On the receiving end: ecology of streams draining agricultural landscapes

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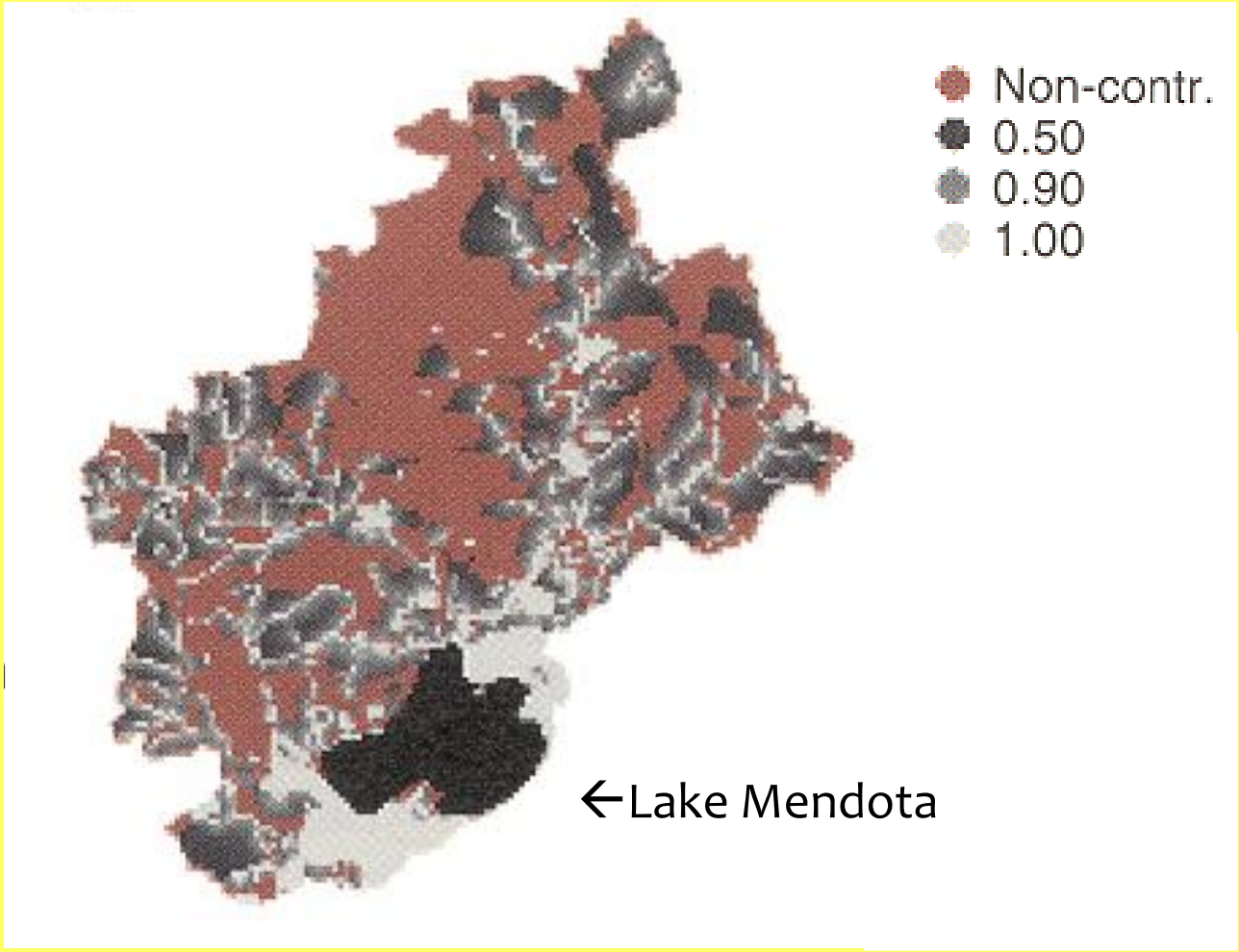
NSF

LTER

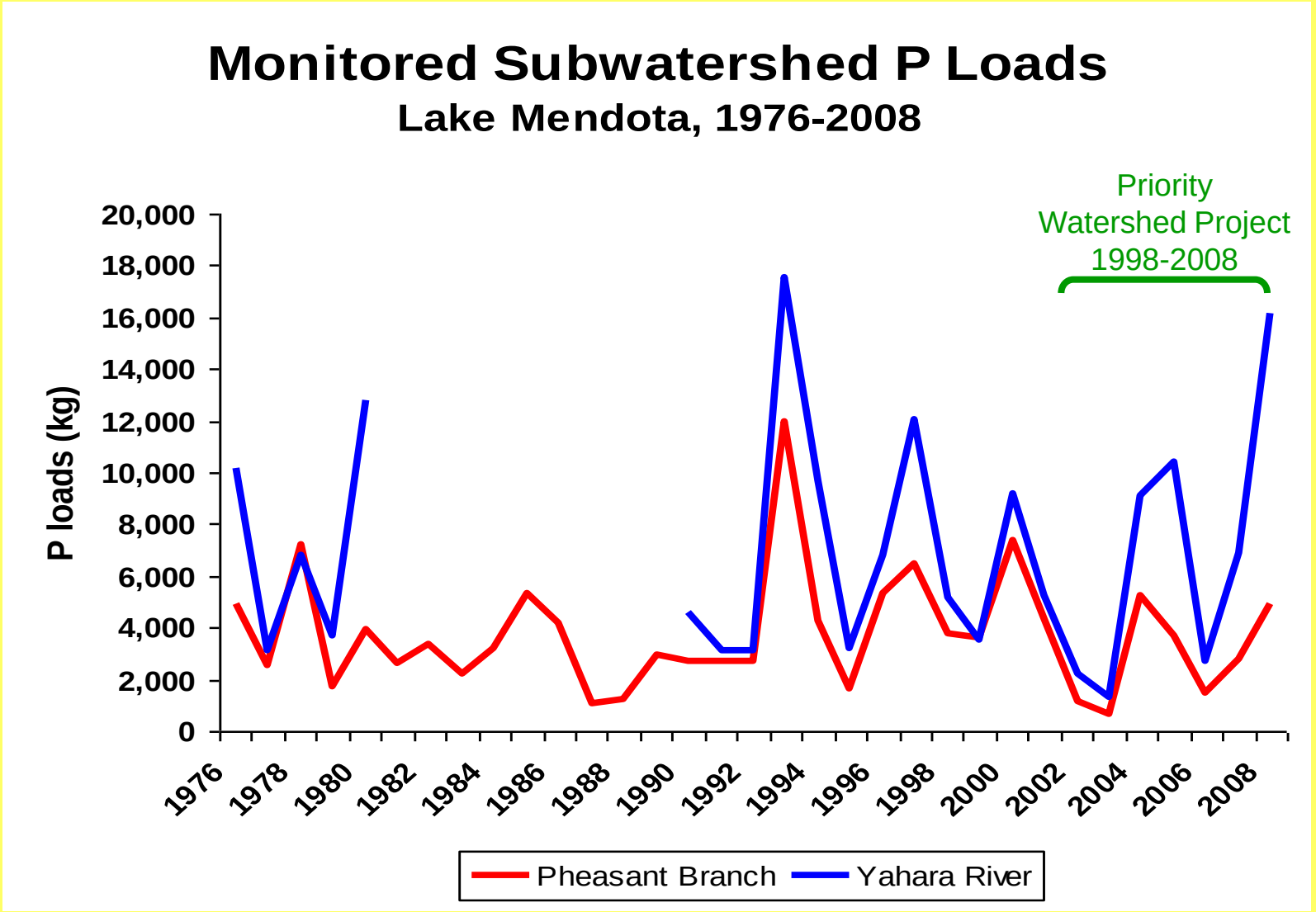
USGS
science for a changing world

Stream as conduits connecting land to lake

Soranno et al. (1996)

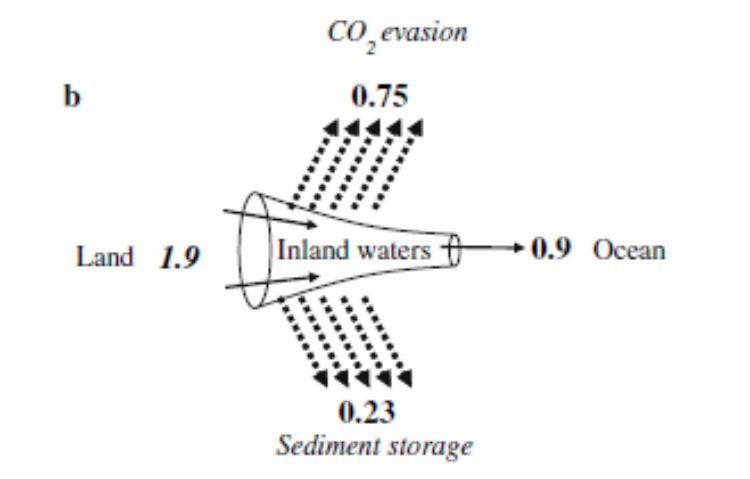


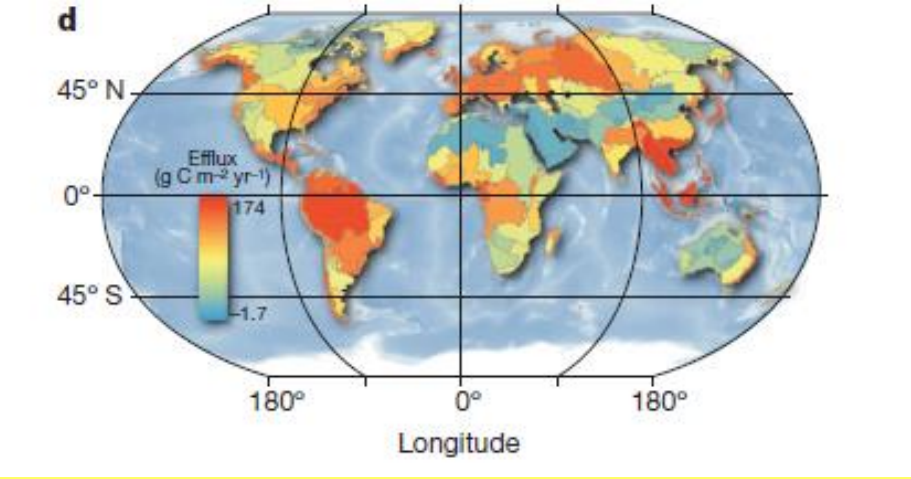
Lathrop & Carpenter (2013)



