How much sediment is too much, according to stream macroinvertebrates?

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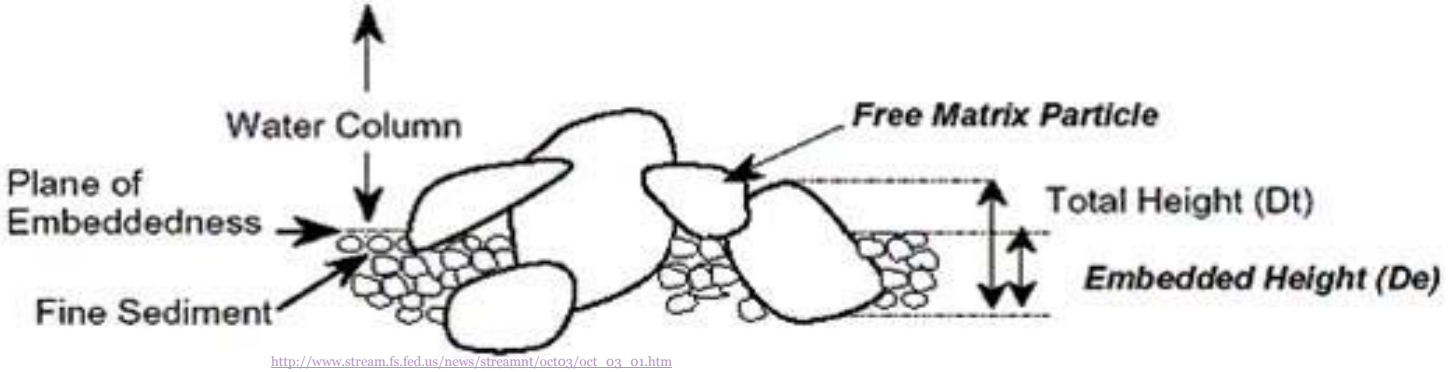
Driven to Discover

NOAA
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Minnesota's Lake Superior Coastal Program

Sediment

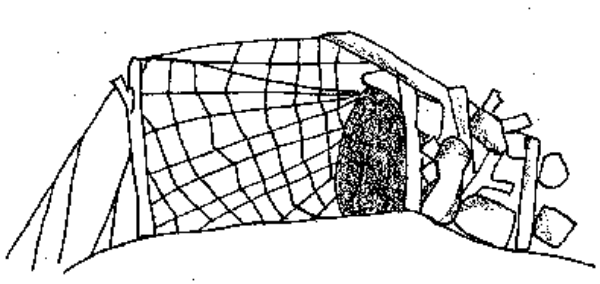
- North shore steams have known turbidity issues
- Land use history:
  - Completely logged 150 years ago
  - Drainage ditches and roads built
  - Only partially reforested
  - Steep slopes and erodible clay loam soils



http://www.stream.fs.fed.us/news/streamnt/oct03/oct_03_01.htm

Why use macroinvertebrates?

