Denitrification Hotspots in Fluvial Systems

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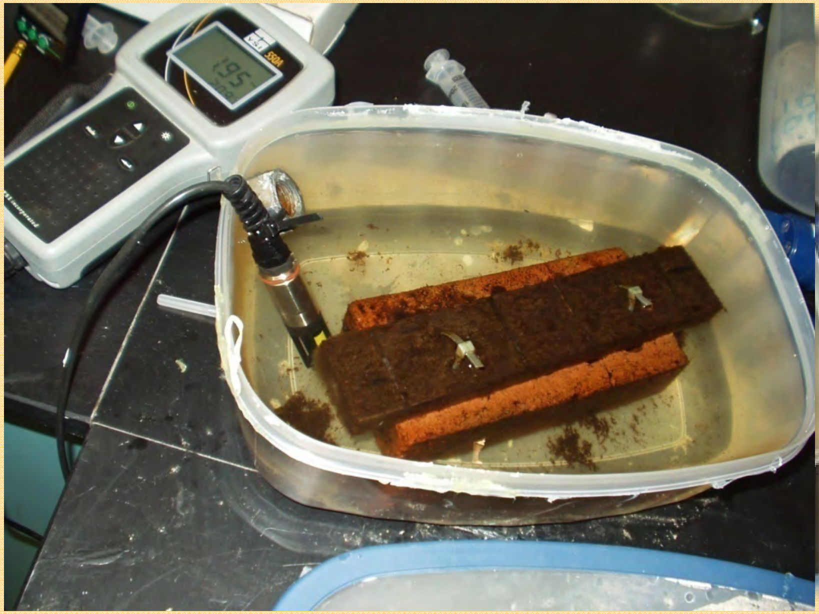
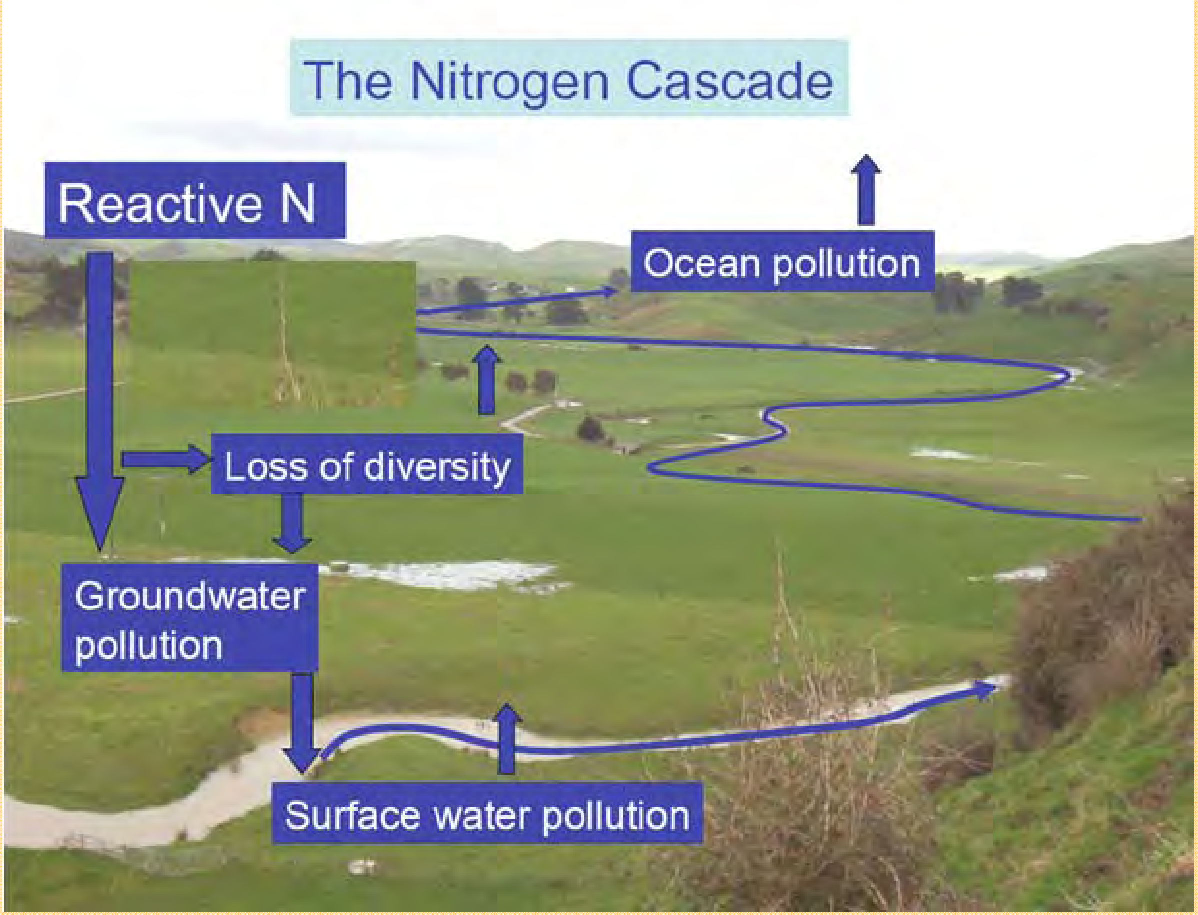