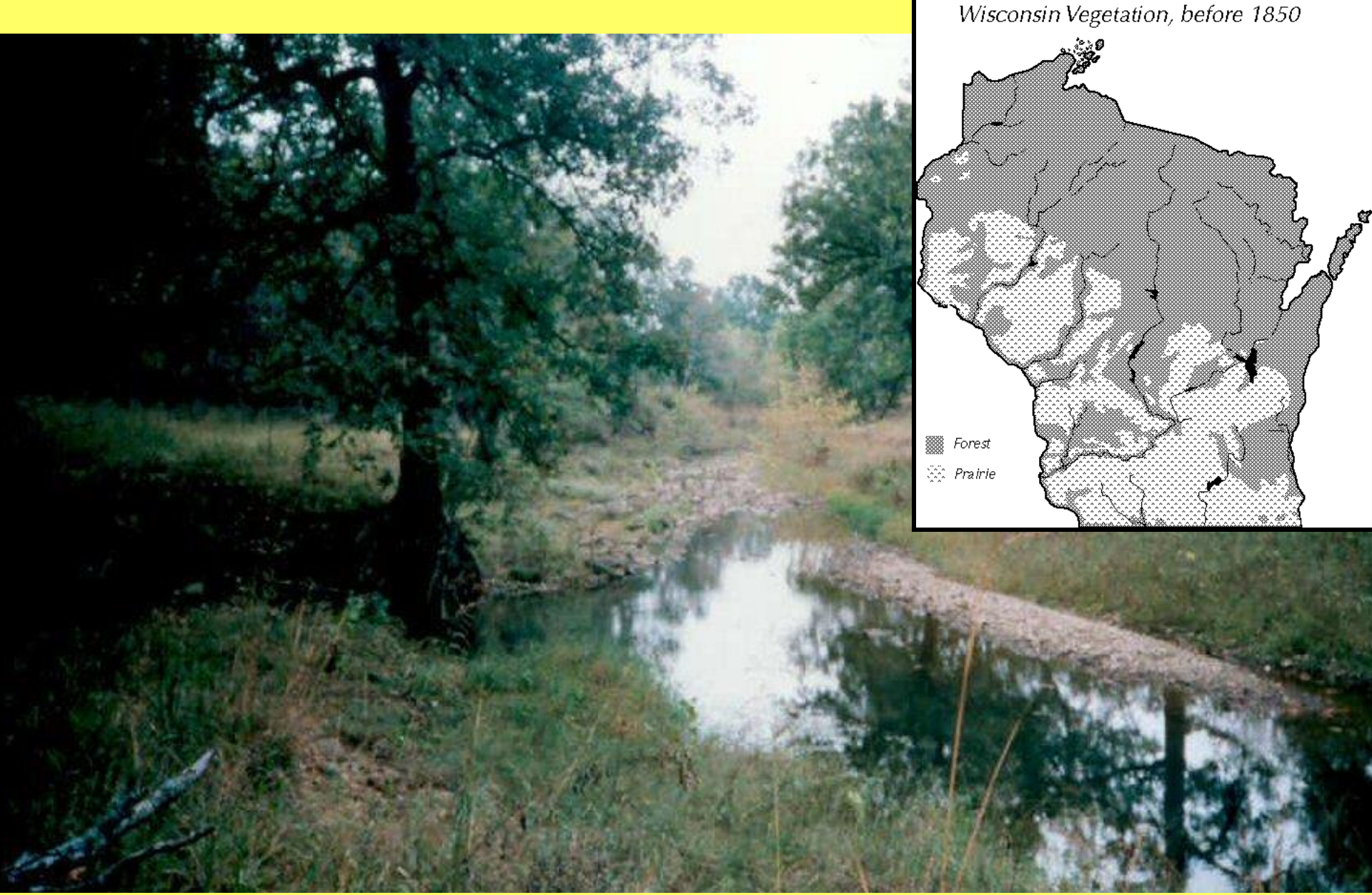
“Carbocentric World”

- Aquatic systems as transporters AND transformers
  (Cole et al. 2007, Tranvik et al. 2009, Raymond et al. 2013)



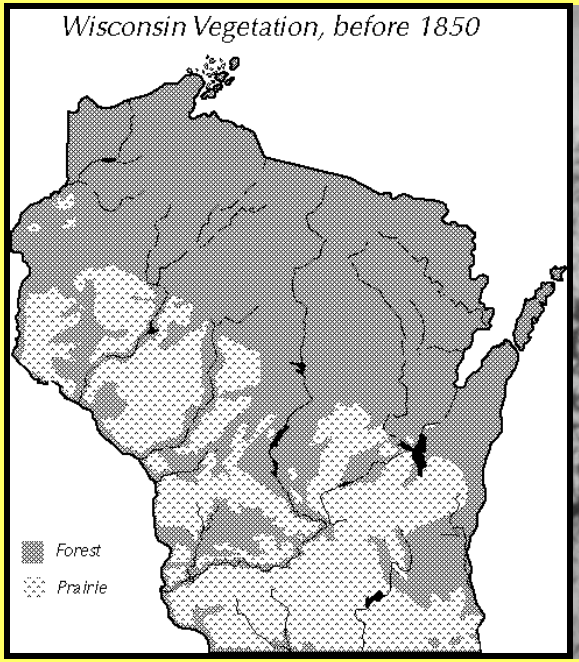


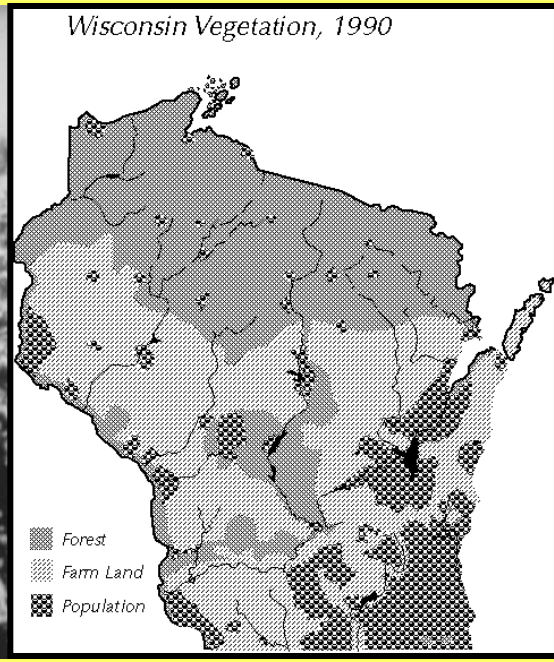
- How do human land uses affect aquatic carbon dynamics?
- LTER: long-term and cross-site perspective



How does human land use affect stream carbon balance?
A history of prairie streams in WI