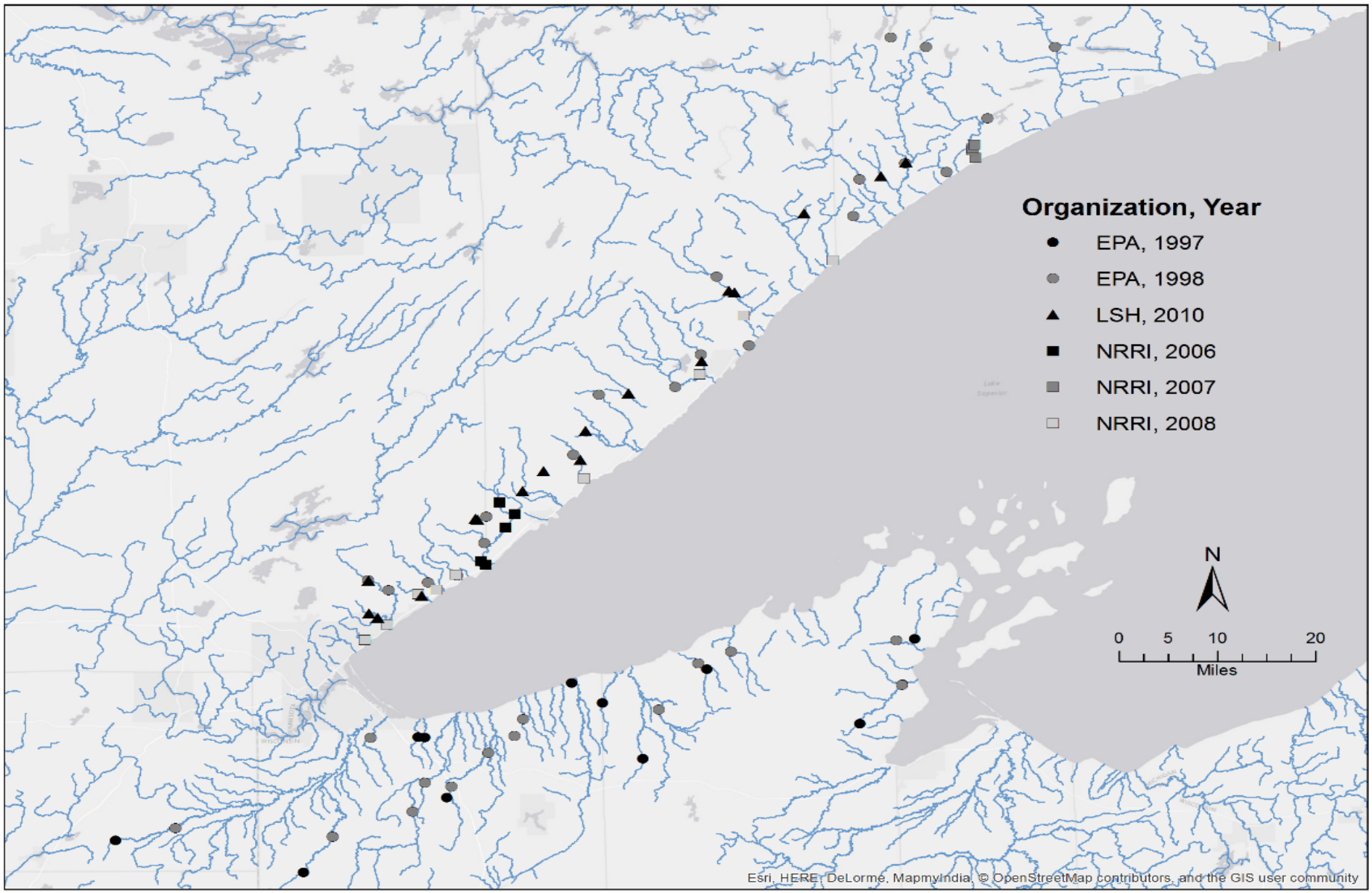
- Relatively limited mobility
- 1-2 year life cycles
- High taxonomic diversity
- Food web intermediates
- Vulnerable traits and needs



Research

- Can we see effects on macro-invertebrates caused by sediment?
- At what sediment amounts do impacts become detectable?

Study Sites


Organization, Year
EPA, 1997
EPA, 1998
LSH, 2010
NRRI, 2006
NRRI, 2007
NRRI, 2008
N
0 5 10 20
Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