Anthropogenic N Loading

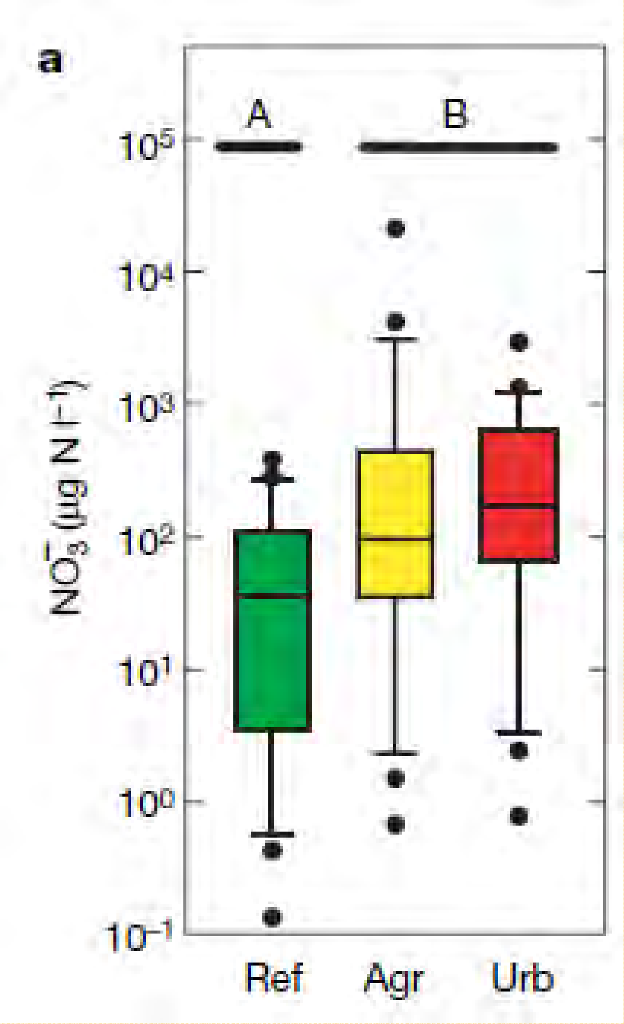
- Cultural N increase
- Terrestrial N saturation
- More N entering ground and surface water