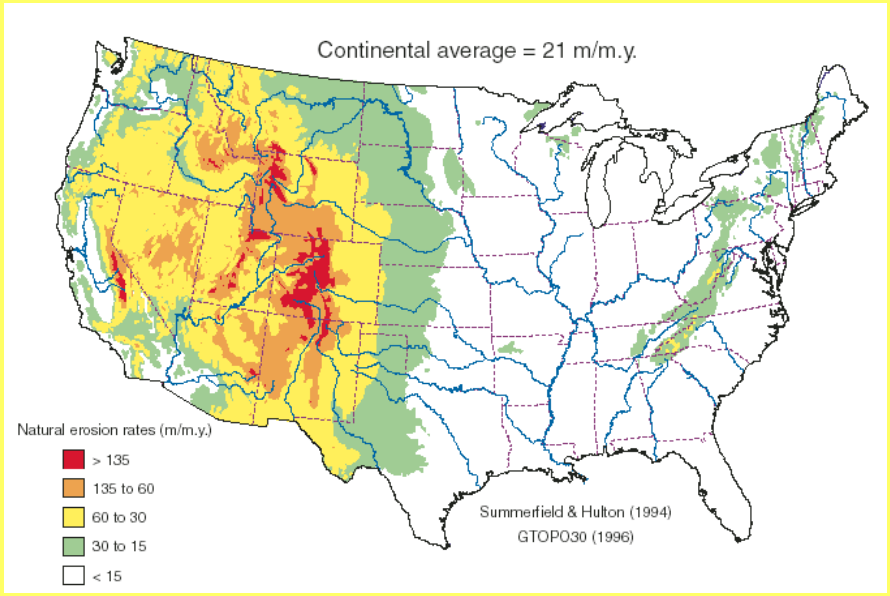
Land use change



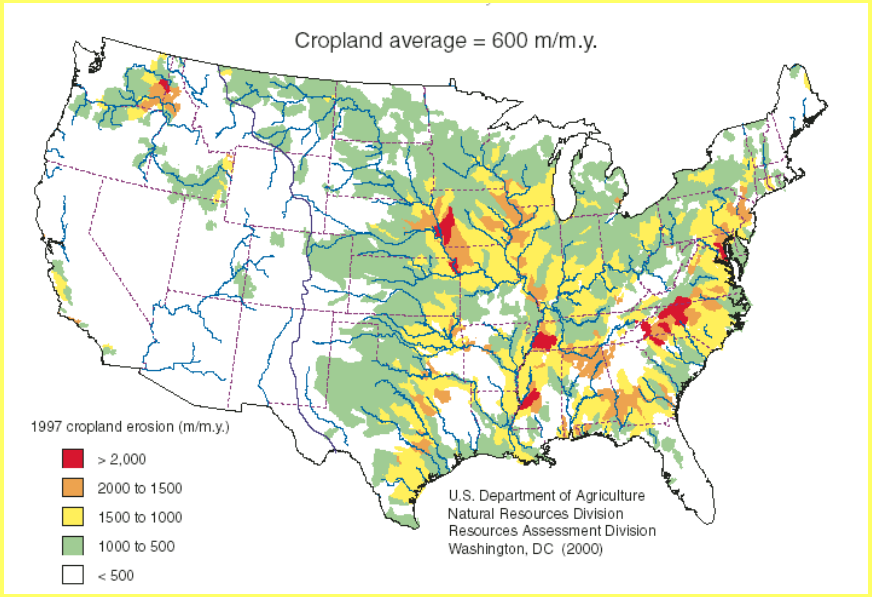


Soil erosion

Natural erosion; avg = 21m/my

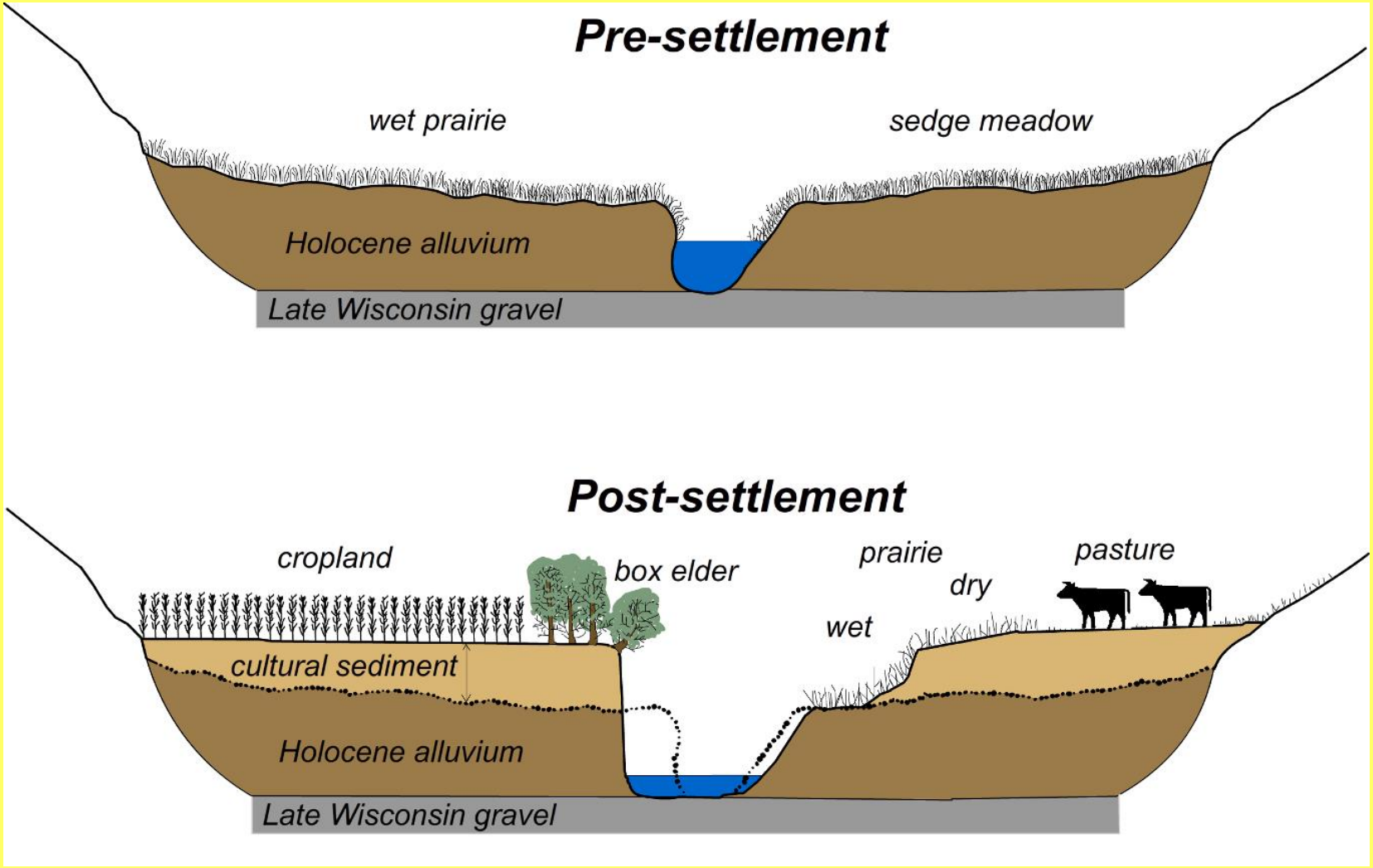


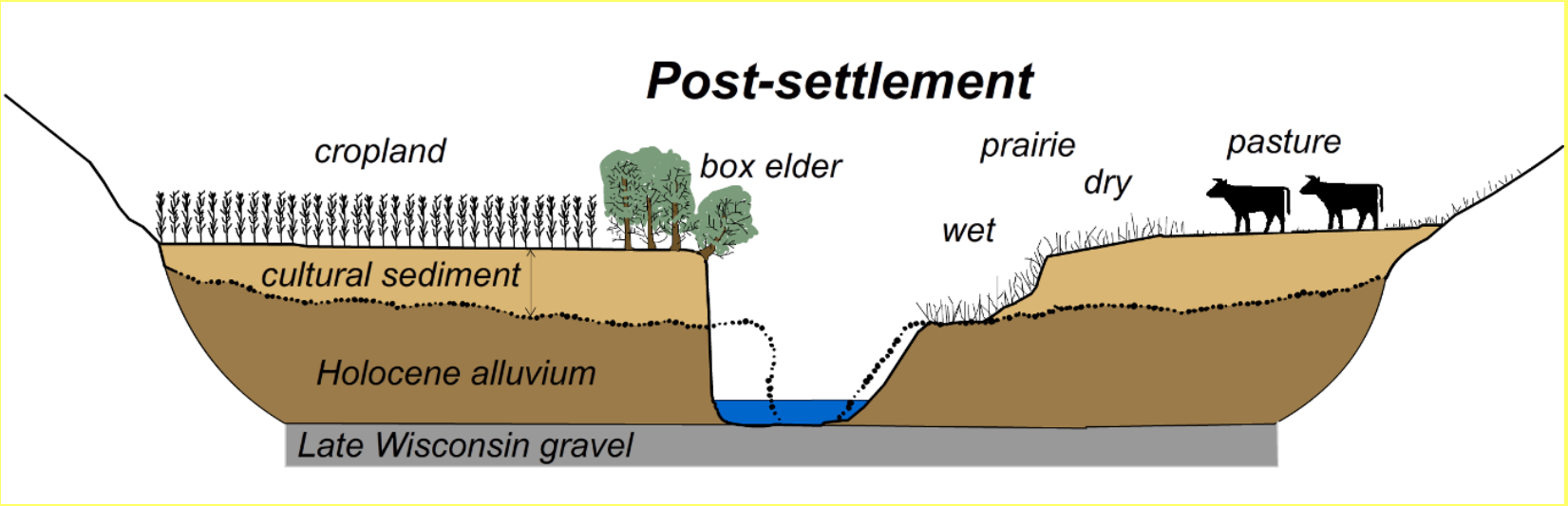
Cropland erosion; avg = 600m/my



Wilkinson & McElroy (2007)

"Post-settlement alluvium accumulation is probably the most important geomorphic process taking place on the surface of our planet."