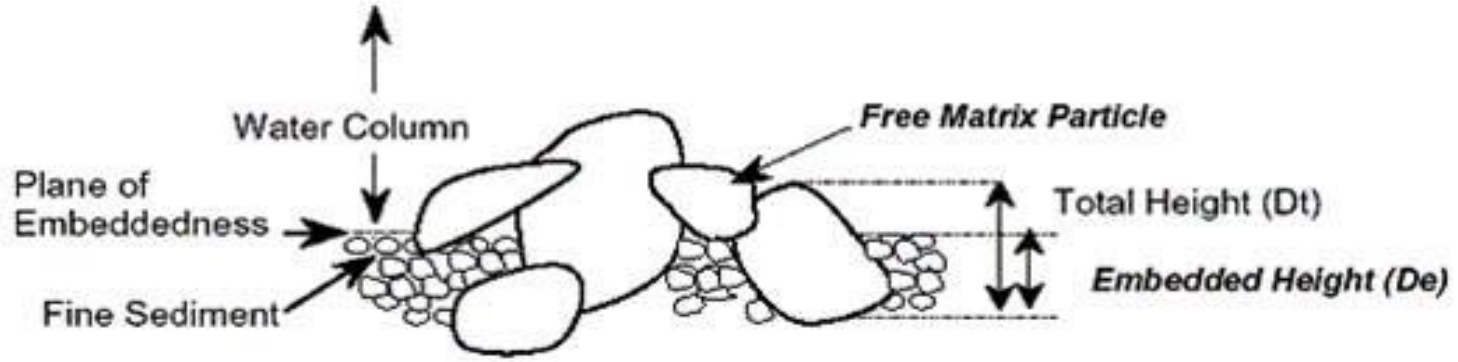
Methods Summary

- Substrate, sediment, water quality, and flow data collected during summer
- Macroinvertebrates and stream habitat sampled at end of summer
- Samples collected along a permanent cross-sectional transect, with a focus on riffles

Methods-Sediment

Mid to lower riffle

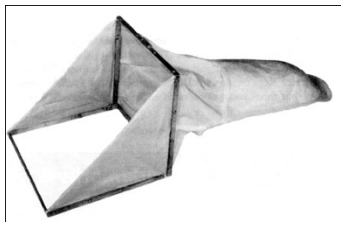
- Quadrat (embeddedness)
  - 4-5 across stream
  - Estimated percentages of different particle size classes
  - Estimate % embeddedness
- Depth of fines



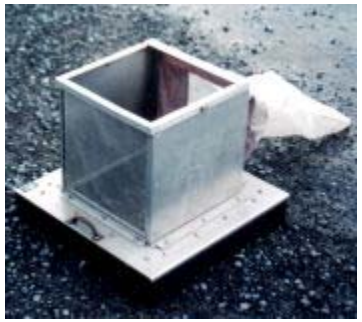
Methods-Macroinvertebrates

Upper riffle

- Quantitative samples
- Sampling device dependent on stream characteristics
  - Shallow streams
  - Boulder/cobble dominant
  - Low flow