Mulholland et al., 2008



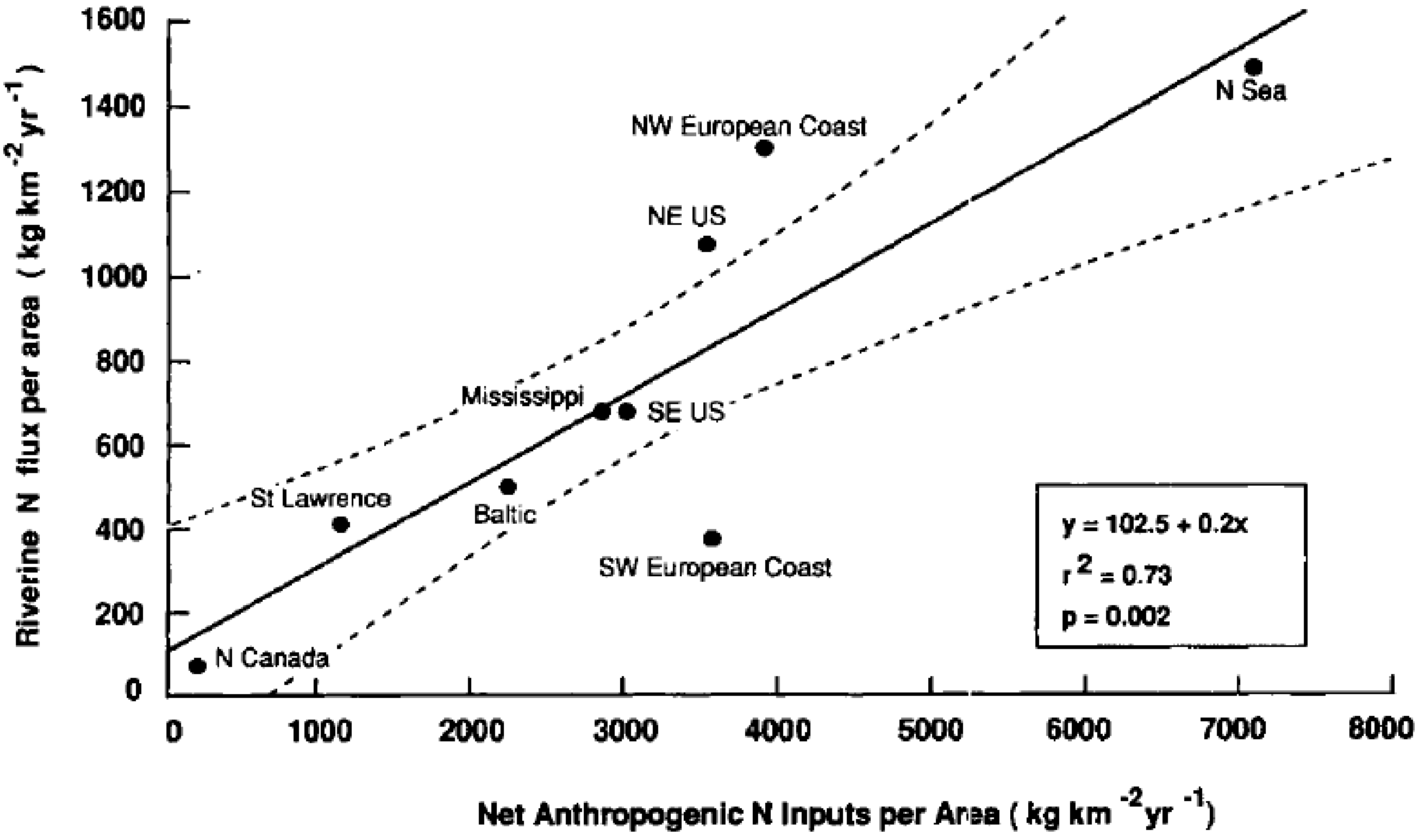
Schipper, 2009

Land use has a significant effect on NO_3^- concentration, *$p \leq 0.005$*



Mulholland et al., 2008

20-25% of N added to biosphere is exported from rivers to ocean



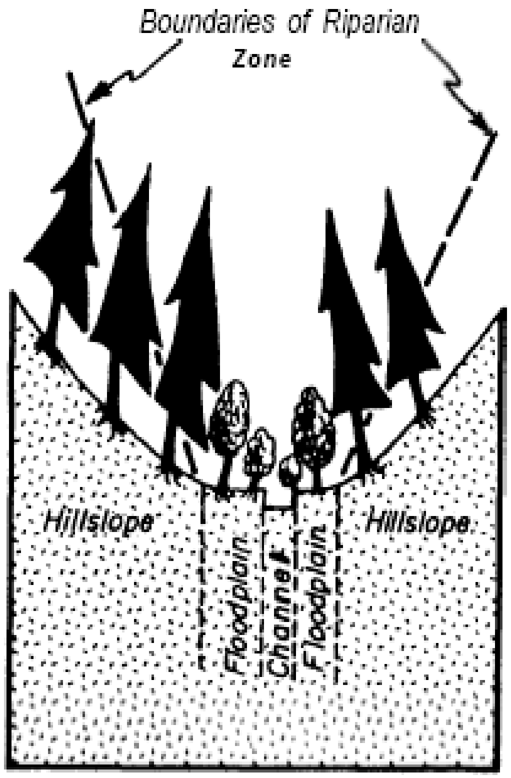
Howarth et al., 1996

Hot Spot Hypothesis

(Tiedje et al., 1984; McClain et al., 2004; Groffman et al., 2009)

- Denitrification focused in select, localized settings and thought to be a function of:
  - Pools of labile C
  - Extended residence time

Function of Vegetation in Riparian Zone



RIPARIAN VEGETATION

SITE	COMPONENT	FUNCTION
above ground-above channel	canopy 8 stems	1. Shade-controls temperature & In stream primary production 2. Source of large and fine plant detritus 3. Source of terrestrial insects
in channel	large debris derived from riparian veg.	1. Control routing of water and sediment 2. Shape habitat - pools, riffles, cover 3. Substrate for biological activity
streambanks	roots	1. Increase bank stability 2. Create overhanging banks -cover
floodploin	stems & low lying canopy	1. Retard movement of sediment, water and floated organic debris in flood flows

Naiman and Decamps, 1997

Woody Debris

- Woody debris results in longer residence times
- Provides habitat for fish and macroinvertebrates
- Retains plant seeds and fragments, protects them from erosion and herbivory
- Offers protection for small mammals and birds

Naiman and Decamps, 1997

Woody Debris

- Accumulates during floods in piles
- Each pile has one “big” piece that traps other smaller pieces, increasing pile size
  - Can find 160 piles per km of stream
- Piles affect streams
  - Dissipating energy
  - Trapping moving materials
  - Forming habitats
  - Redirecting water currents to create erosional and depositional environments

