In-stream Losses of Nitrogen

Mark B. David

University of Illinois

Department of Natural Resources & Environmental Science

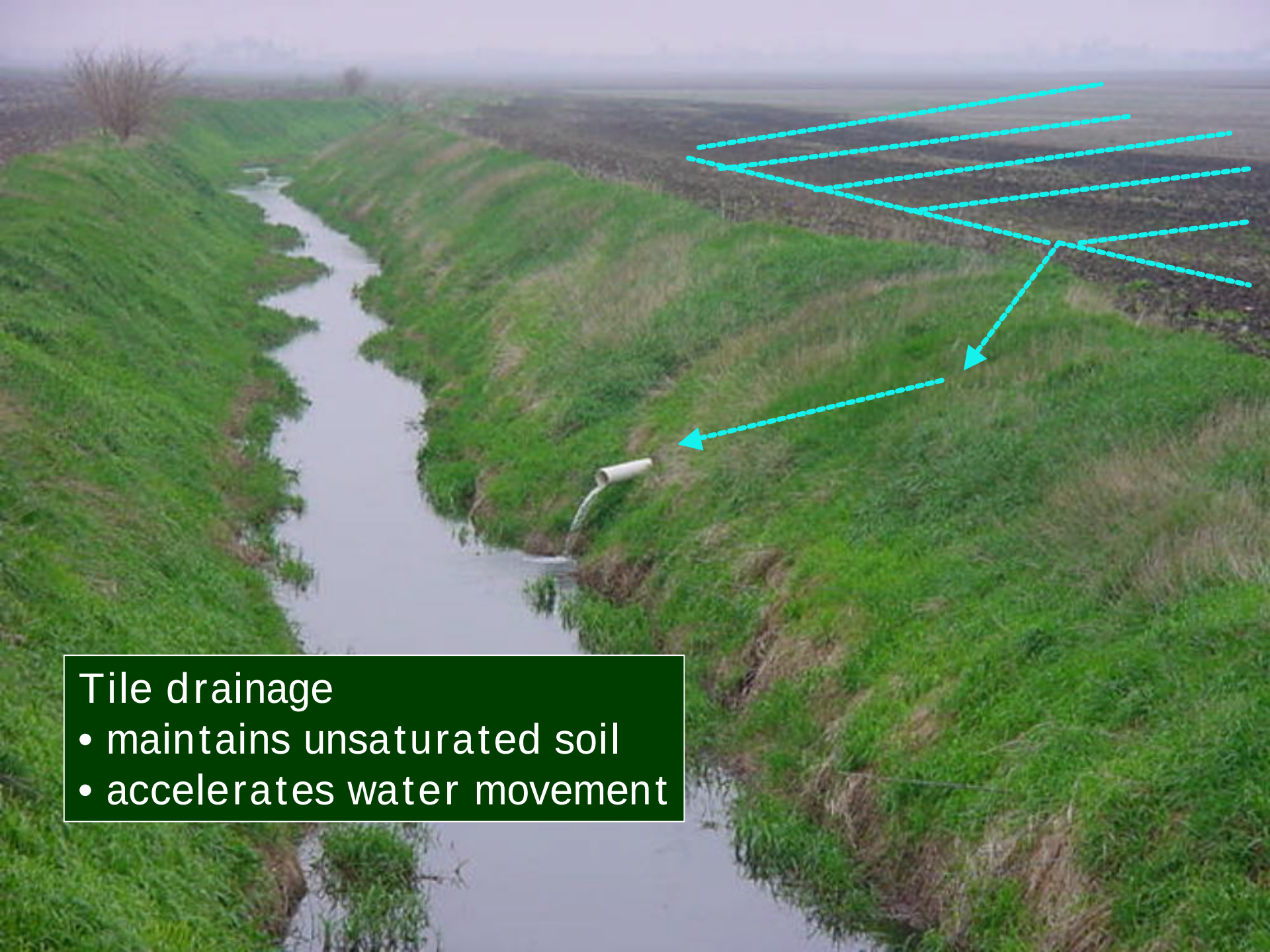
8 February 2006

Overview

- Examine stream and reservoir denitrification in Illinois
- Put rates in context of stream N loads
- Determine potential importance of denitrification in streams or reservoirs in closing N mass balances