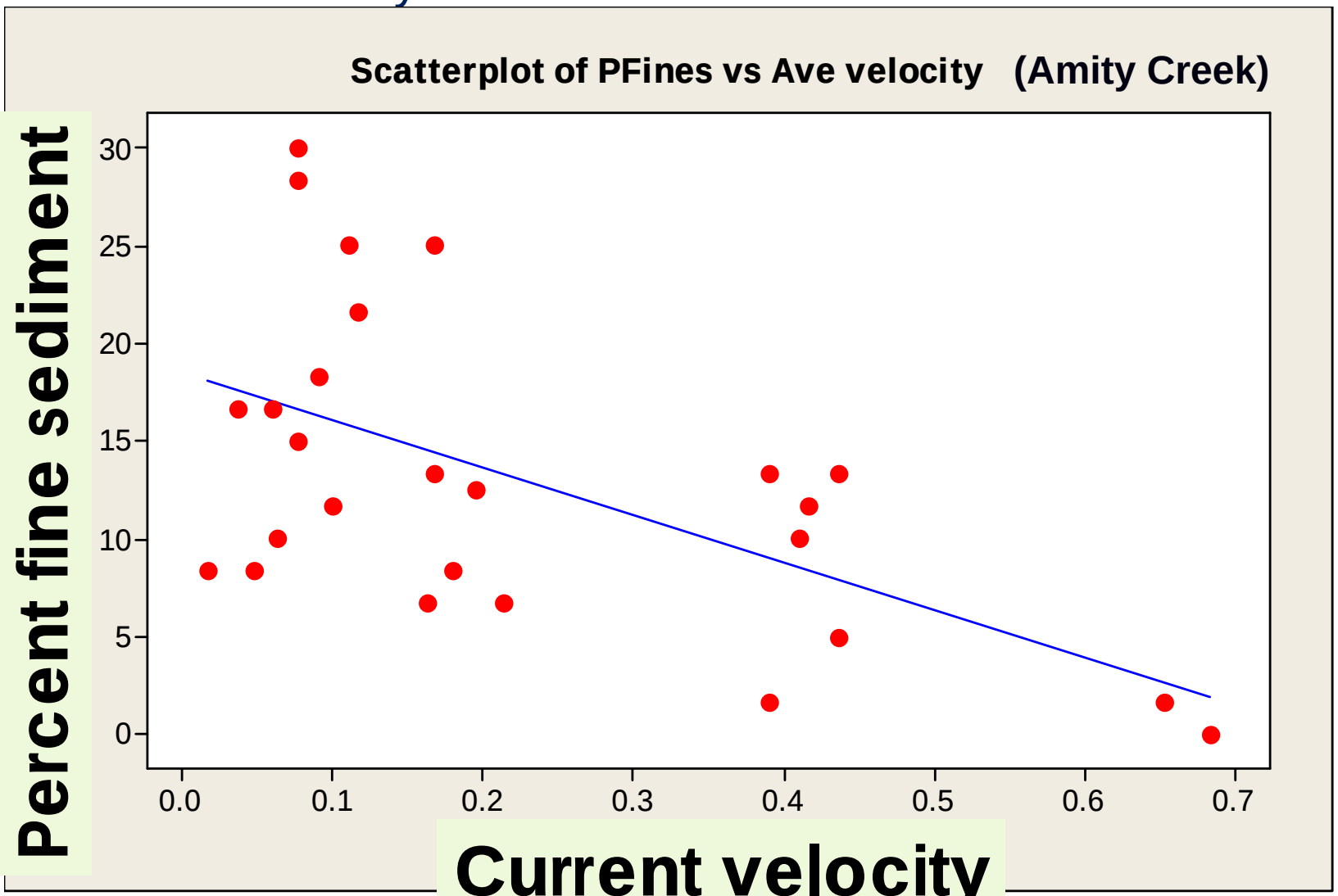
http://www.rickly.com/as/surber.htm



http://www.upstatefreshwater.org/html/biology.html

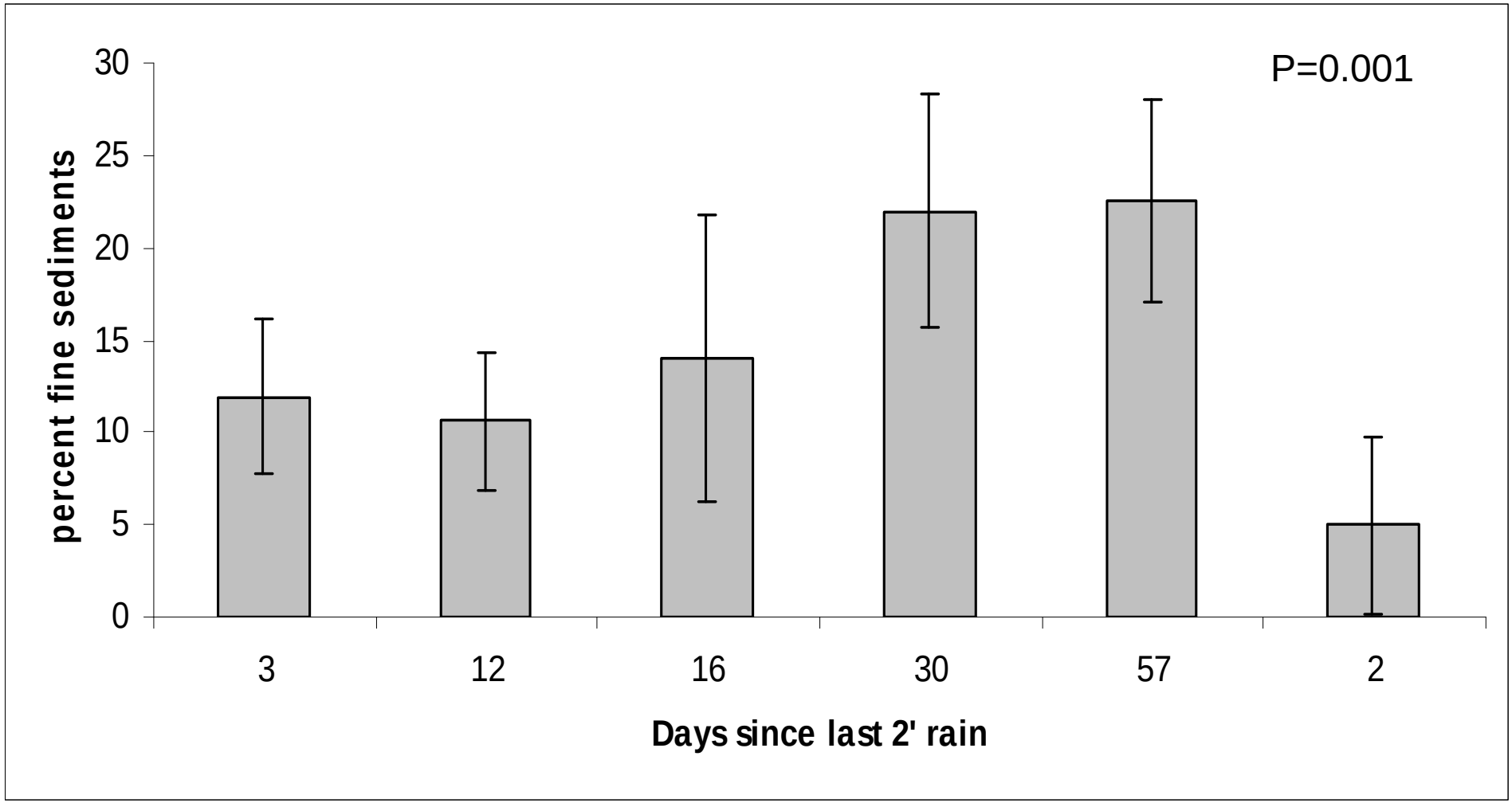
