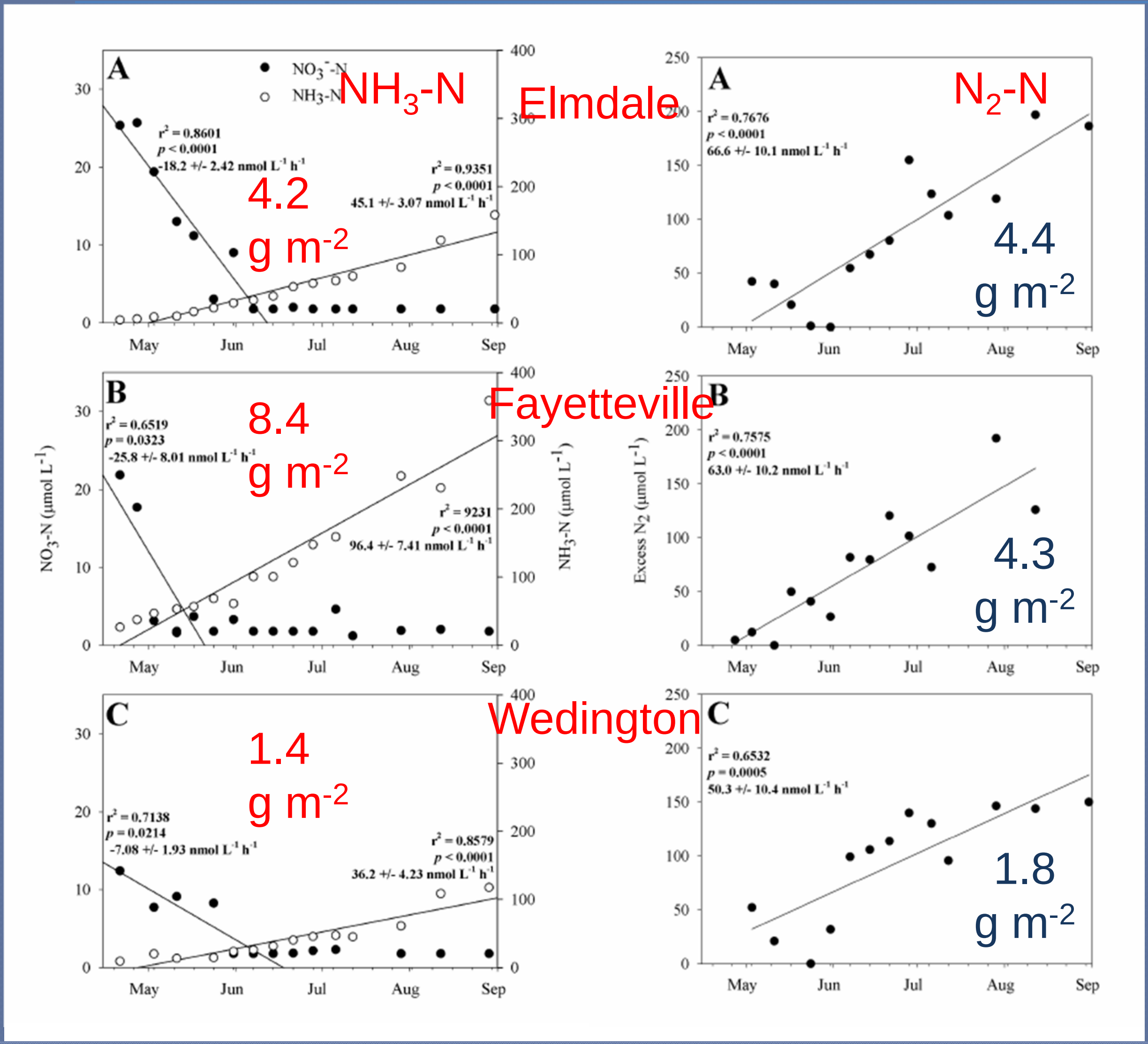
- Ambient NO_3-N regulates direction of flux



- NH_3-N Flux greatest in warm season

Hypolimnion Solute Accumulation

- Excess N_2 (mg/L) = N_2sample – N_2sat



- N fraction conc. measured in hypo over time
- Slope of linear regression analysis = rate
- Also used for meta DNF

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Retention & DNF Efficiency

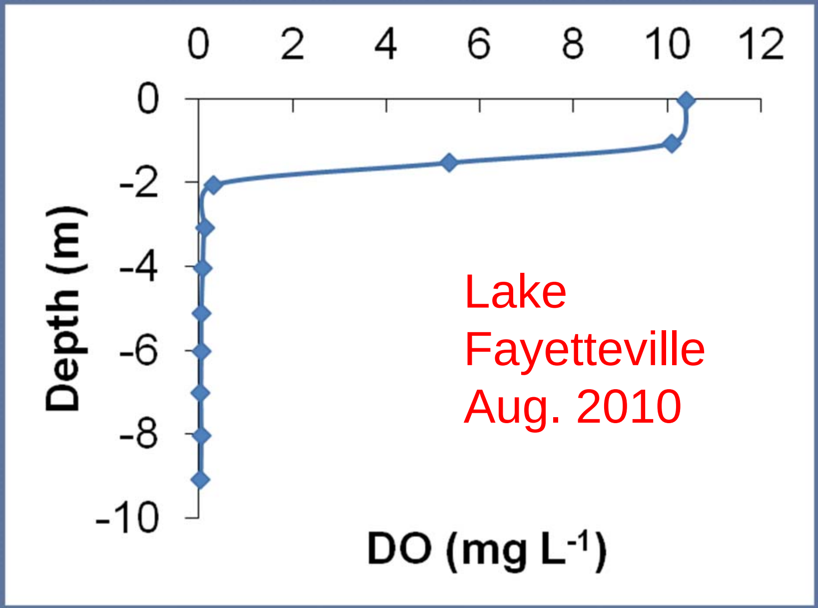
	Ecosystem Fluxes in g N m^{-2} y^{-1}		
	Elmdale	Fayetteville	Wedington
Inputs*	41	52	30
Watershed loading	22	29	18
N_2 fixation	13	13	8.2
Mineralization	4.5	8.5	1.8
Output	14	20	3.5
Retention (%L_{Ret})	27 (66%)	32 (62%)	26 (87%)
DNF (%L_{DNF})	18 (67%)	23 (72%)	12 (46%)

*Sum of listed inputs, plus estimated regional atmospheric deposition to the reservoir surface, 1.8 g N m^{-2} y^{-1}

Retention & Clean Lakes & Watersheds

- Consistent trophic state differences in magnitude of N cycling rates
- Potential watershed influences on retention efficiency
- Potential shift to internal, more labile inputs in eutrophic/impacted lakes
- Retention: ecosystem service or path to eutrophication?

It's all about priorities…



- For the Lake Fayetteville Watershed Alliance…
- But for sensitive downstream water resources…

42 Mg y^{-1}, 2% of 2,200 Mg y^{-1} NPS loading to Lake Tenkiller

0.03% of the drainage area

Acknowledgements

- Scott Biogeochemistry Lab staff 2008-2011
  - Bryant Baker, Bill Bond, Bodie Drake, Stefaney Cepeda, Kelly Fitch, Aki Kogo, Stephanie Kulesza, Alden Smartt, Ayla Smartt Lucy Stowe, Erin Scott, Ben Thompson, & Joe Wyatt
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Questions?