Headwater streams in central Illinois

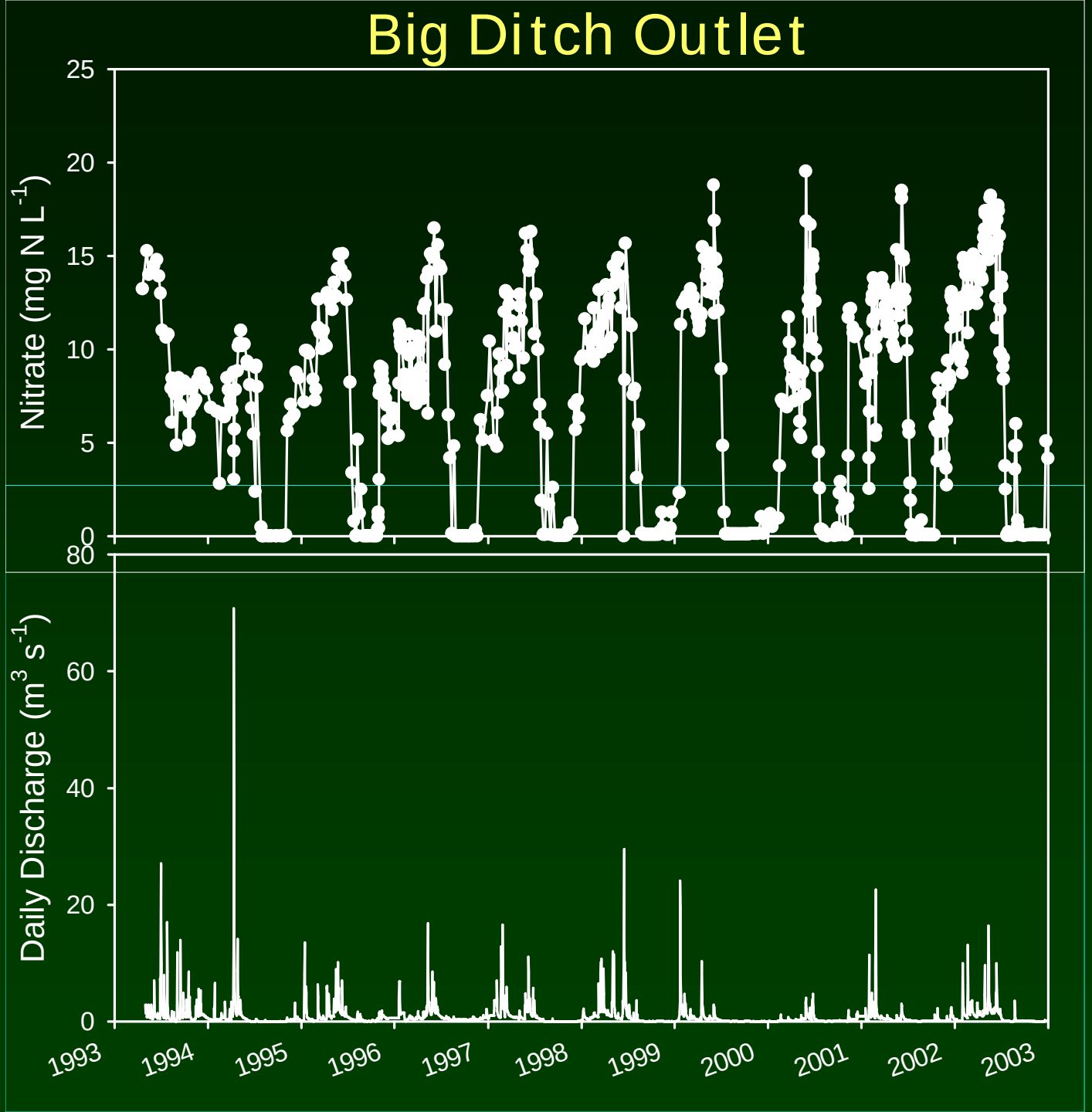
Meandering reaches


Tile drainage
• maintains unsaturated soil
• accelerates water movement

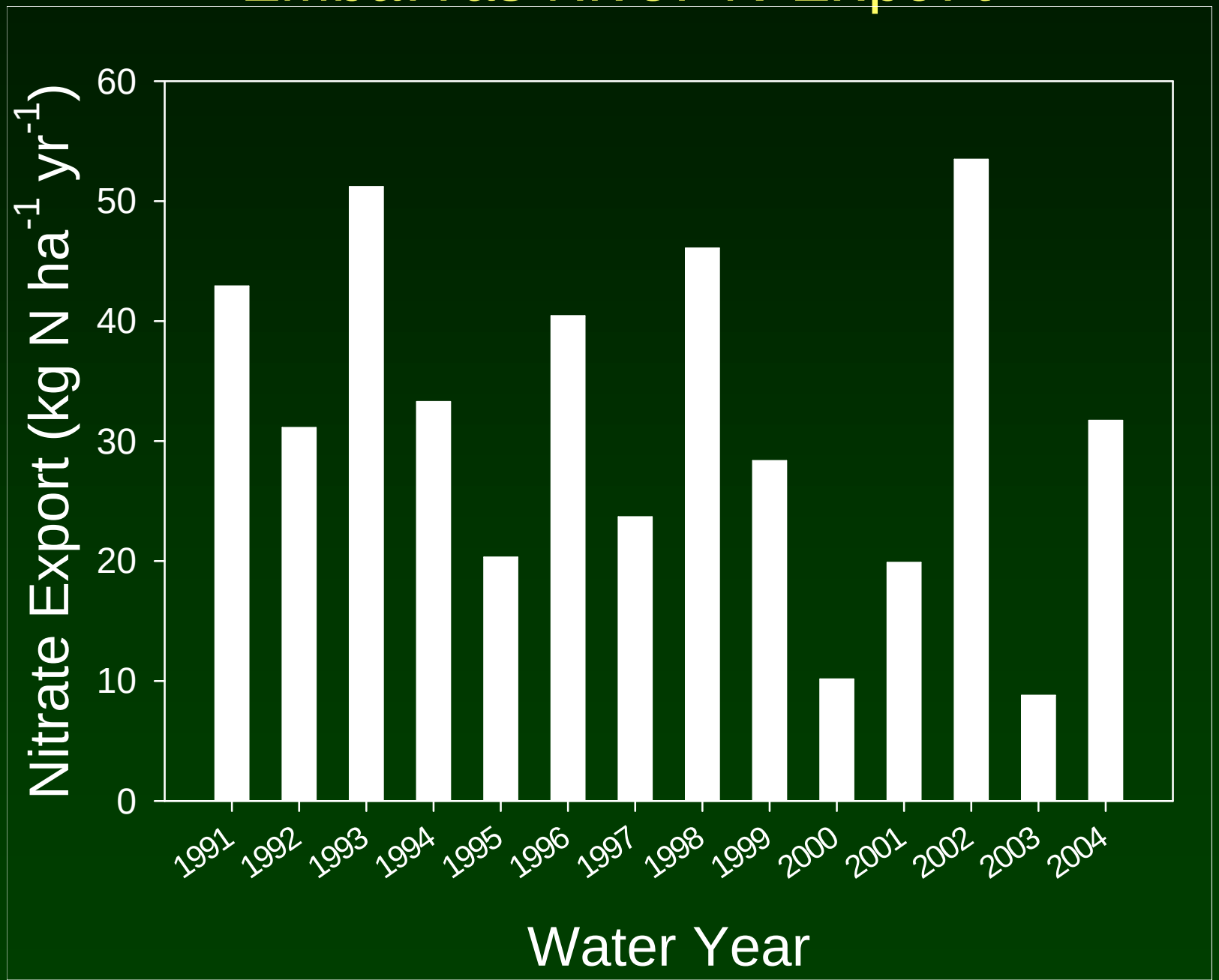

NH_3
Nitrification
NO_3^-
Transport in tile water

Embarras River - Camargo

Big Ditch Outlet



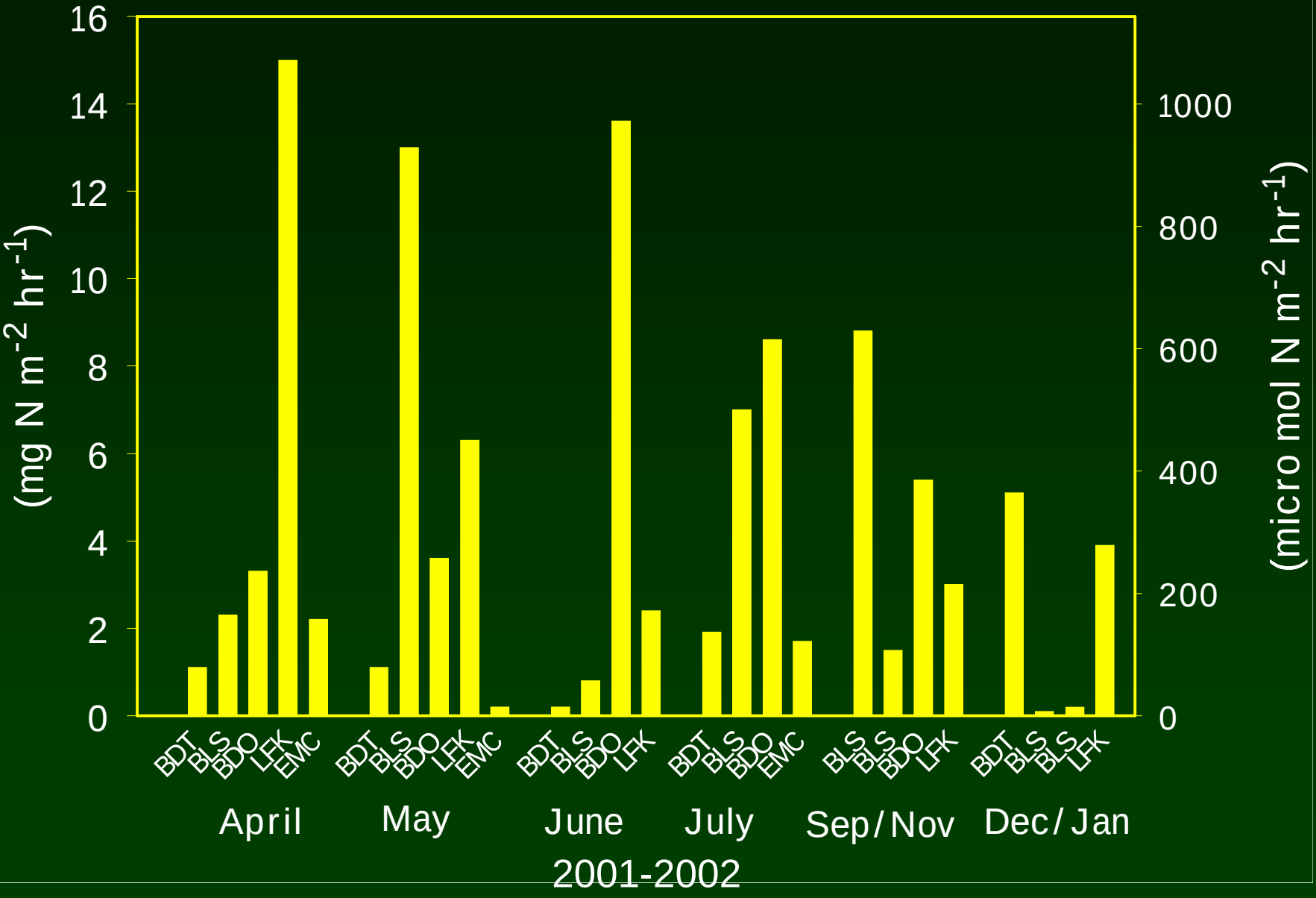
Embarras River N Export



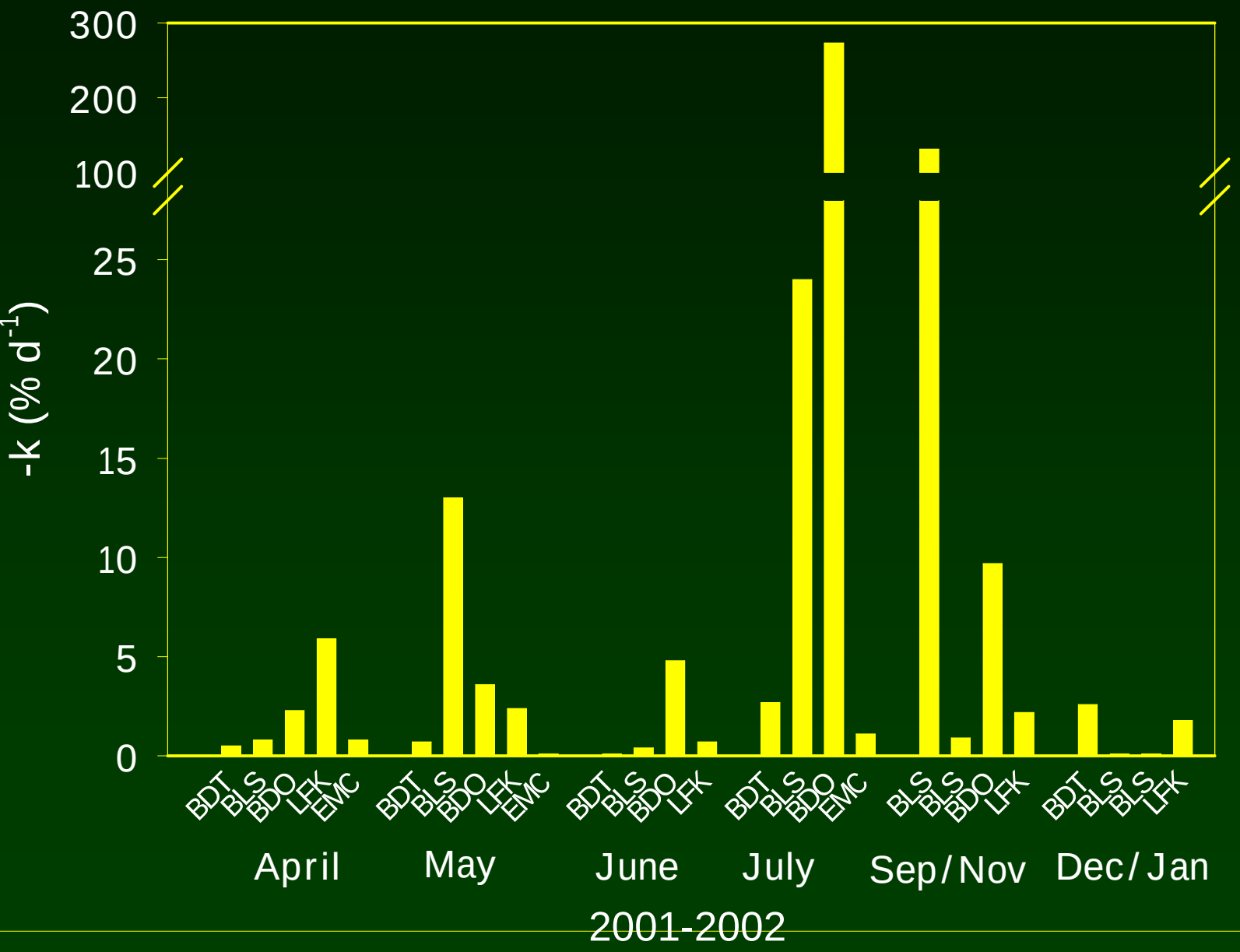
Our Approach

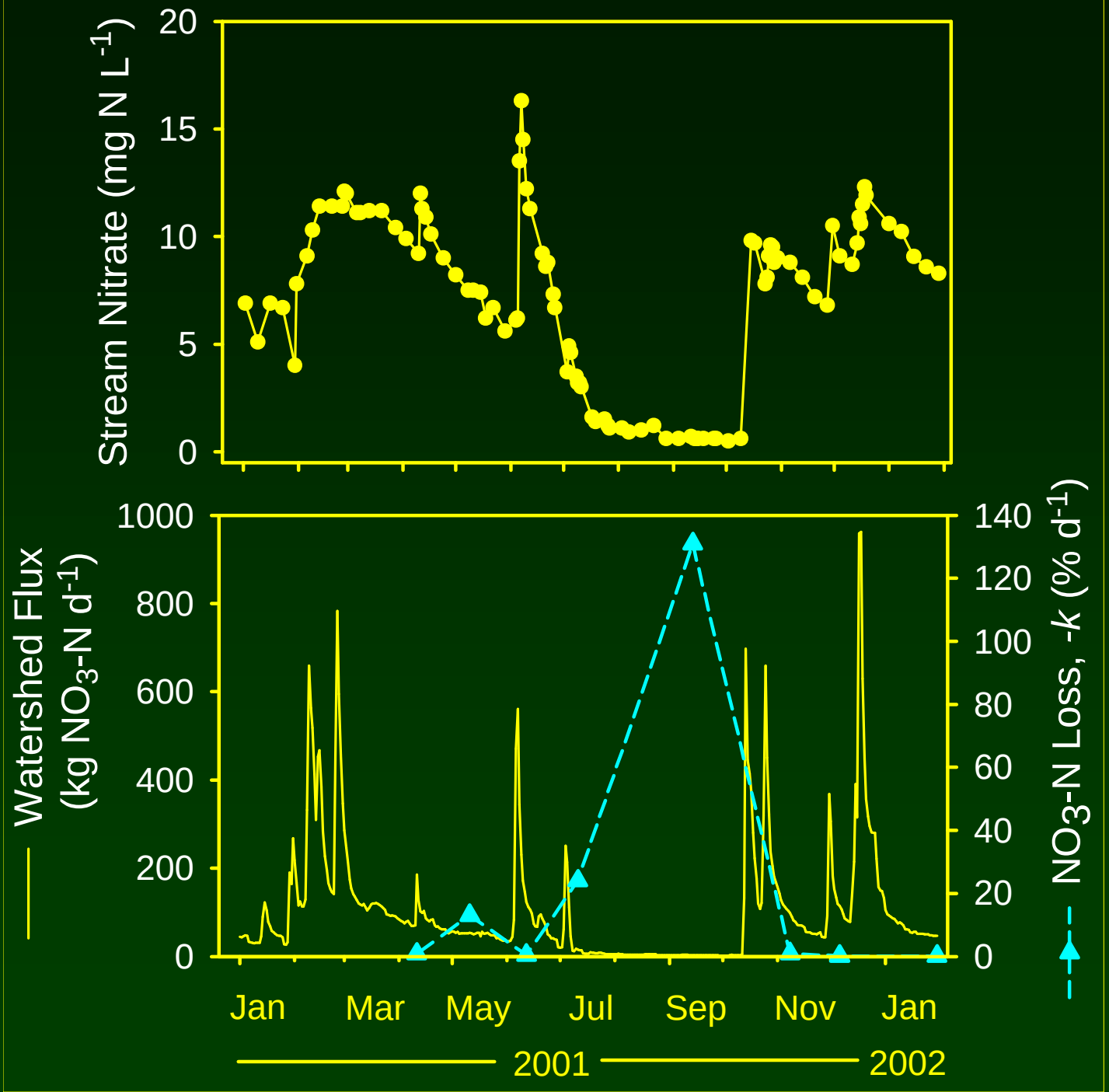
- Measure denitrification in tile-drained, headwater streams
  - Representative of the corn belt
  - Row-crop agricultural dominate land use (80 to 91% corn/soybean)
  - Channelized and meandering reaches
  - Measured in sediments and in plant biomass using acetylene and chloramphenicol
- Monitor discharge and sample nutrients intensively
- All stream flow conditions and throughout year
  - Did not allow use of of ^{15}N
- Examine denitrification in large reservoir
  - Measure sediment rates for one year
  - Examine long-term patterns