Pre-settlement
wet prairie
sedge meadow
Holocene alluvium
Late Wisconsin gravel
Post-settlement
cropland
box elder
prairie
dry
wet
pasture
cultural sediment
Holocene alluvium
Late Wisconsin gravel


Post-settlement
cropland
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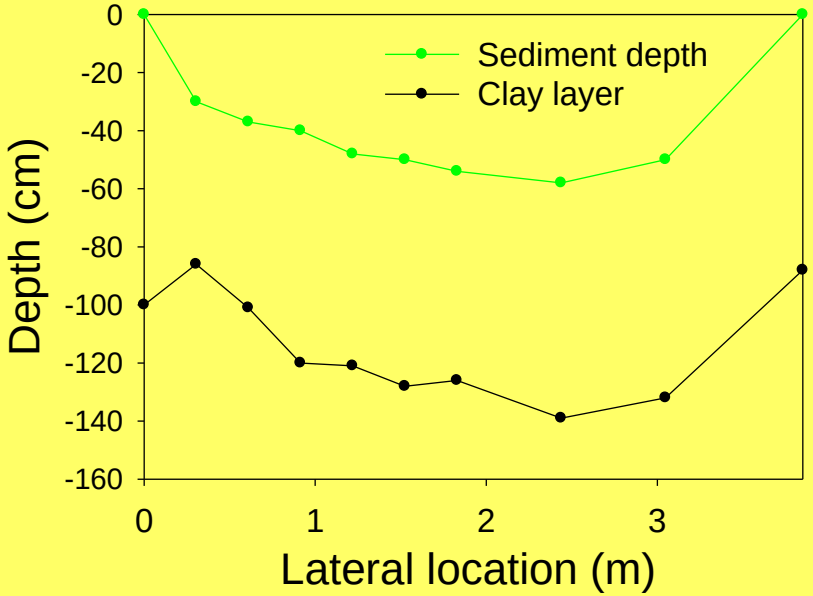
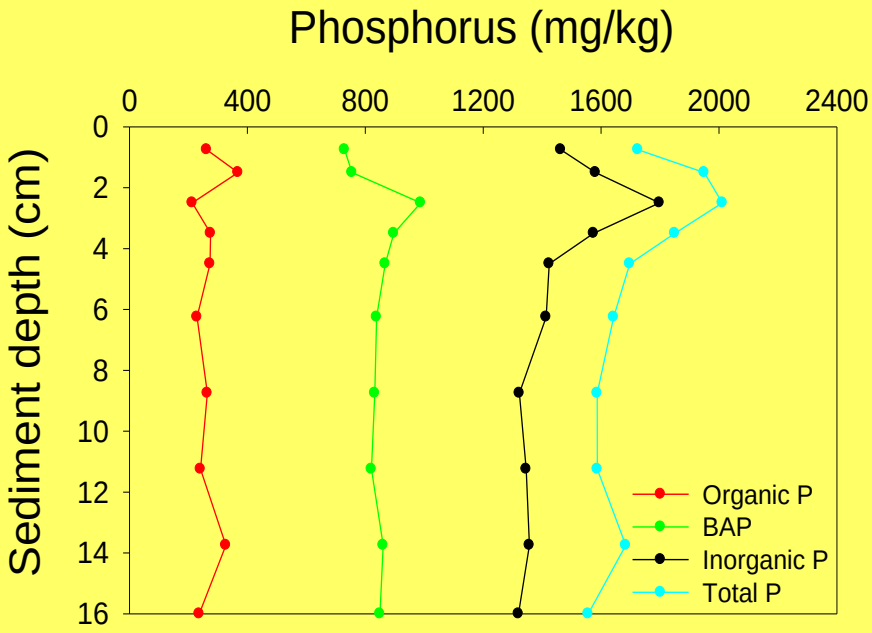
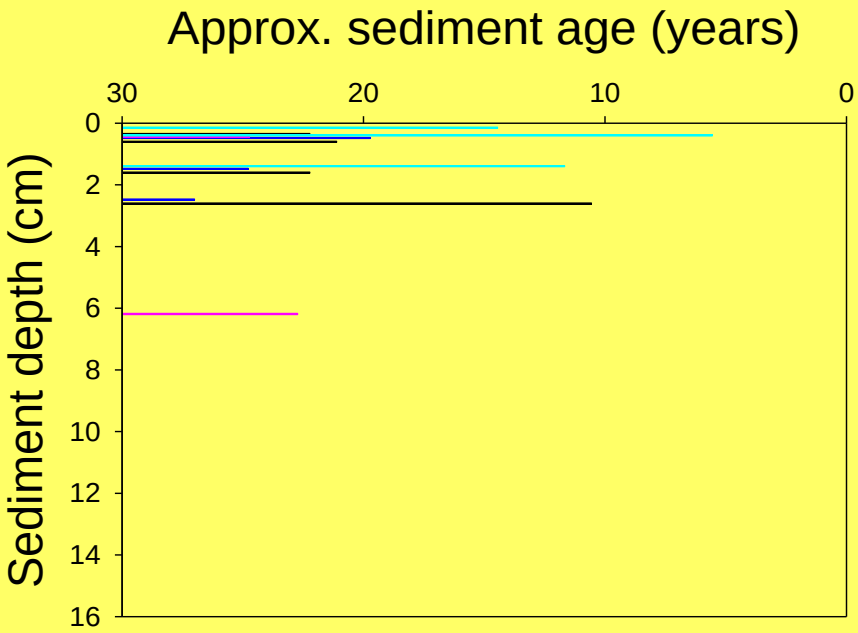
cultural sediment
Holocene alluvium
Late Wisconsin gravel

Hoffman et al. (2008)



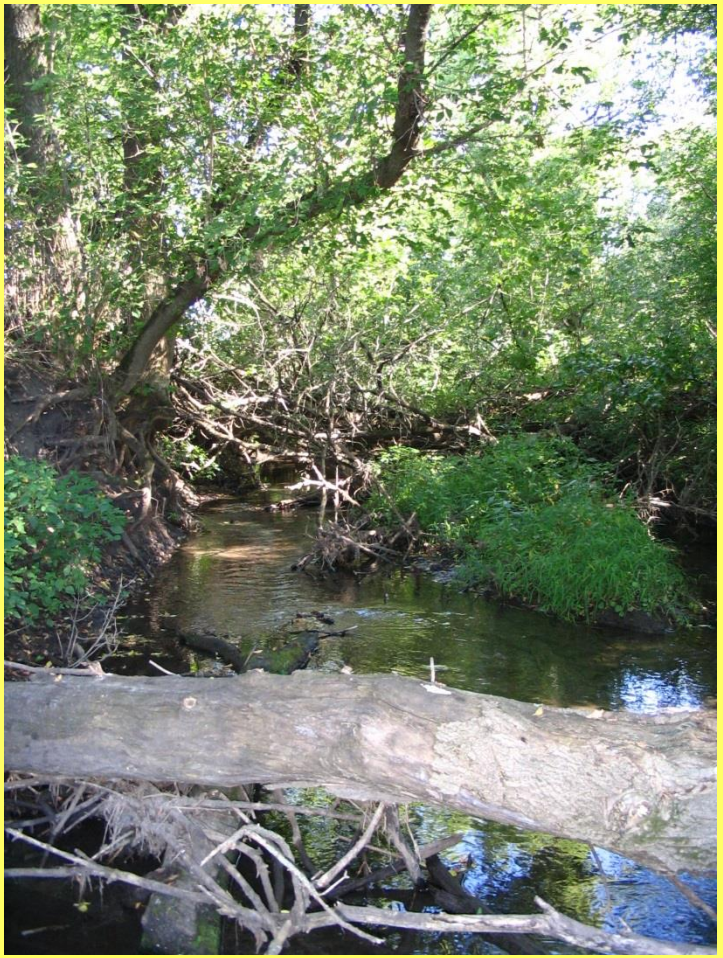




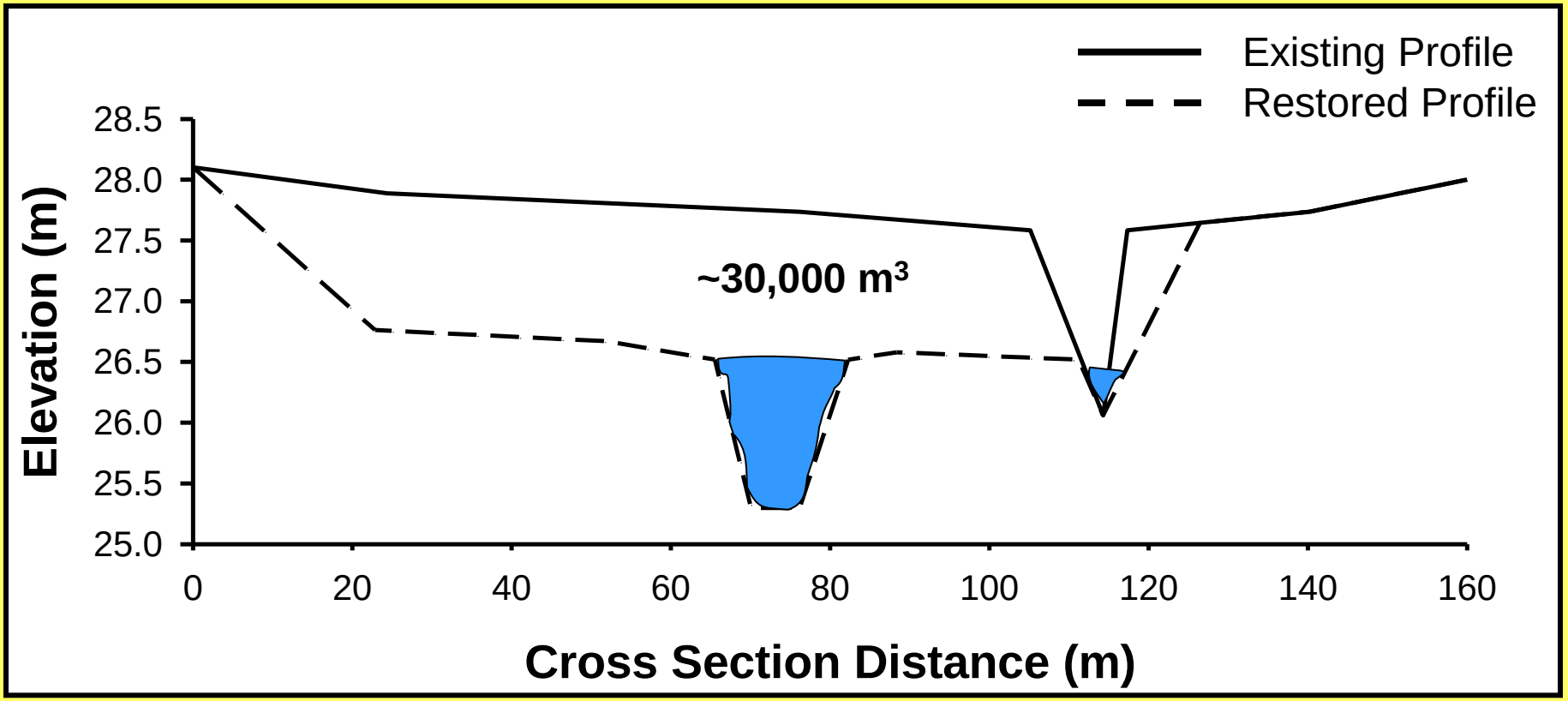
Stream restoration

- Improve cool water fish habitat
- Remove post-settlement alluvium
- Re-create wet meadows