More current = less fines

Data from R. Lindsey



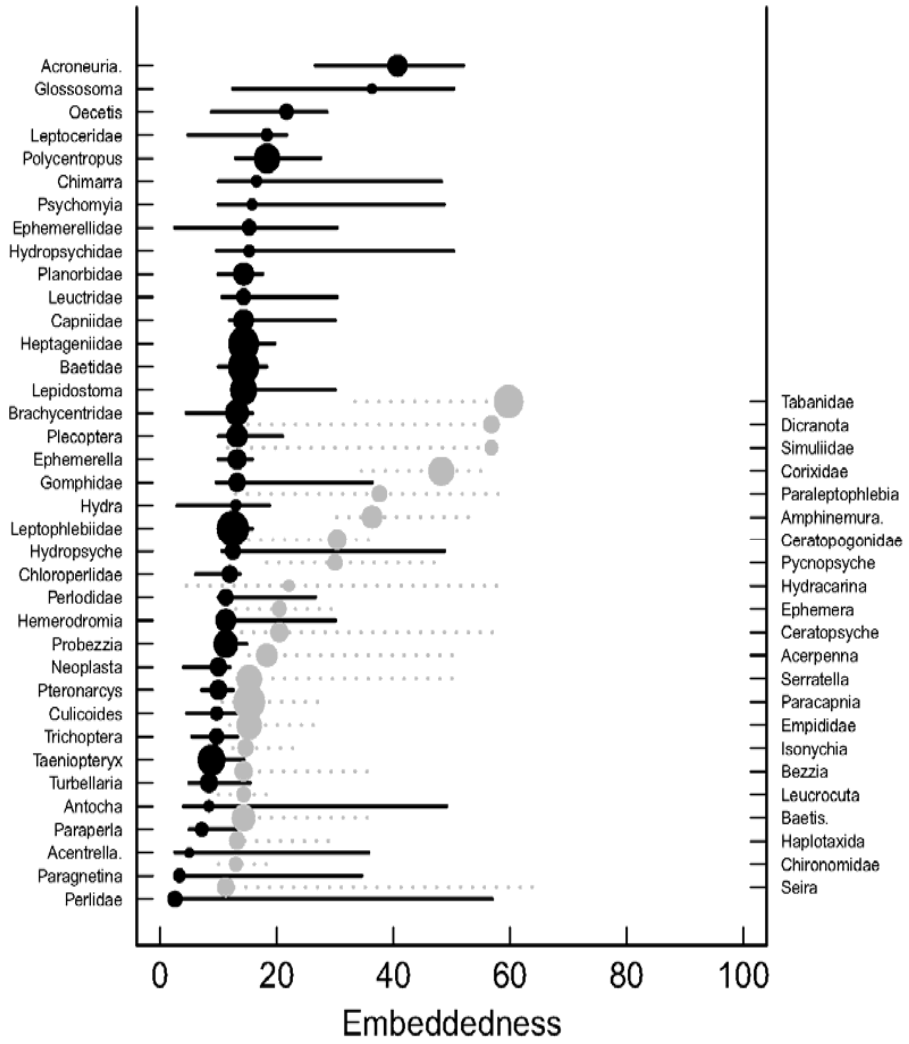
Amity Creek: % fines and the last 2 inch rainfall