Benthic Denitrification Rates



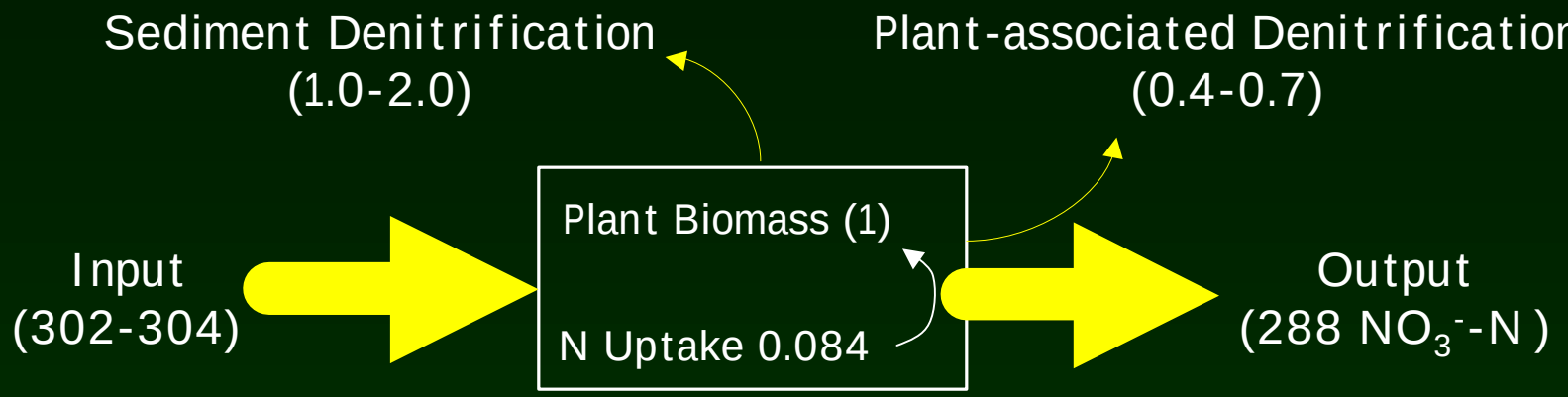
Nitrate Loss Rates



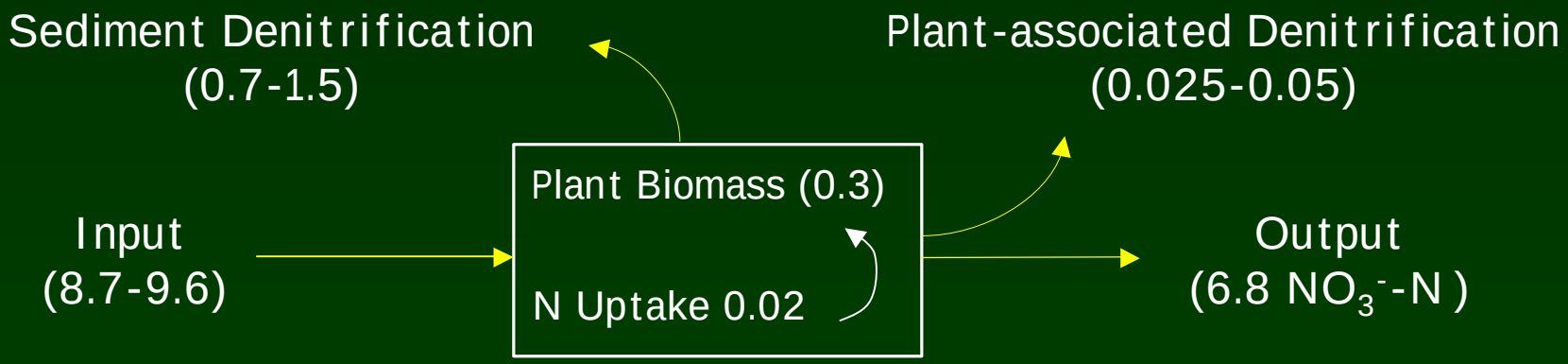

Stream Nitrate (mg N L-1)
20
15
10
5
0
Watershed Flux
(kg NO3-N d-1)
1000
800
600
400
200
0
140
120
100
80
60
40
20
0
NO3-N Loss, -k (% d-1)
Jan
Mar
May
Jul
Sep
Nov
Jan
2001
2002


Cladophora biomass can exceed 200 g dry mass m^{-2}

April-June 2002

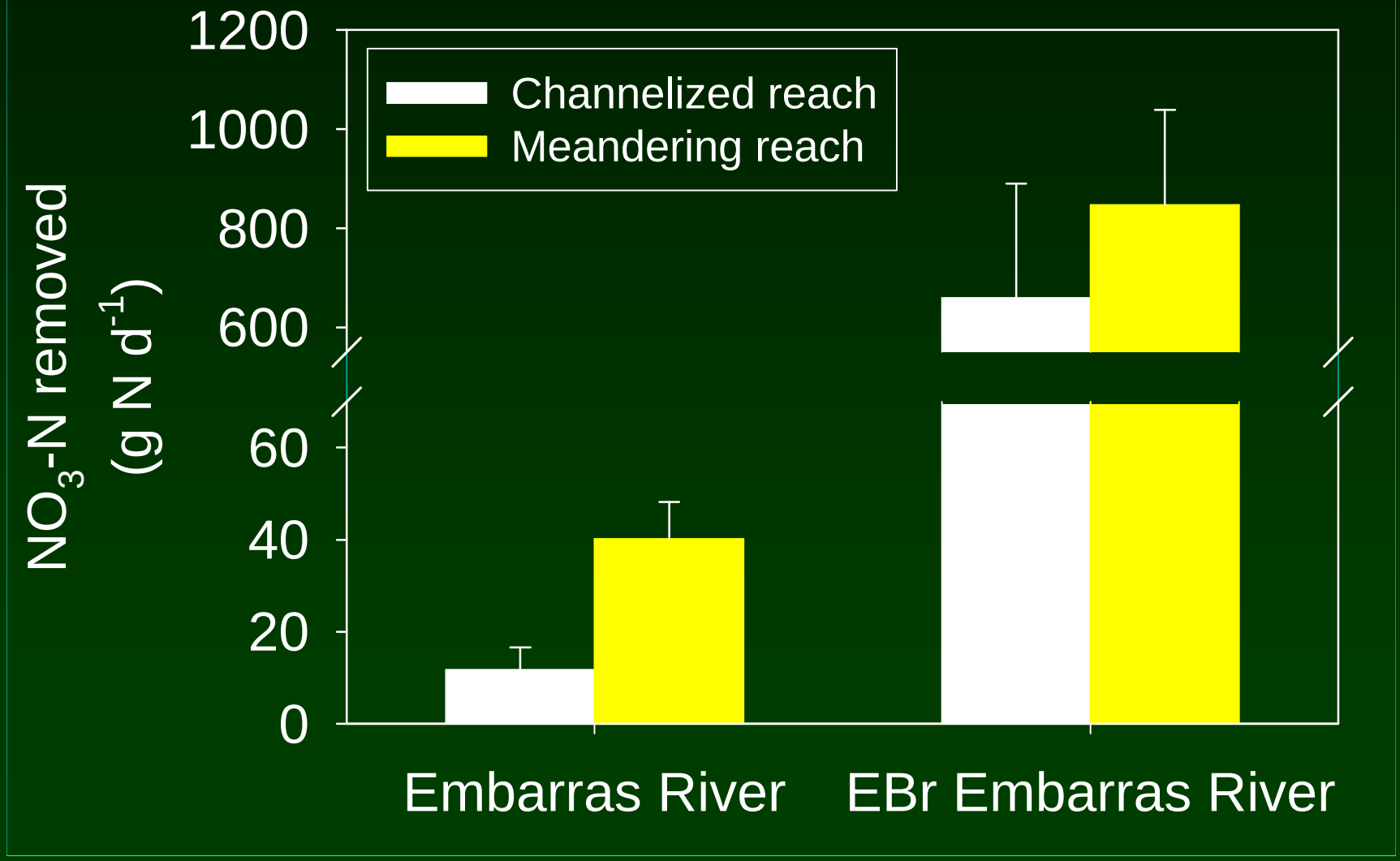


July-September 2002



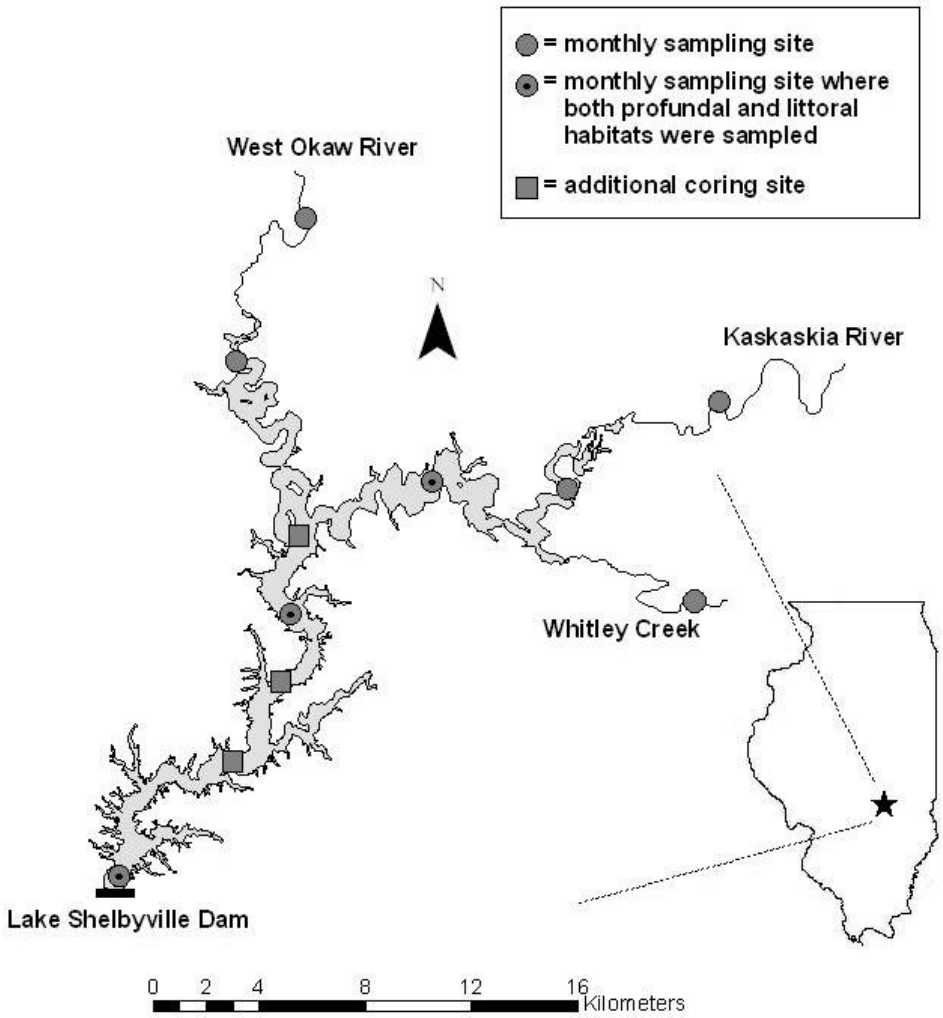
- All values in Mg N
- Arrows are proportional