East Branch- Pecatonica River

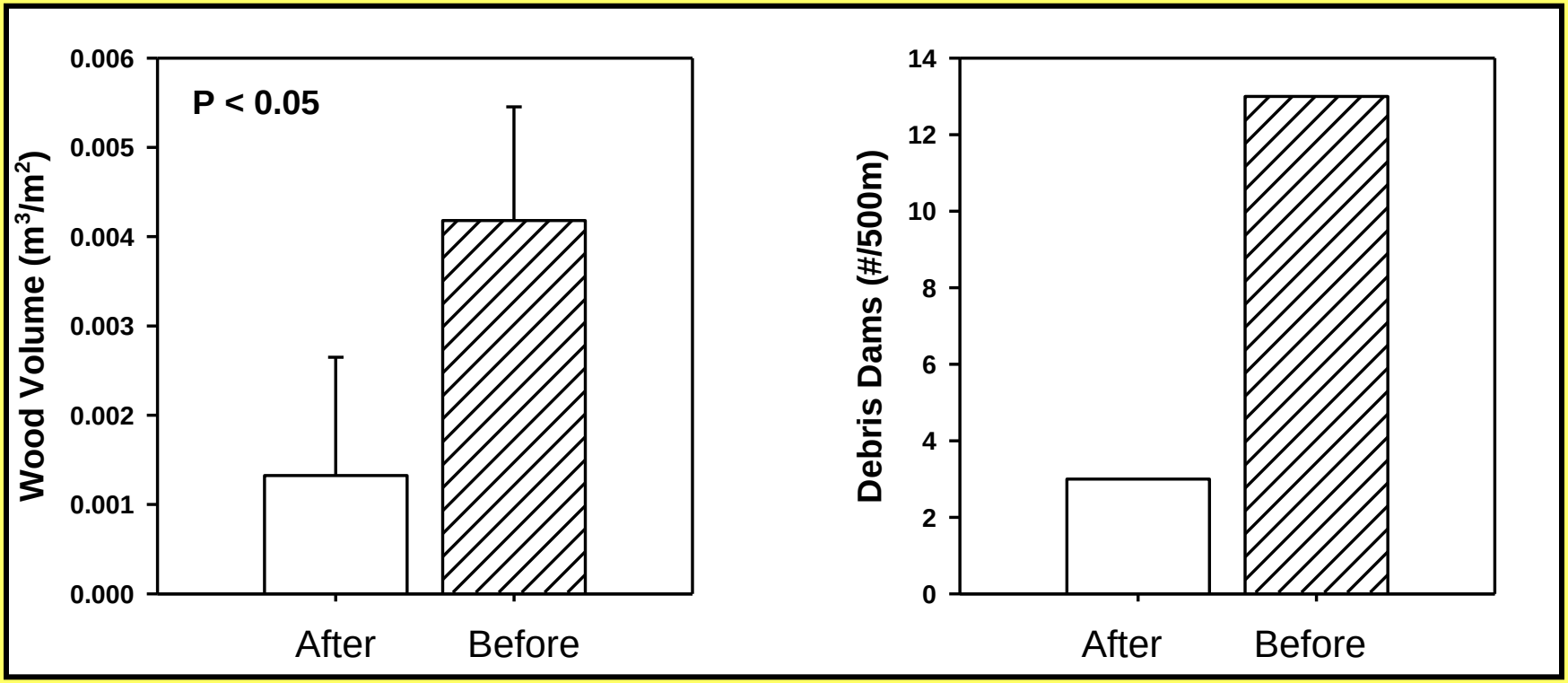


Stream restoration



Lottig & Stanley (unpublished)

What happens when trees are removed…



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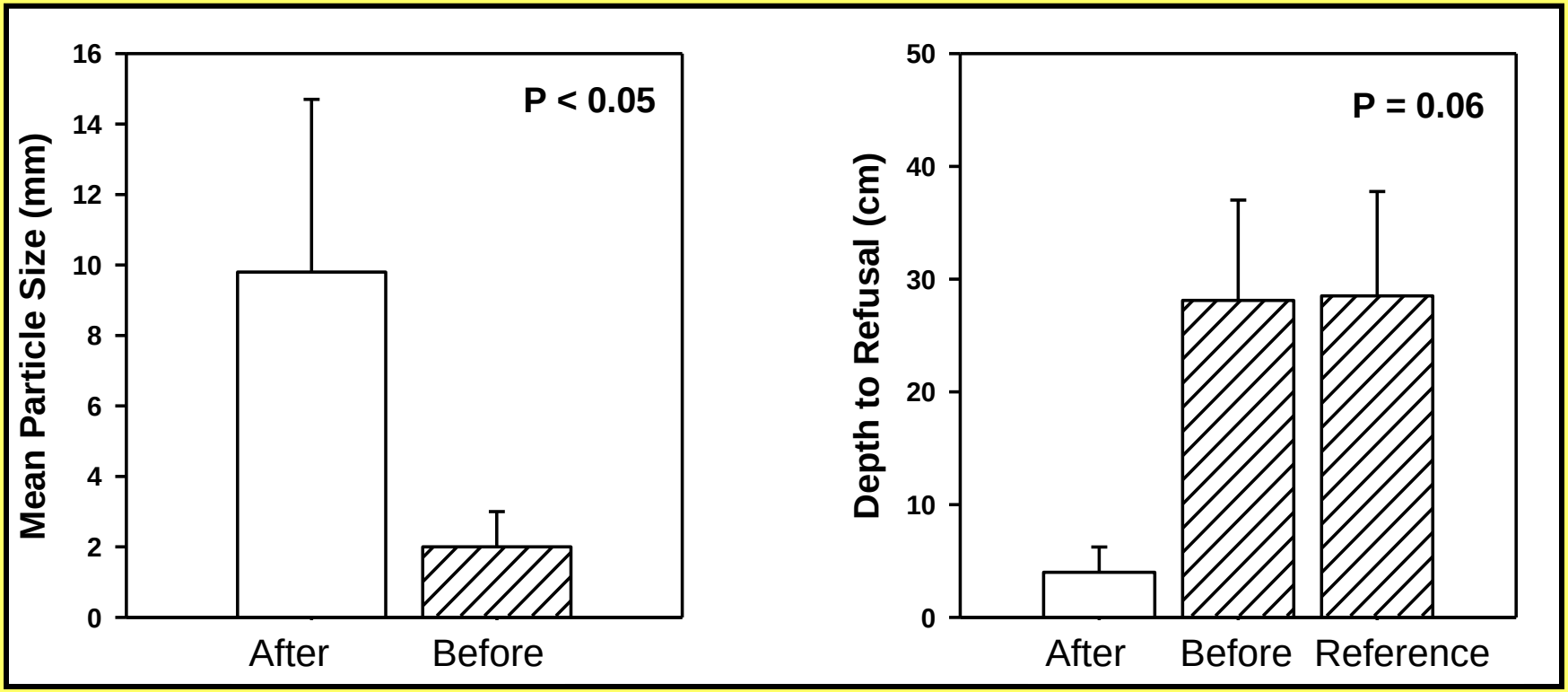


Lottig & Stanley (unpublished)