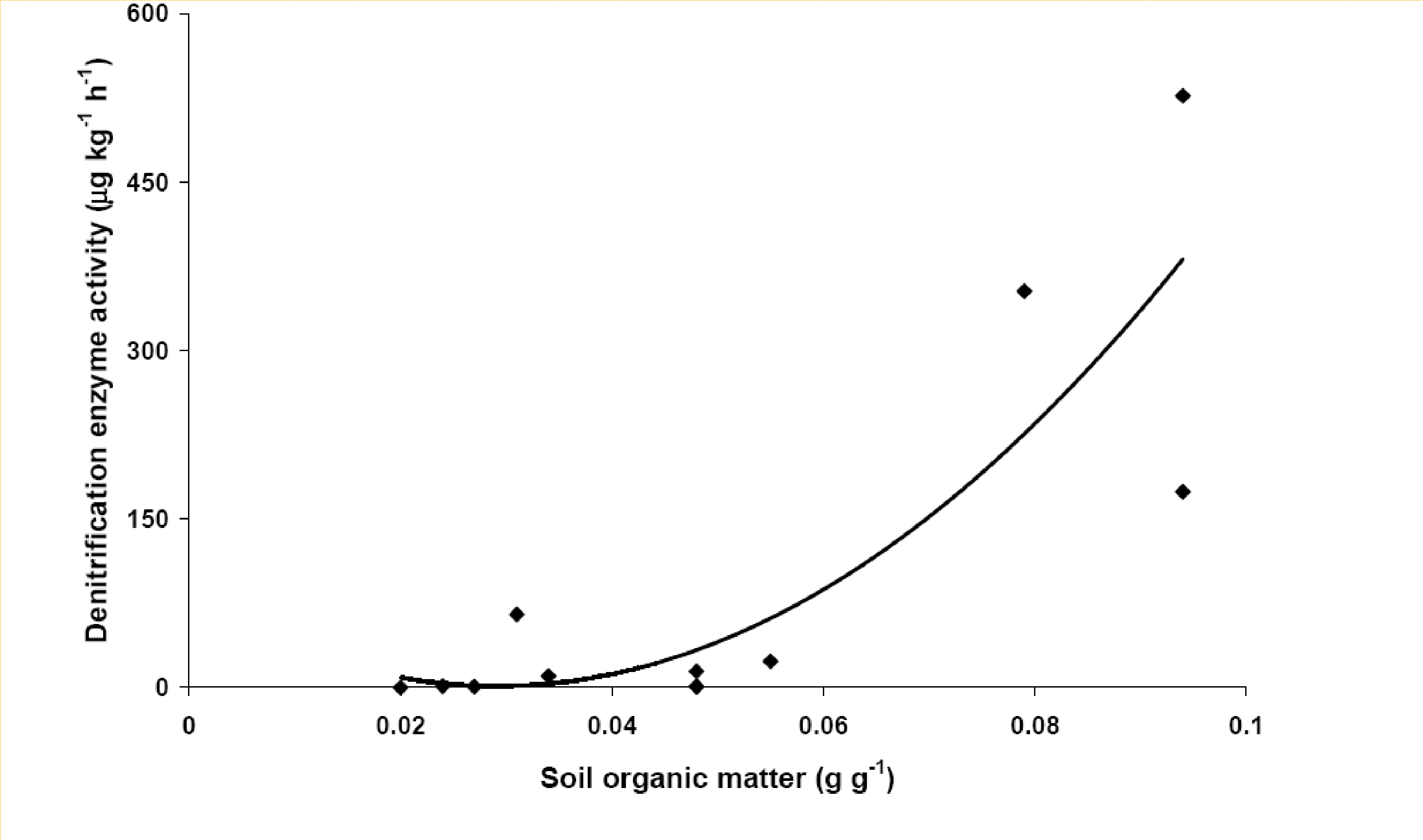
Naiman and Decamps, 1997

Streams may be important N sinks

- Hydrological connectivity with terrestrial systems
- Biological activity
- Streambed sediments