Geomorphology Effects




Lake Shelbyville
US Army Corps of Engineers
Dam West Access Area

Lake Shelbyville



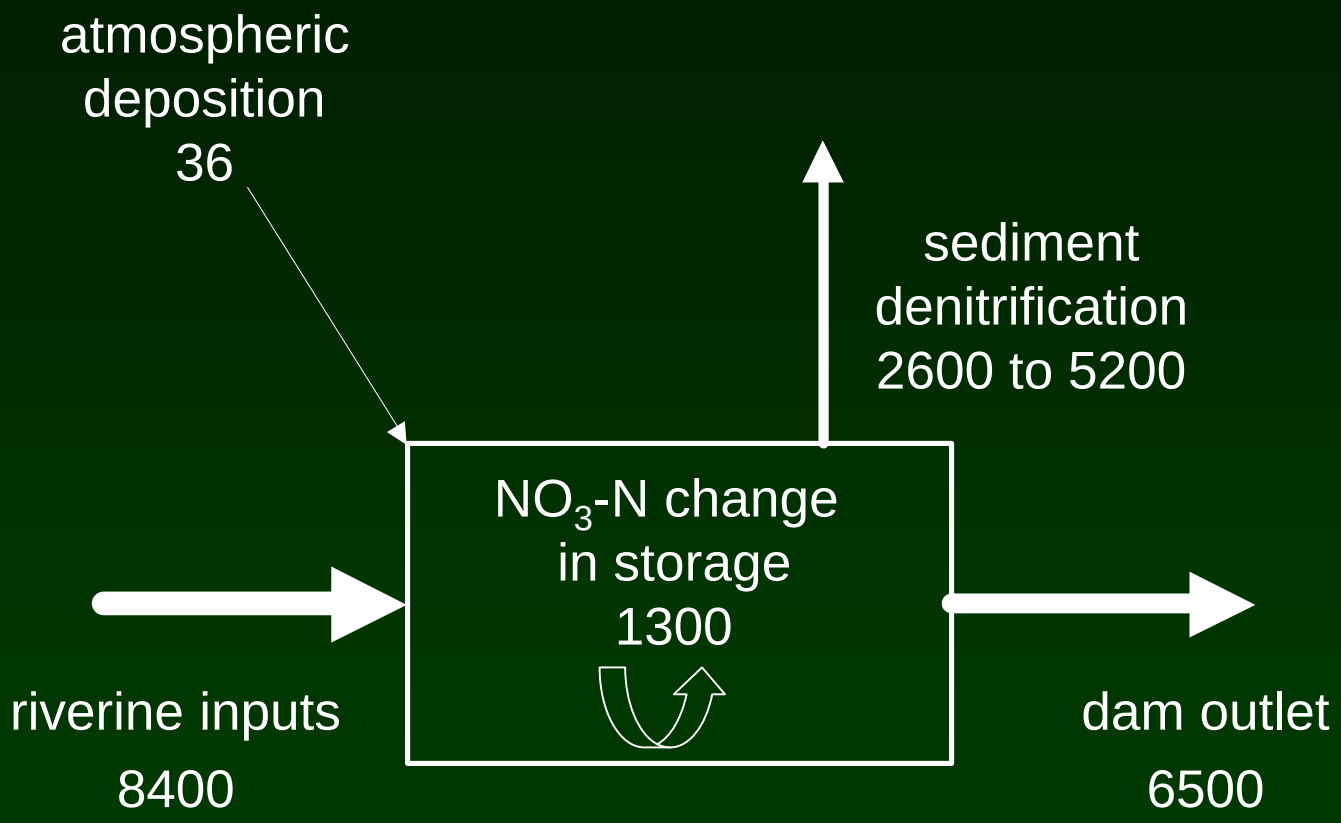
Impoundment on the Kaskaskia River

Drains 273,000 ha of mostly row-crop agriculture

Surface Area = 4,382 ha

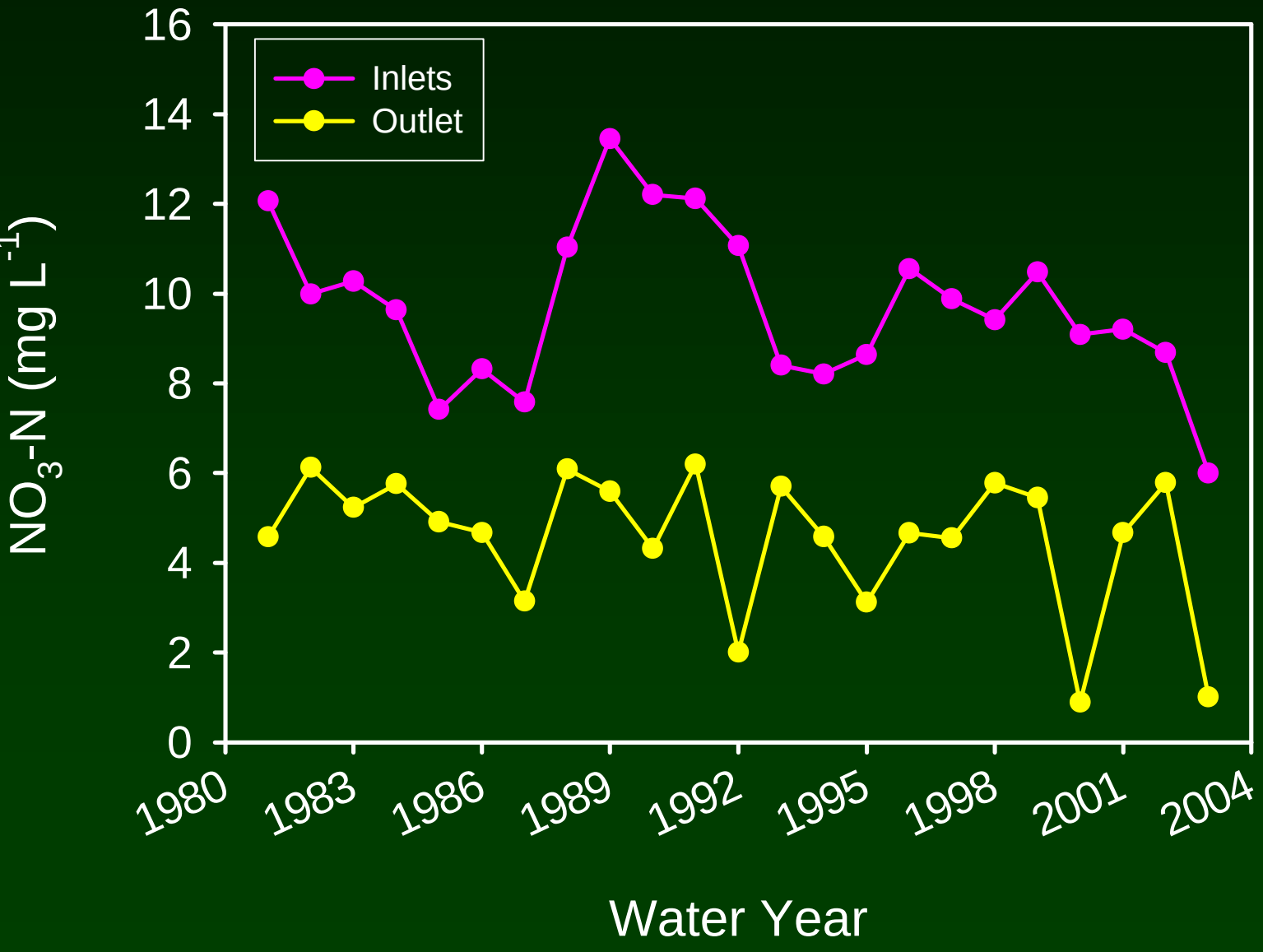
Mean depth = 5 m

Lake Shelbyville Mass Balance
(March 2002 to March 2003)