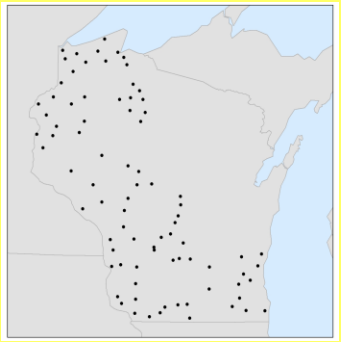
What happens when trees are removed…

- Removal of wood, sediments →
- Removal of current, future stored carbon

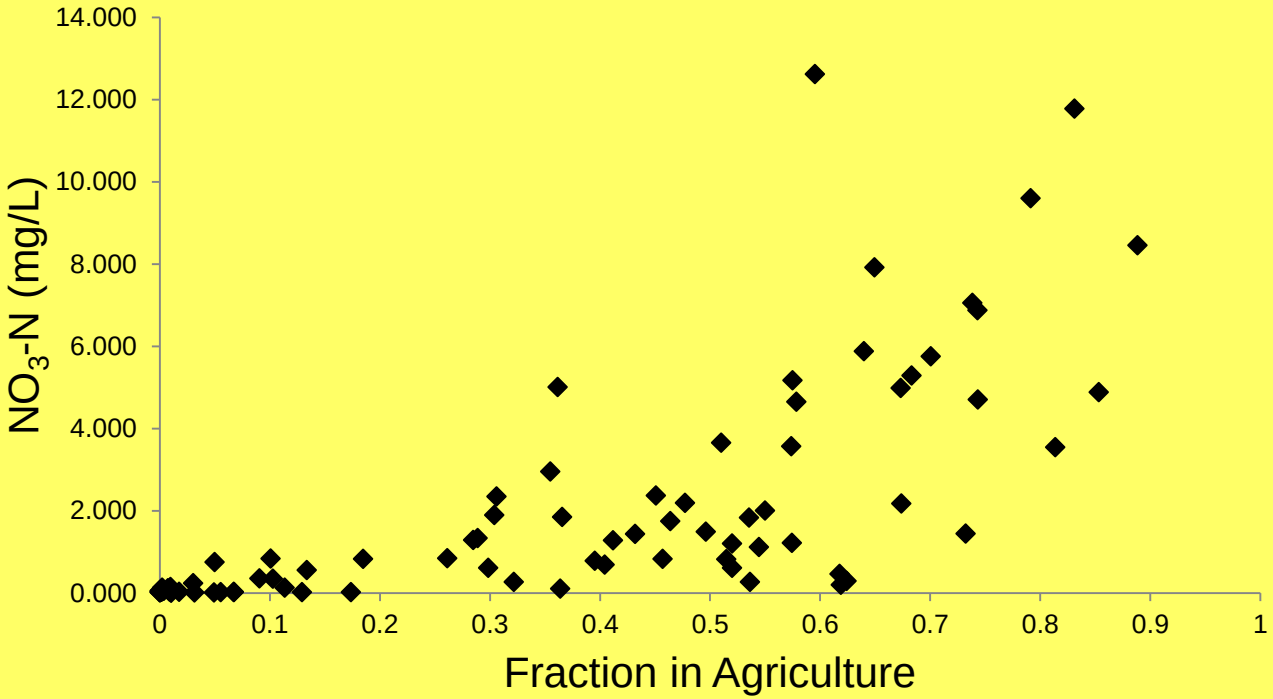
- → Streams as regionally significant sites of C storage?

Carbon goes in…. Outputs?

- Downstream transport
- Storage
- Decomposition (respiration) of organic matter (OM)
  - Greenhouse gas (GHG) production: CO_2 and CH_4
  - Hypothesis: added OM-rich sediment supports GHG production in these streams
  - But…



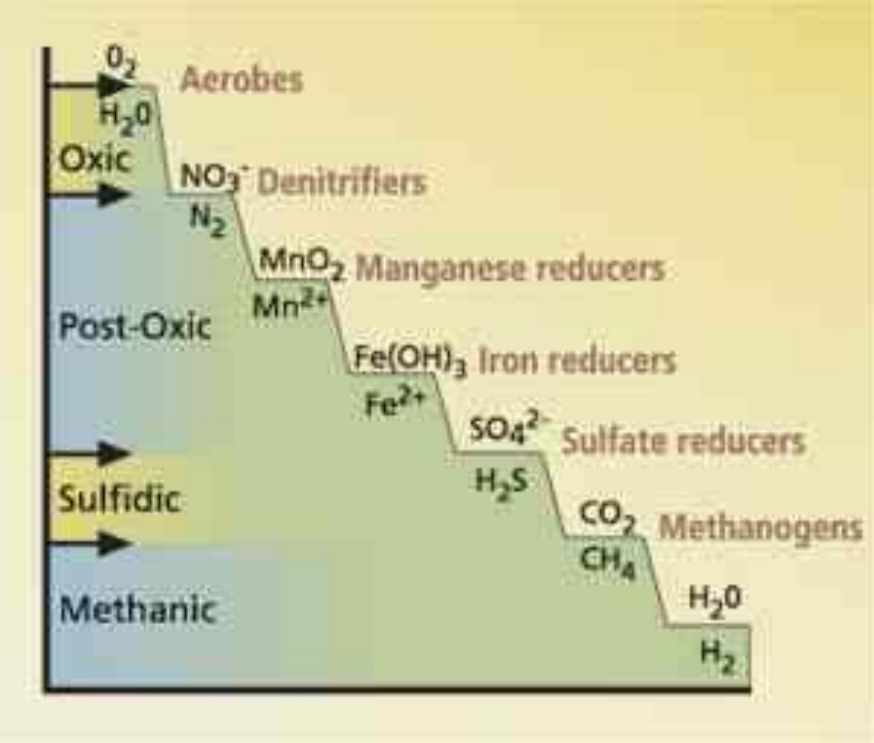
Nitrate enrichment



Stanley & Maxted (2008)

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Substitutes for O_2: NO_3^-, Mn^{3+}, Fe^{3+}, $SO_4^=$, acetate/CO_2



http://californiaagriculture.ucanr.edu/

CH4 production = only when all other alternative are gone

If there are better terminal electron acceptors, (e.g., NO3), CH4 should not be produced

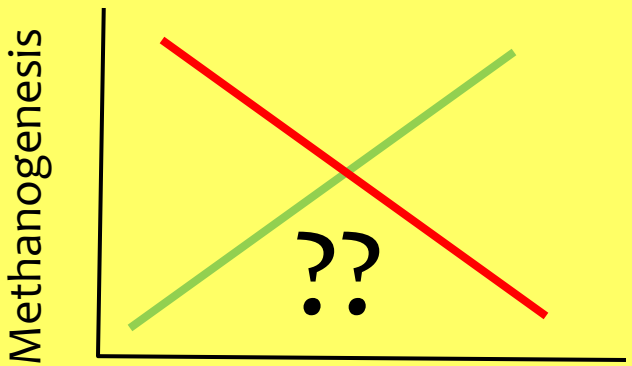
What are CO_2 and **CH_4** concentrations in agriculturally-influenced streams?
(trivial or do we need to pay attention?)

Increased sediments/OM

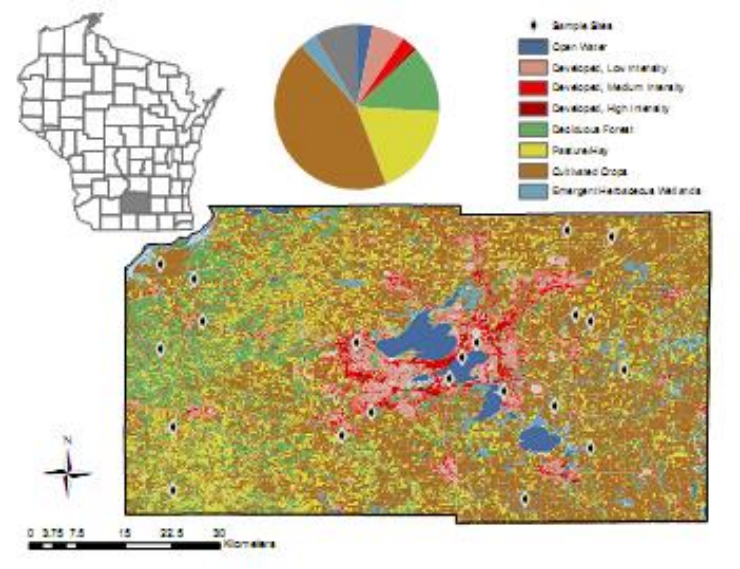
Anoxic,
OM-rich
Habitat
↑

Increased nitrate

Alt. e^-
acceptor
↓



Crawford & Stanley (in prep)