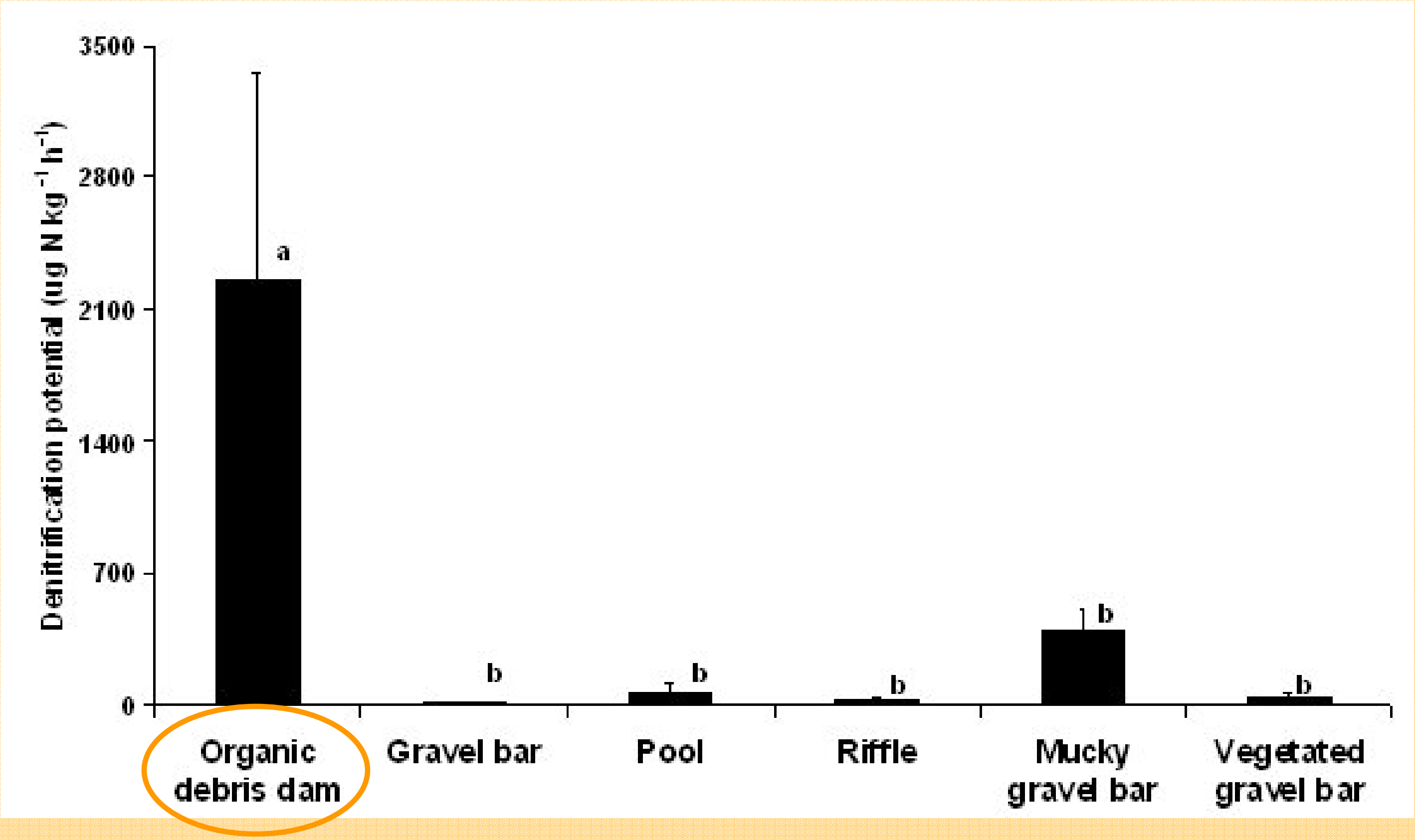
Mulholland et al., 2008

Denitrification increases with soil organic matter



Gift et al., 2008

Watershed mass balance studies suggest considerable disappearance of N in landscape sinks



Groffman et al., 2005

Denitrification

$NO_3^- \rightarrow NO_2^- \rightarrow$ **$NO \rightarrow N_2O \rightarrow N_2$**

water soluble *gases*

- Anaerobic
- Heterotrophic (requires organic C)
- Microbes, C, and N must mix

Research Interests

- What is the effect of fresh inputs of woody debris on nitrogen cycling in streams?
- What is the effect of biofilm on N cycling in streams of differing N enrichments?
- How do woody debris influence N cycling in zones of extended retention times (i.e. beaver dams, river impoundments, natural pools)?

example of biofilm

Evaluated denitrification rates from 3 different substrates in two locations

- Fresh Red Maple wood blocks
- Woody debris naturally found in stream
- Ceramic blocks
- All in stream for 9 weeks; developing biofilms

Big Spring Run, Lancaster County, PA

Mawney Brook, East Greenwich, RI

Big Spring Run, PA	Mawney Brook, RI
NO3-N: 8.6 mg/L (agricultural)	NO3-N: 0.47 mg/L (suburban)
sun	shade
No riparian buffer	Forested riparian buffer
0.2-0.5 m depth	0.5-1.0 m depth