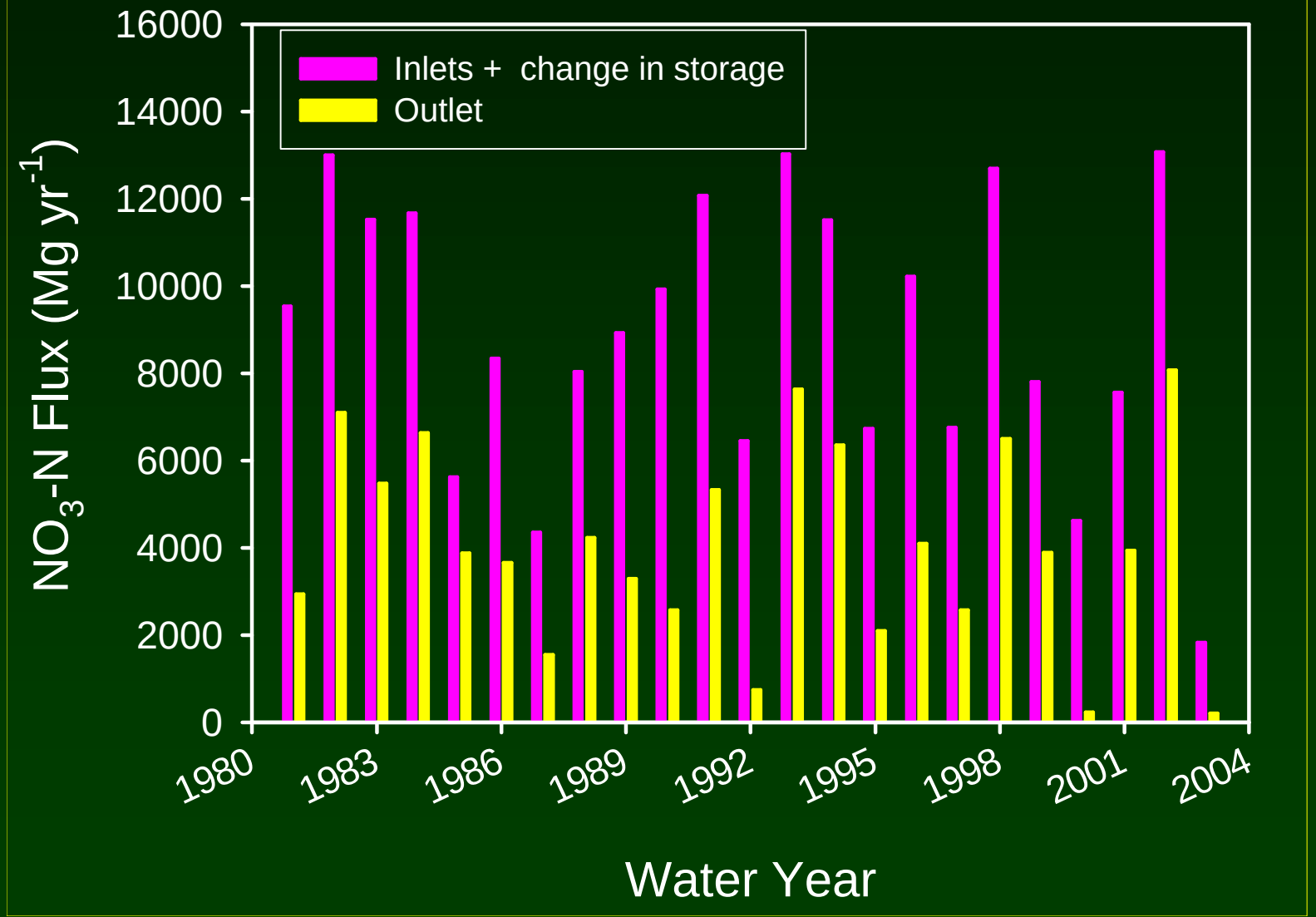


All units Mg N yr^{-1}

Lake Shelbyville N Concentrations

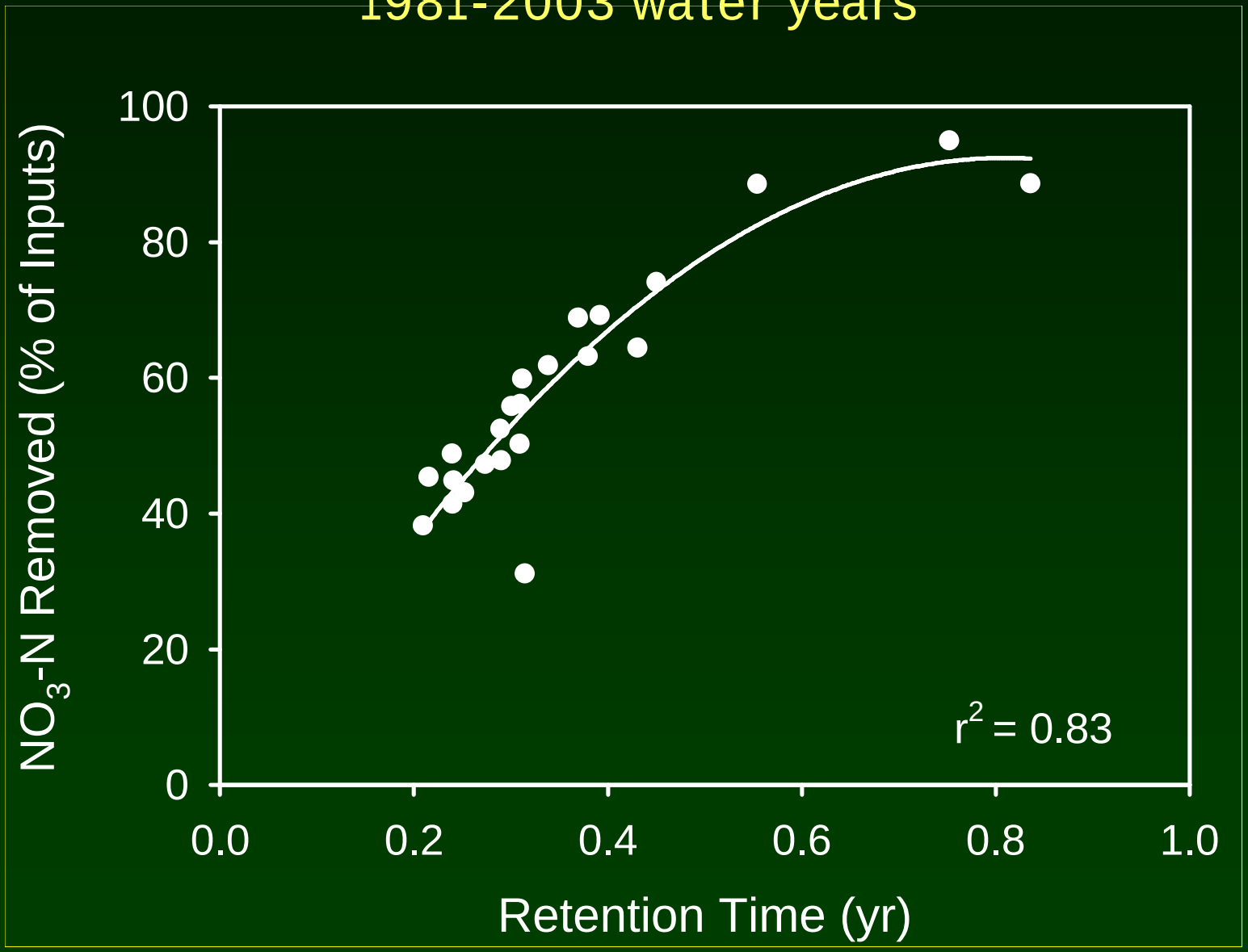


Lake Shelbyville N Flux



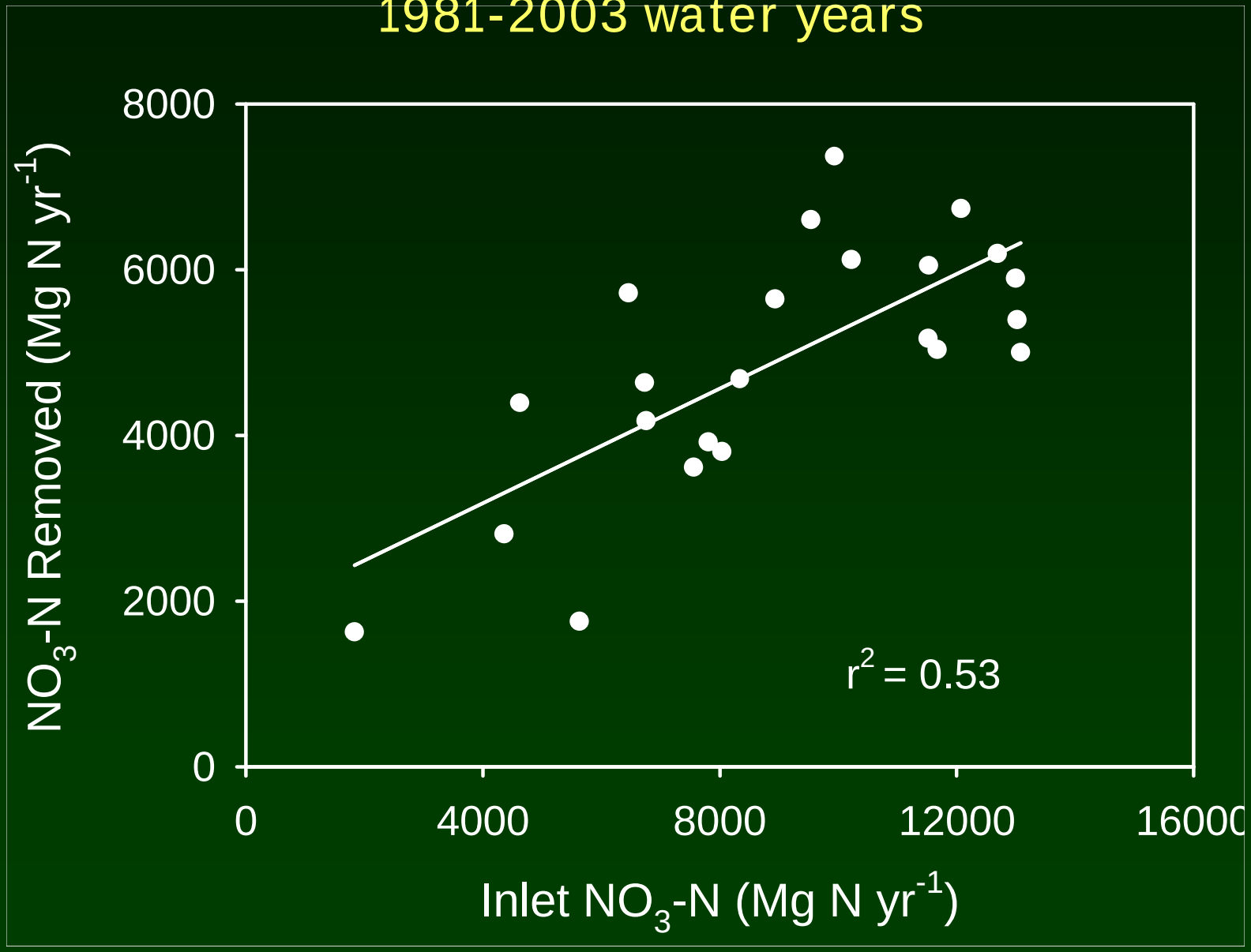