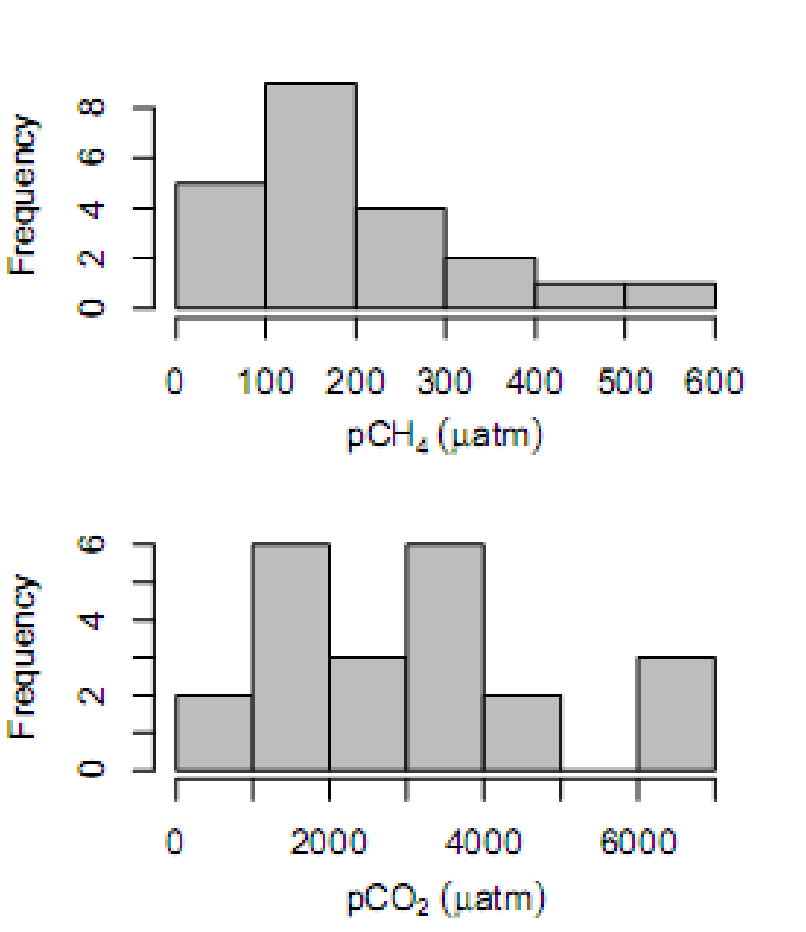
Summer survey 23 streams

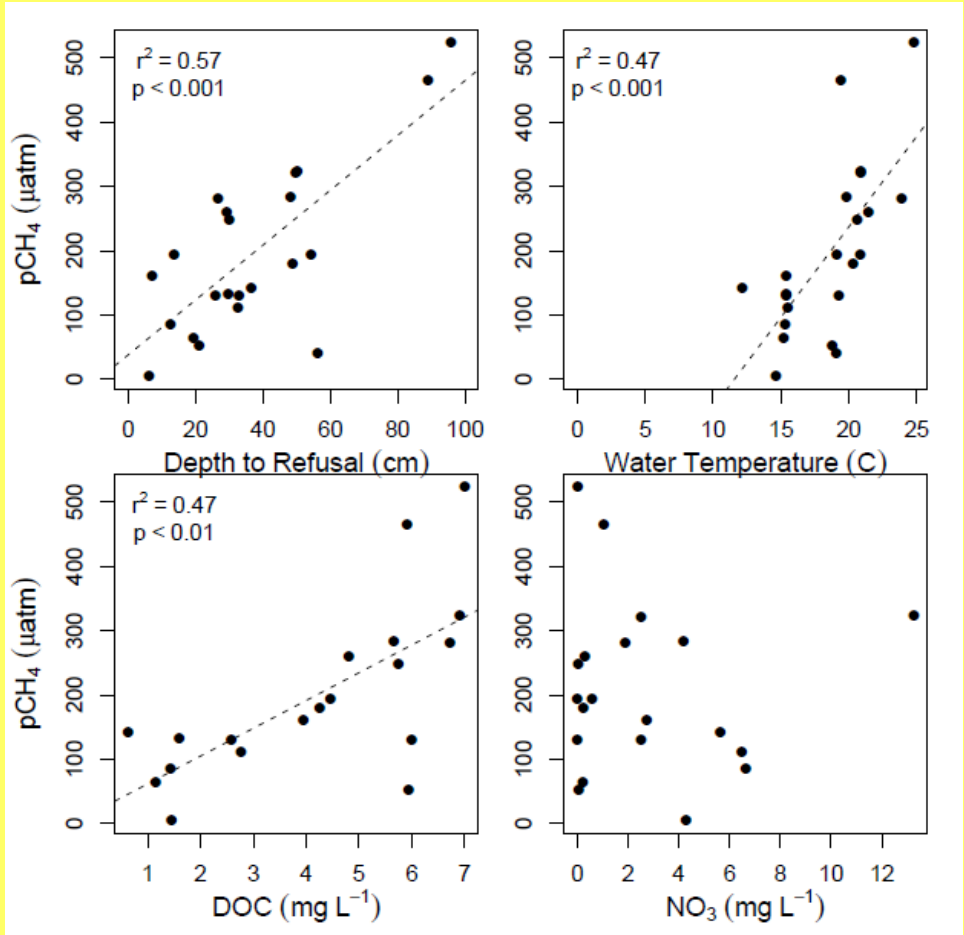
-(NO_2+NO_3)-N range <0.01 - >10 mg/L

-sediment layer thickness 10-100 cm

Crawford & Stanley (in prep)

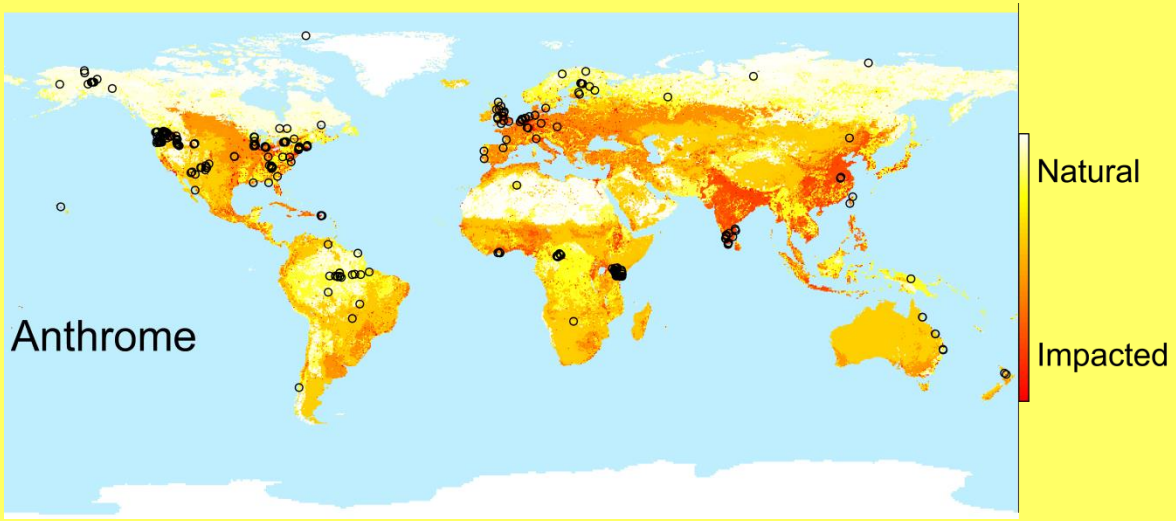
Dane County streams best model- water temp, sediment thickness

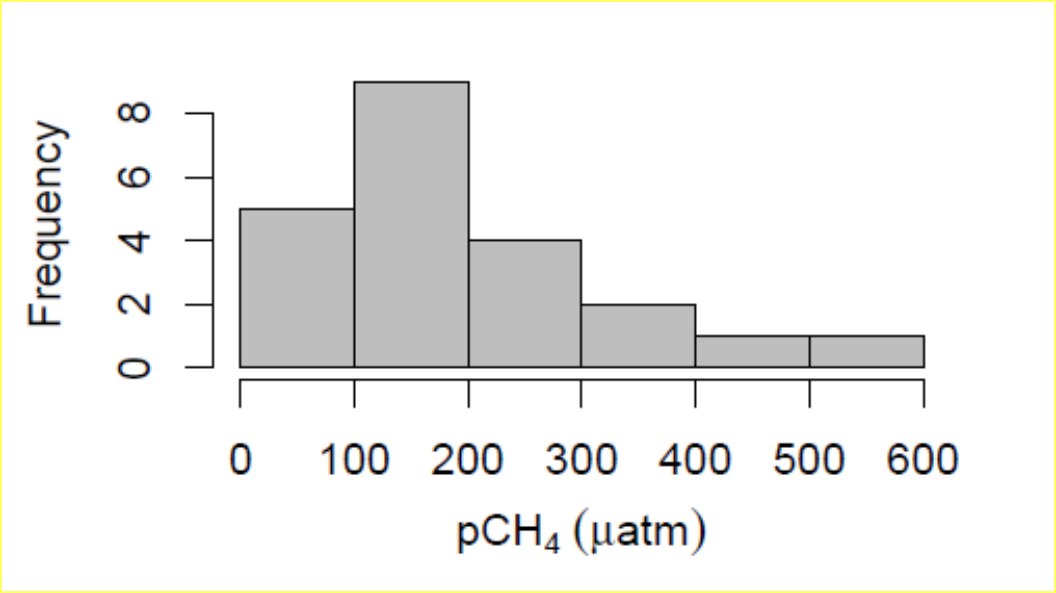




No evidence of NO3 suppression

Crawford & Stanley (in prep)

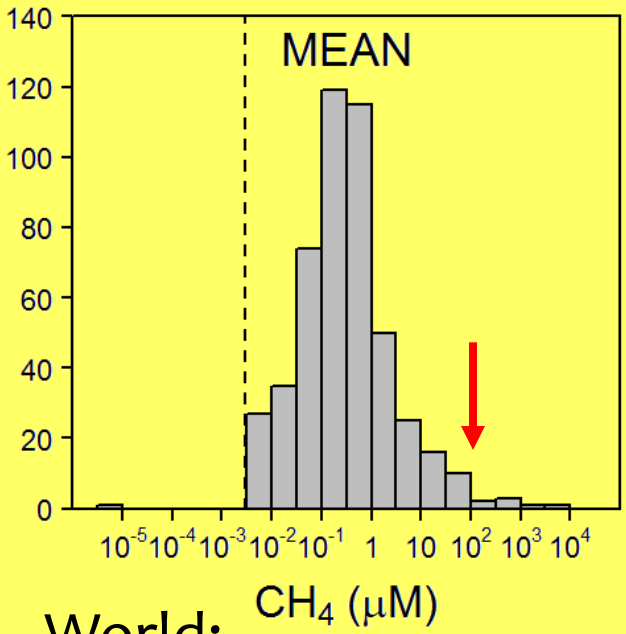




Dane County:

x = 268 (5-523) µatm

Crawford & Stanley (in prep)

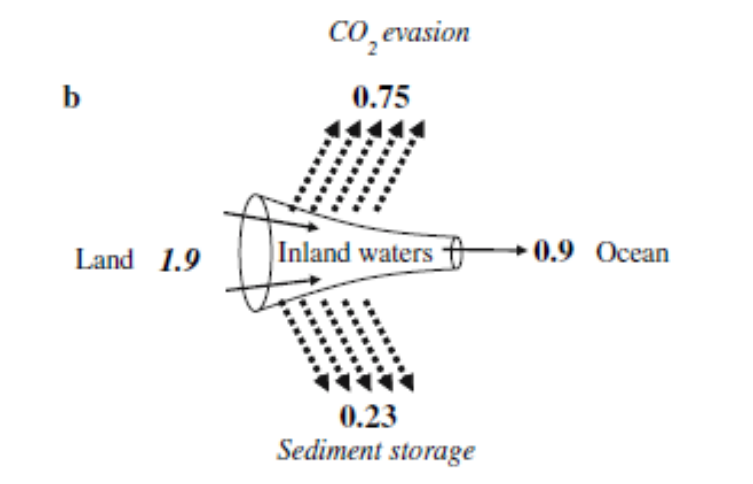


World:

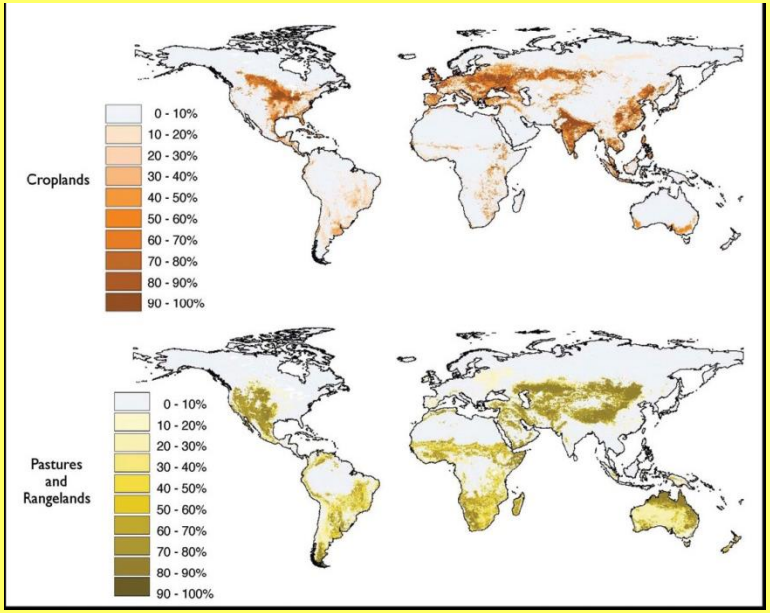
x ~ 5 (0-1000) µM

Stanley et al. (in review)

- Are these effects of farming widespread?
  - Does farming amplify the role of inland waters in regional, global C dynamics?

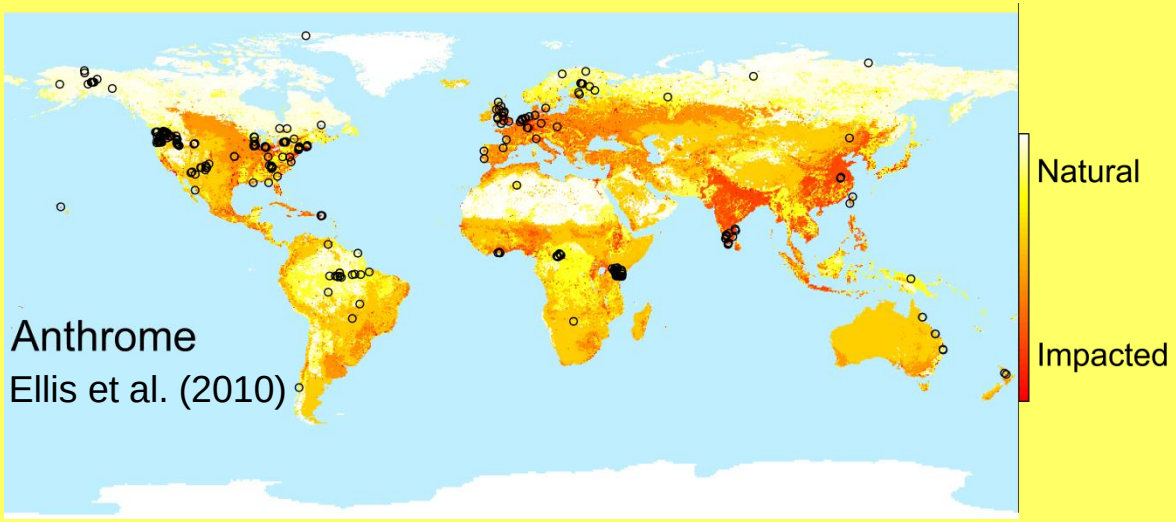


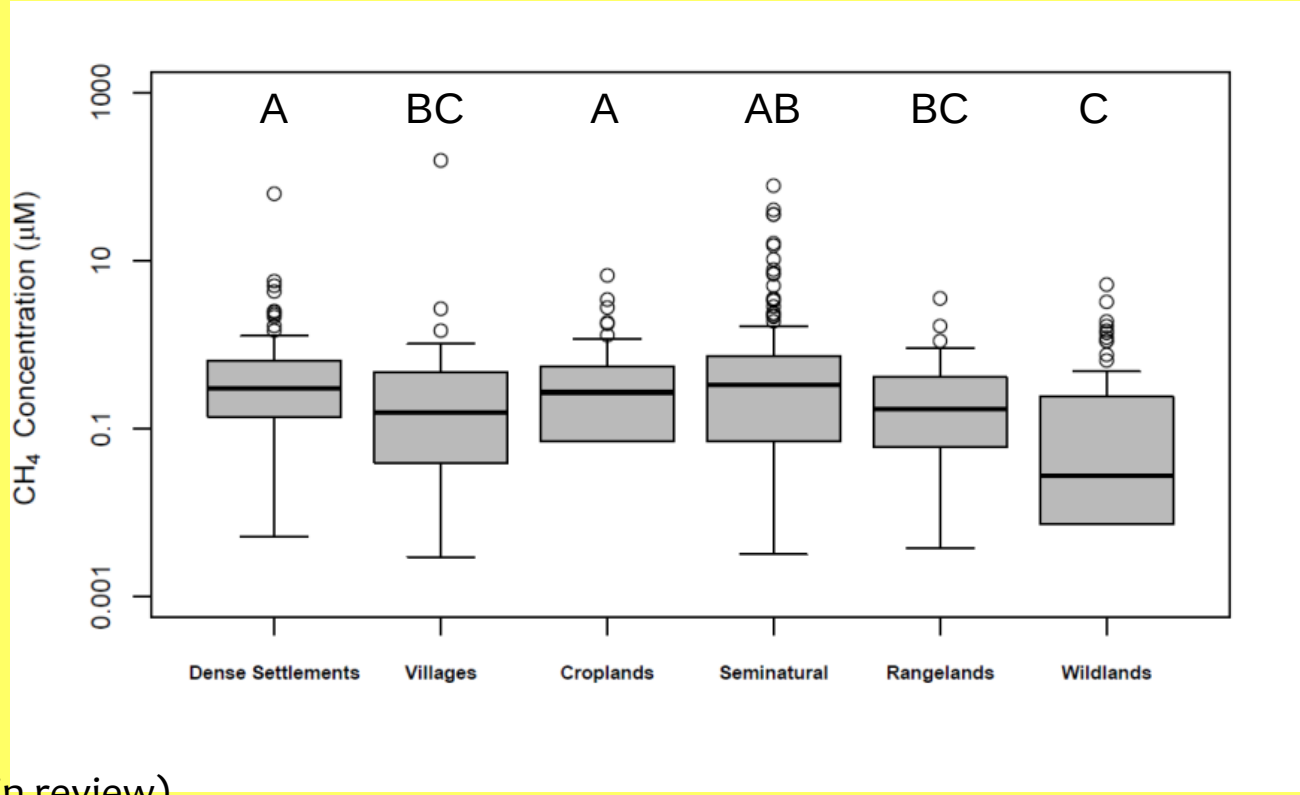
Cole et al. 2007



Ramankutty et al. 2003

Perhaps…





Stanley et al. (in review)

How does human land use affect stream carbon balance?

- In southern Wisconsin: increased C inputs, storage, CH_4 emissions

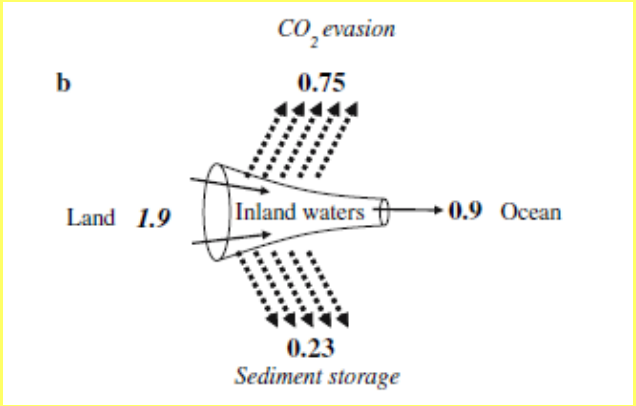
- Generality of this pattern
  - C inputs, storage likely widespread
  - CH_4 concentrations may also be elevated

How does human land use affect stream carbon balance?

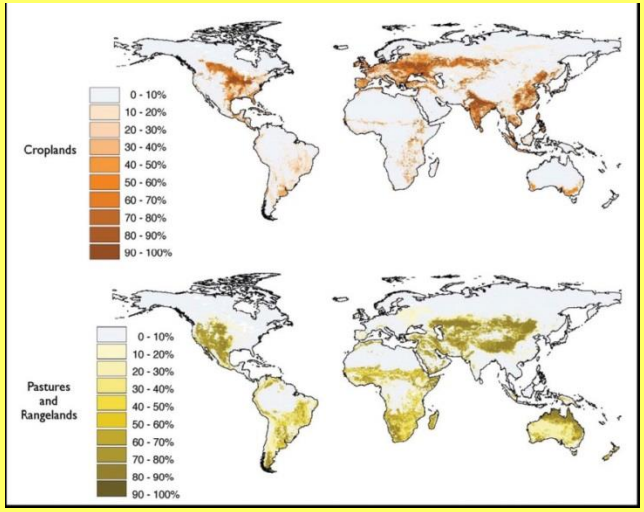
- Other considerations: type of Carbon going in to these streams (crop residues, agrichemicals, not leaves and needles)

How does human land use affect stream carbon balance?

- Now that we recognize the role of inland waters in affecting the movement of carbon from land to sea..



Cole et al. 2007



Ramankutty et al. 2003

Next step: better understanding of how we are influencing this role, and how it' changing over time

Thank you!