CVS
30
SUNBLOCK


Methods

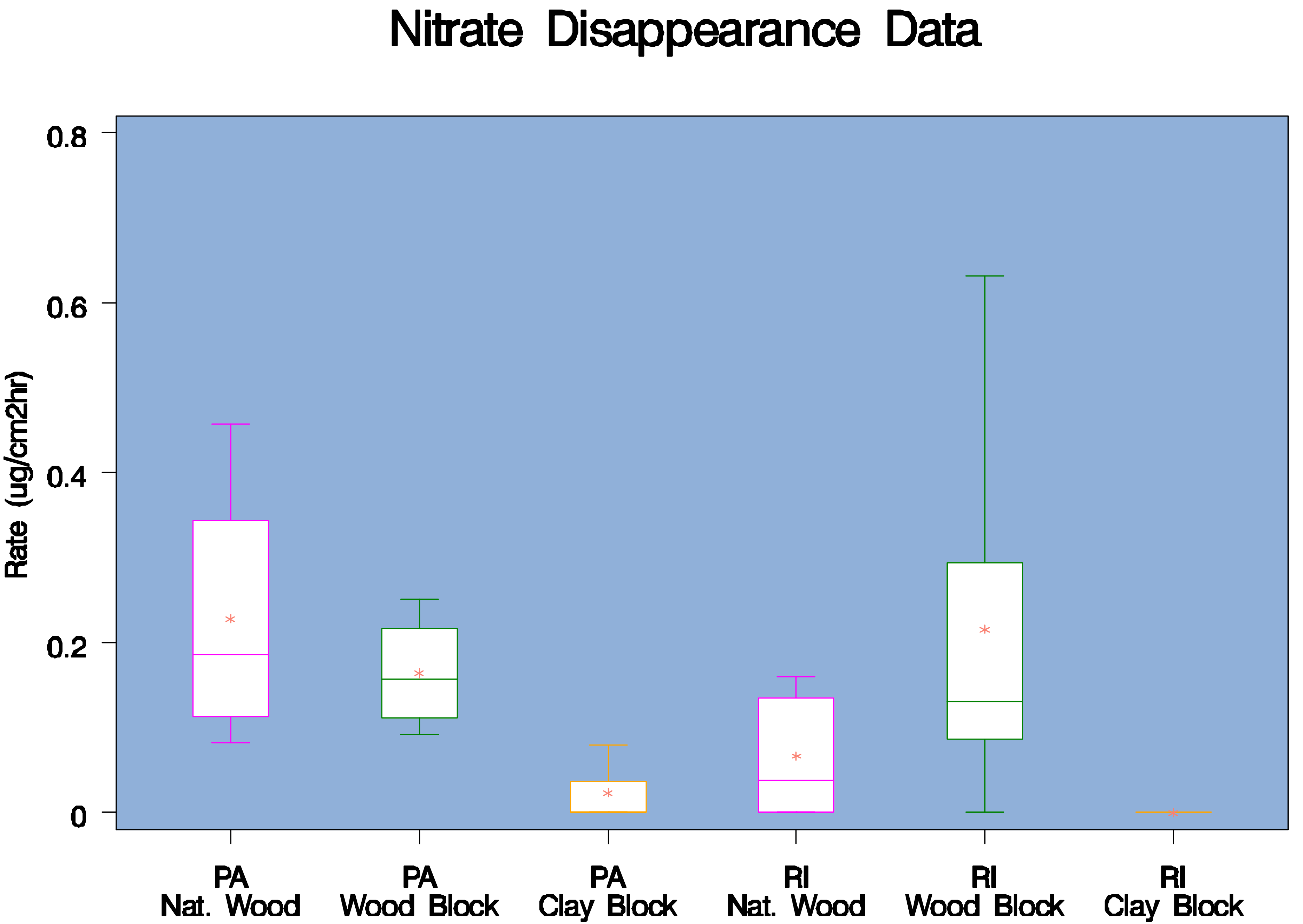
- Nitrate disappearance rate
- Acetylene Block (Yoshinari and Knowles, 1976)
  - Blocks N_2 from forming
  - Estimates DeN by assessing N_2O
- $^{15}NO_3^-$ N tracer
  - Heavier isotope used to trace DeN that occurs in mesocosm
- Incubation samples at time 0, 1.5 hrs, 3 hrs, and 18 hrs
- Both methods were used on all substrates in oxic and anoxic environments
- Rates expressed in ug/cm^{-2} hr^{-1}

Methods 2

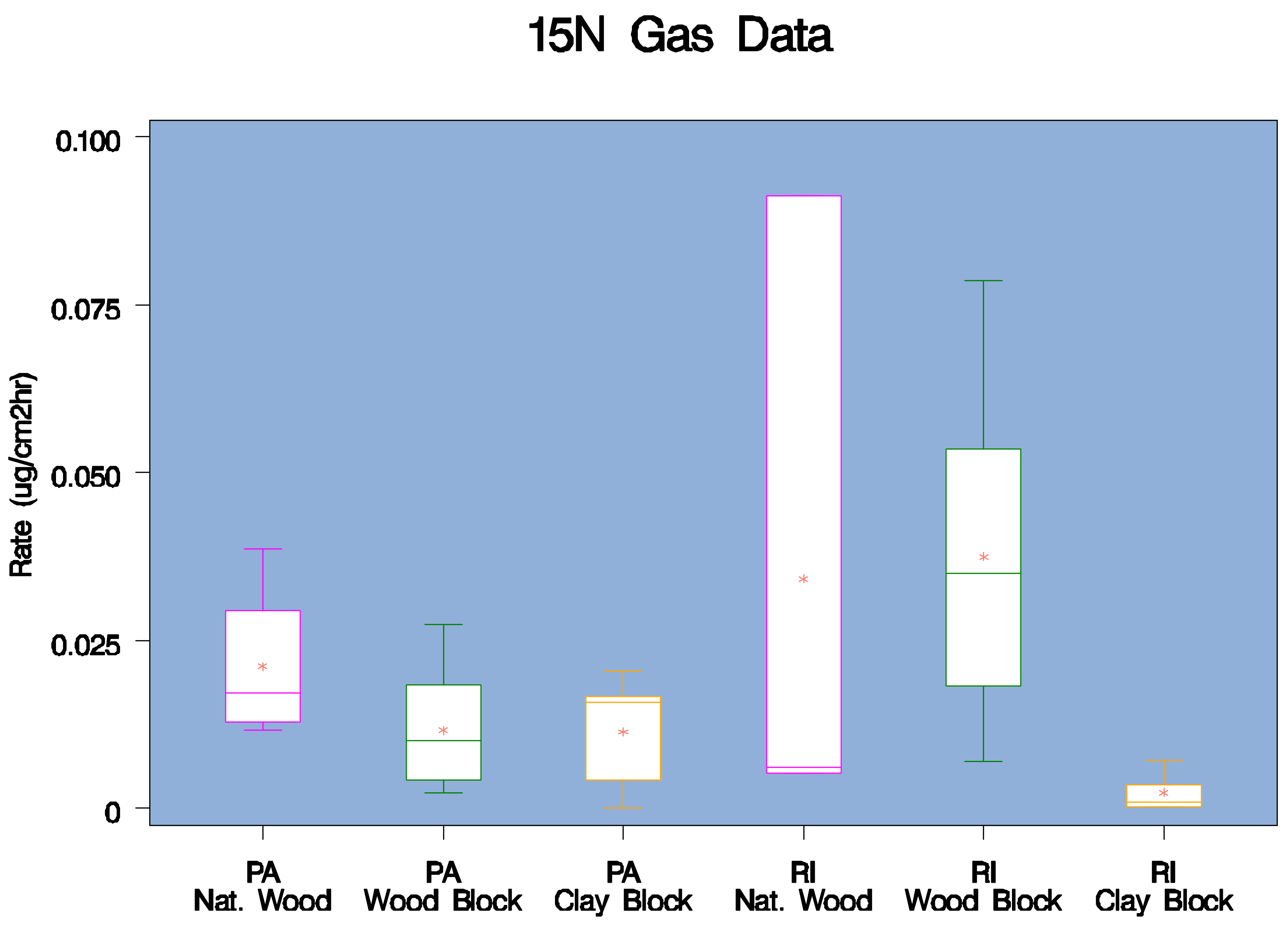
- C:N ratios of wood and biofilms
- Mass of biofilm