Lake Shelbyville

1981-2003 water years



Lake Shelbyville

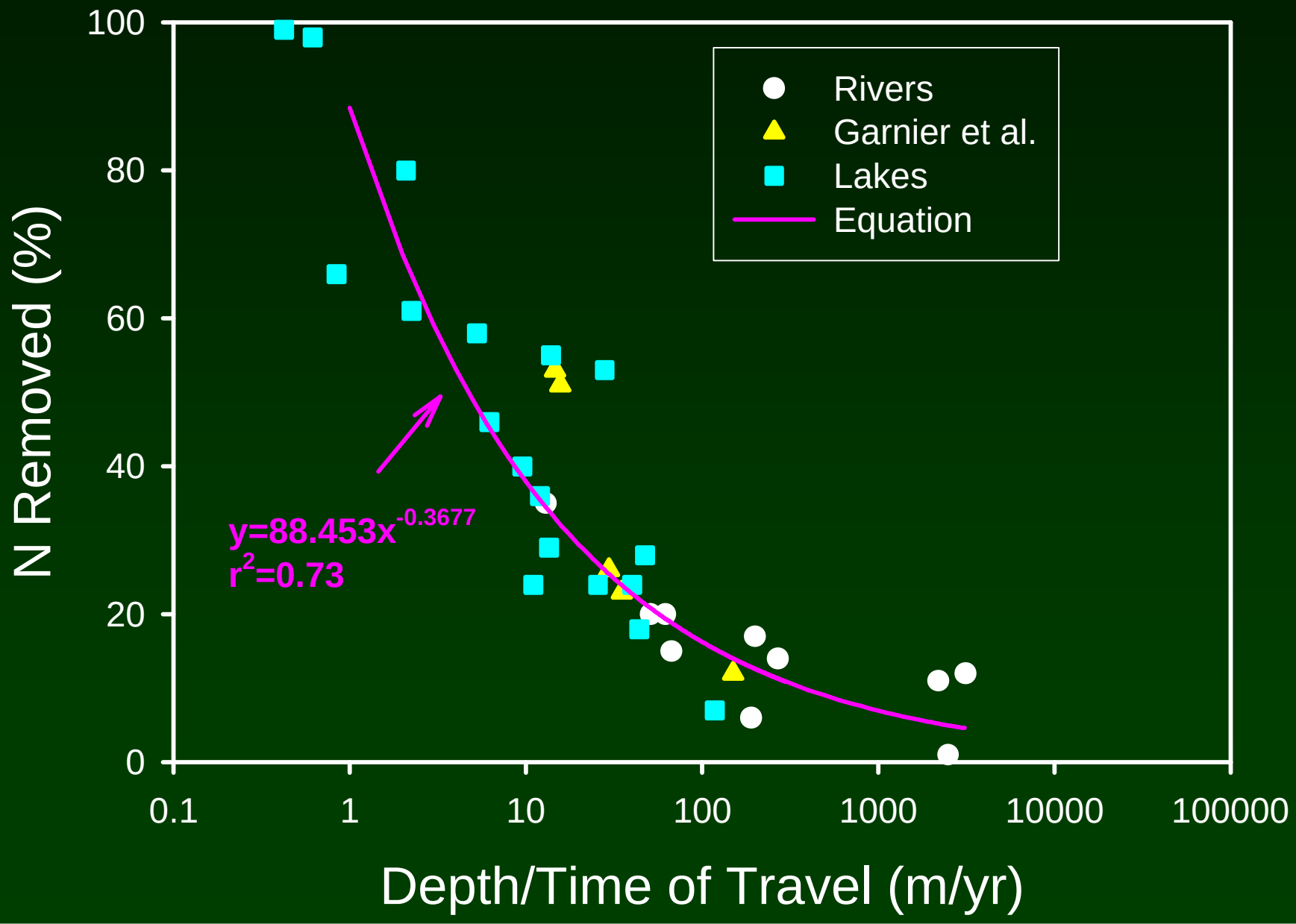
1981-2003 water years



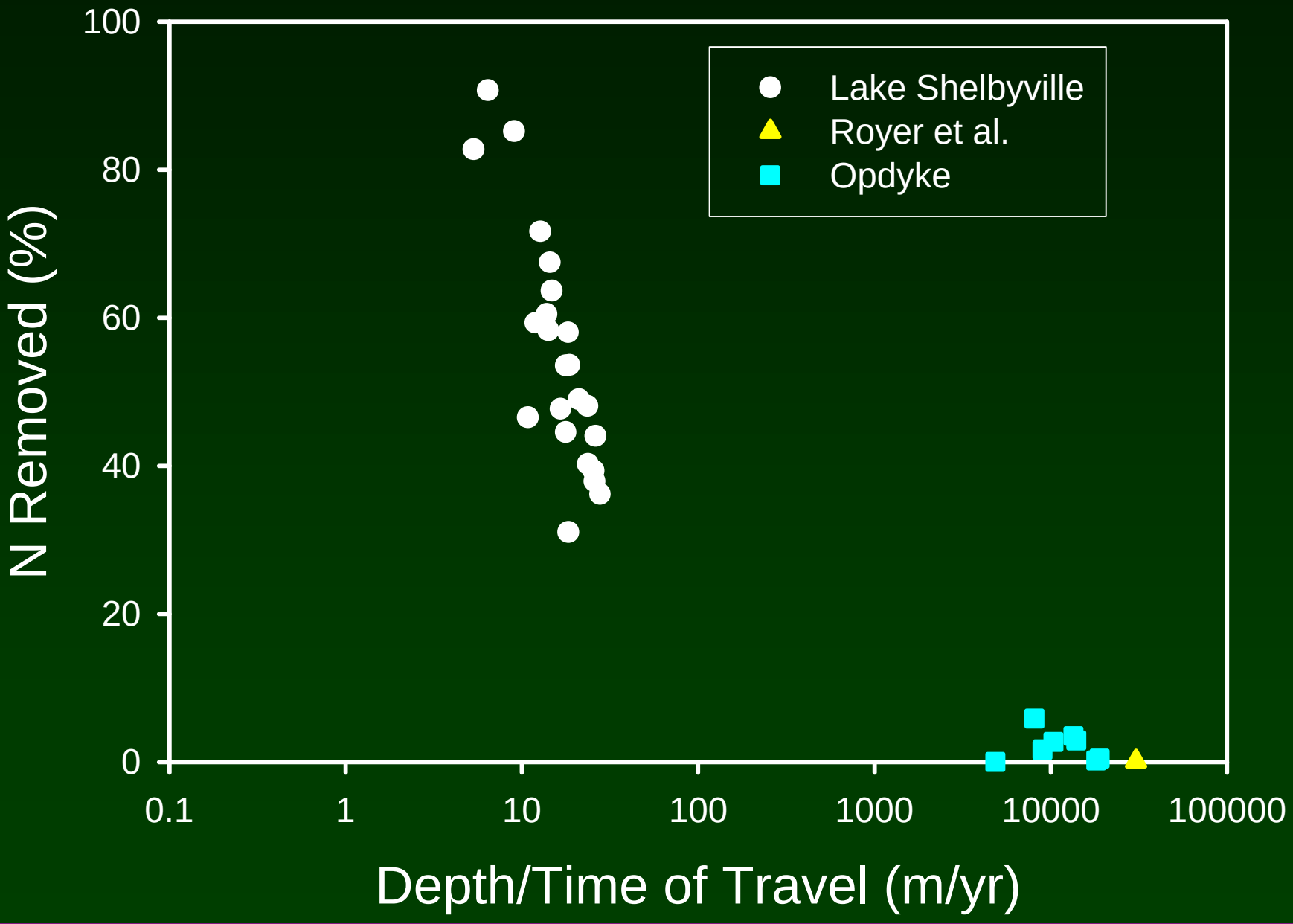
Denitrification in the Mass Balance of Illinois