example of biofilm



Nitrate Disappearance Data
Rate (ug/cm2hr)
0.8
0.6
0.4
0.2
0
PA
Nat. Wood
PA
Wood Block
PA
Clay Block
RI
Nat. Wood
RI
Wood Block
RI
Clay Block


15N Gas Data
Rate (ug/cm2hr)
0.100
0.075
0.050
0.025
0
PA
Nat. Wood
PA
Wood Block
PA
Clay Block
RI
Nat. Wood
RI
Wood Block
RI
Clay Block

Future Work

- Examine role of beaver dams in N attenuation and cycling
  - Routine supply of fresh wood
  - Accumulation of organic matter
  - Beaver populations increasing
- Exploring methods for field and lab components

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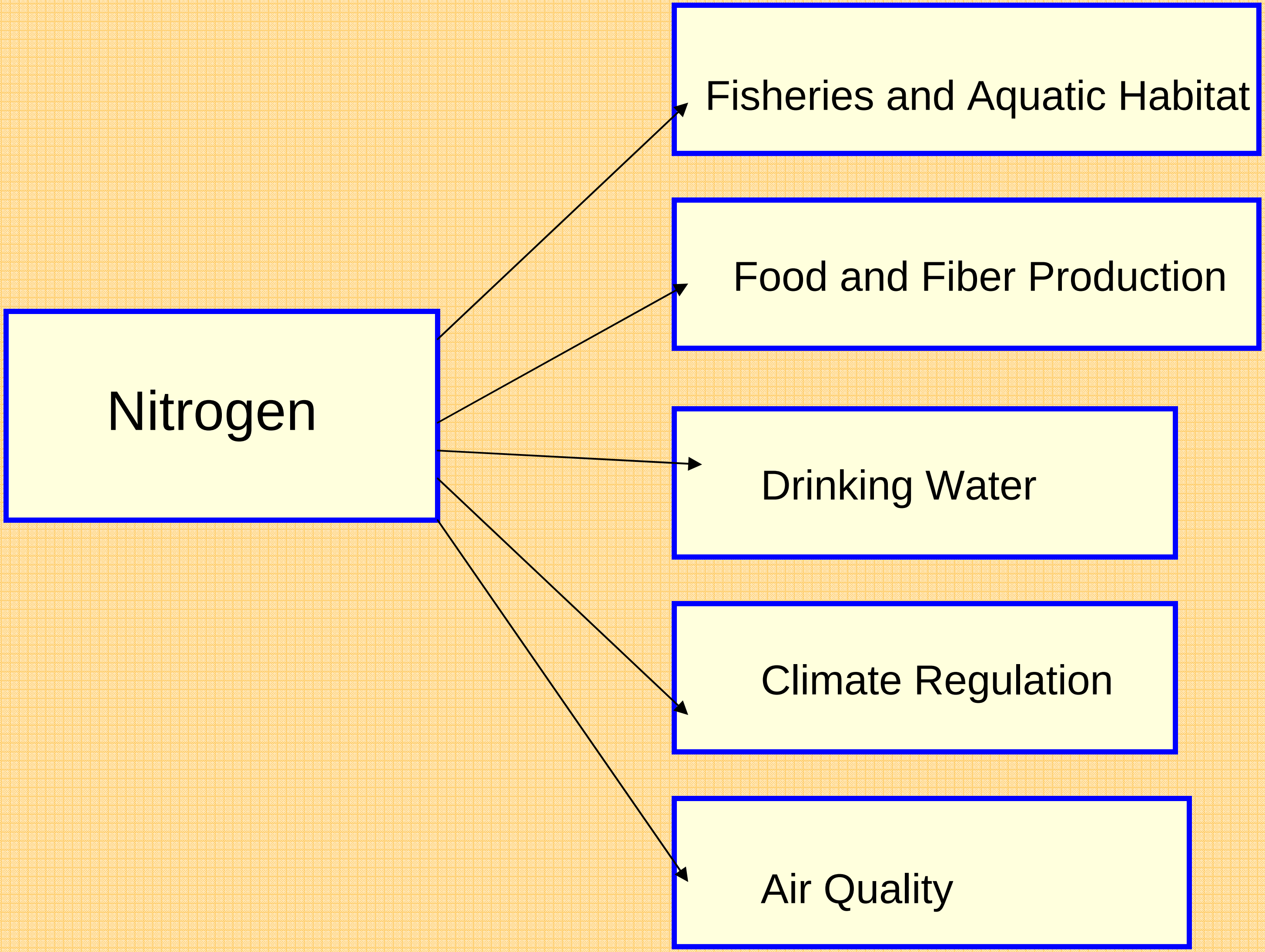
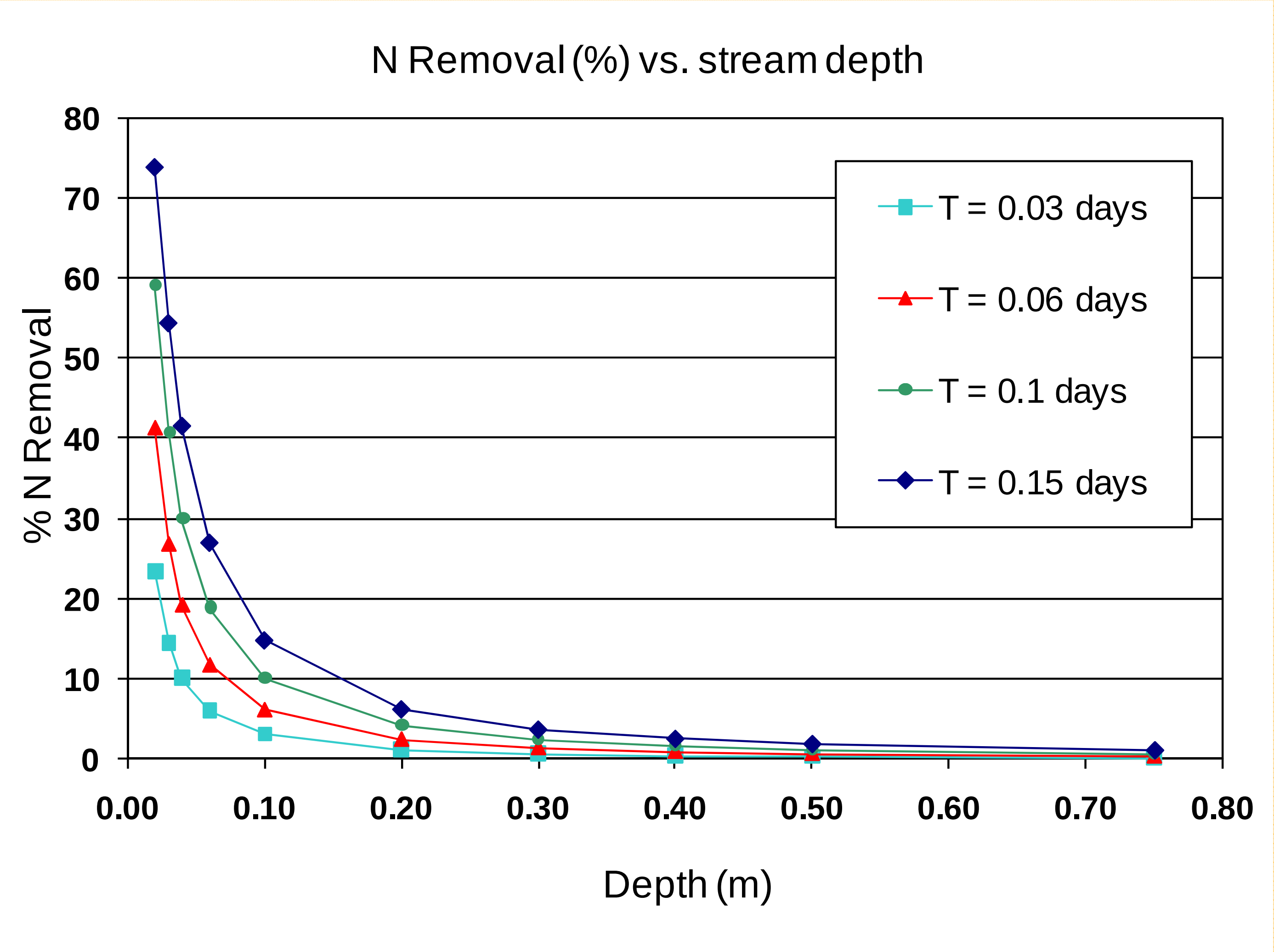
Questions?

Nitrogen Ecosystem Services



EPA. 2008

N removal decreases with depth



Kellogg et al., in press