- David and Gentry (2000) estimated 132,000 Mg N yr^{-1} by in-stream denitrification (87,000 in-field)
- Lake Shelbyville rate was 4900 Mg N yr^{-1} (108 g N m^2 yr^{-1})
- Use rate per unit area for all reservoirs in Illinois in tile drained regions
  - ~ 41,000 ha in 345 additional impoundments
  - ~ 48,900 Mg N yr^{-1} denitrification estimate
  - Streams likely to be small additional sink (~12,000 Mg N yr^{-1})
- Stream export of 244,000 Mg N yr^{-1}, would be 60,900 Mg N yr^{-1} larger (25%)

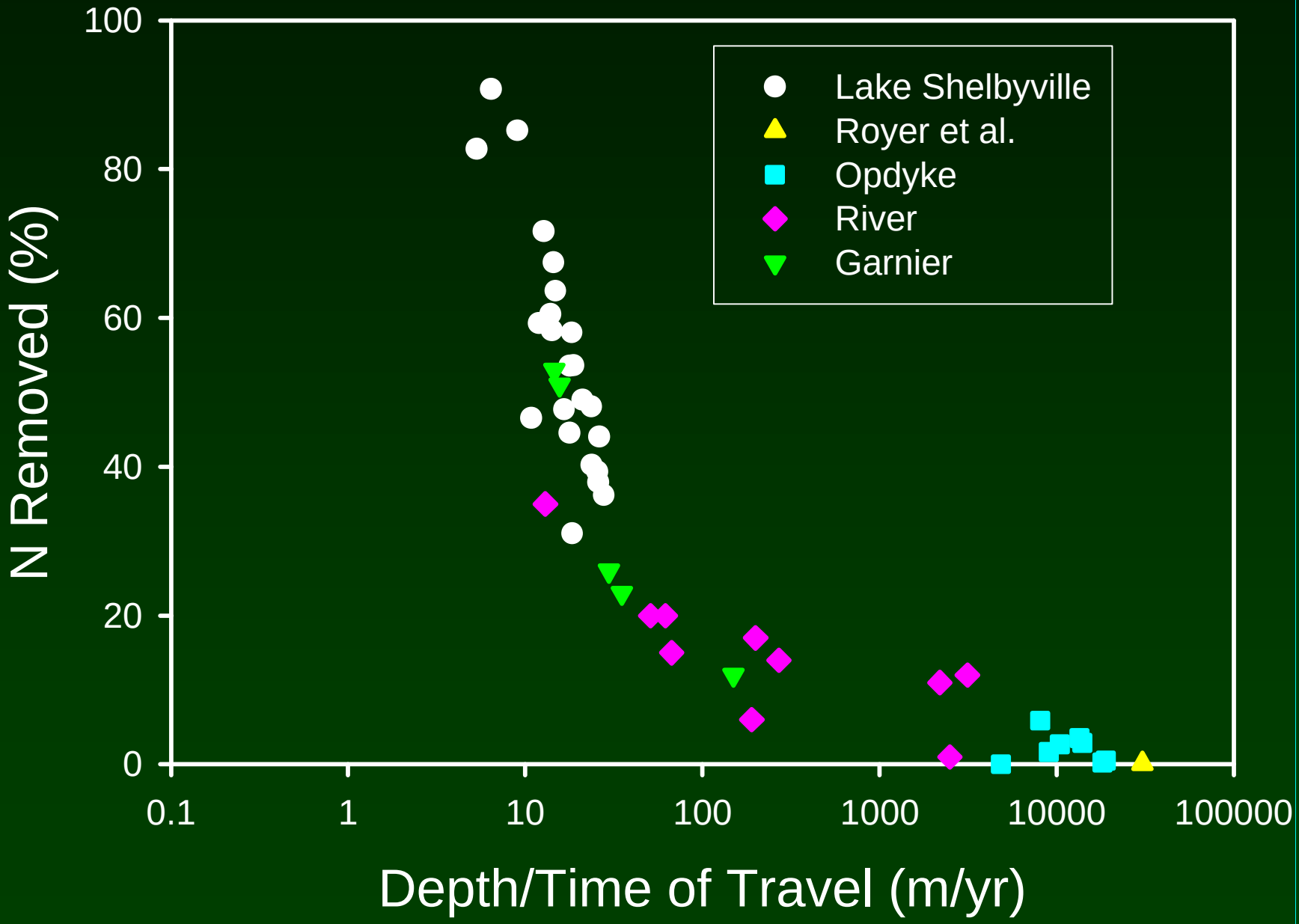
Seitzinger et al. (2002) RivR-N



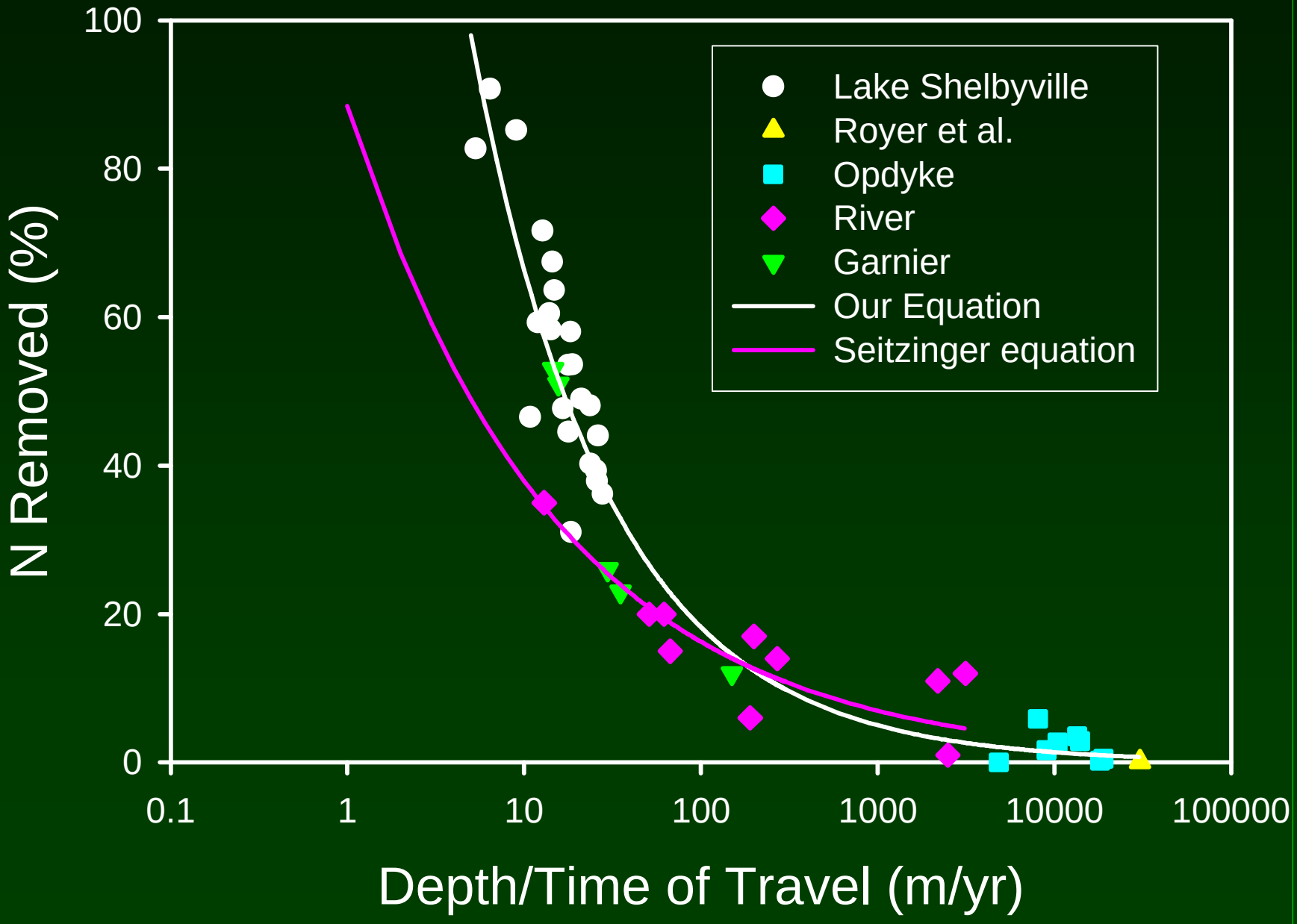
Seitzinger et al. (2002) RivR-N



Seitzinger et al. (2002) RivR-N



Seitzinger et al. (2002) RivR-N



Conclusions

- Hydrology has the major role in N export from headwater areas
- Denitrification is a relatively small N sink in headwater, agricultural streams, but can be a large sink in reservoirs
- Retention time predicts %N loss well, although different than low N lakes
- In the overall N mass balance aquatic denitrification is an important sink, primarily due to reservoirs (stream export 244,000 Mg N yr^{-1}, would be 25% greater)