Data from R. Lindsey

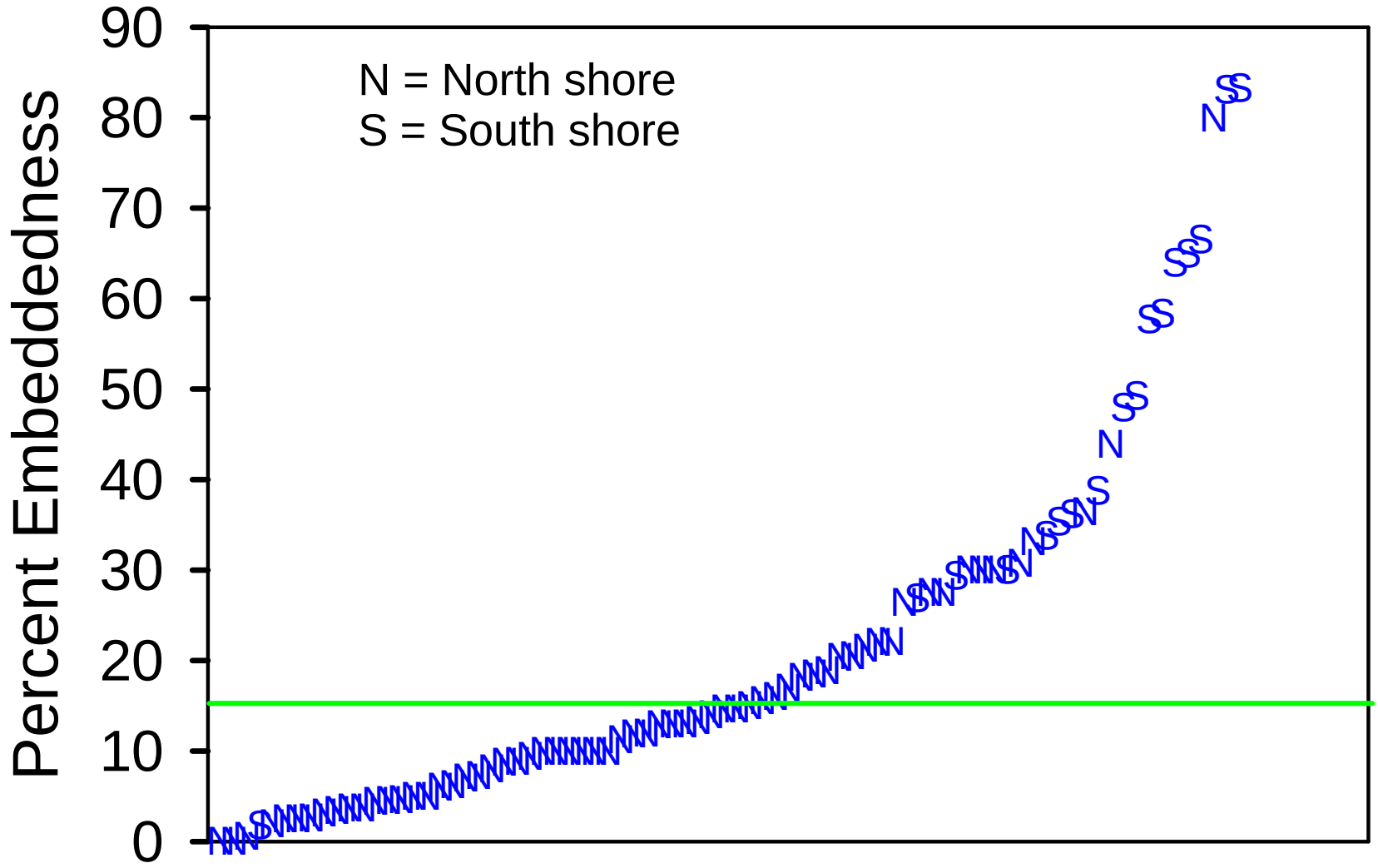


Embeddedness

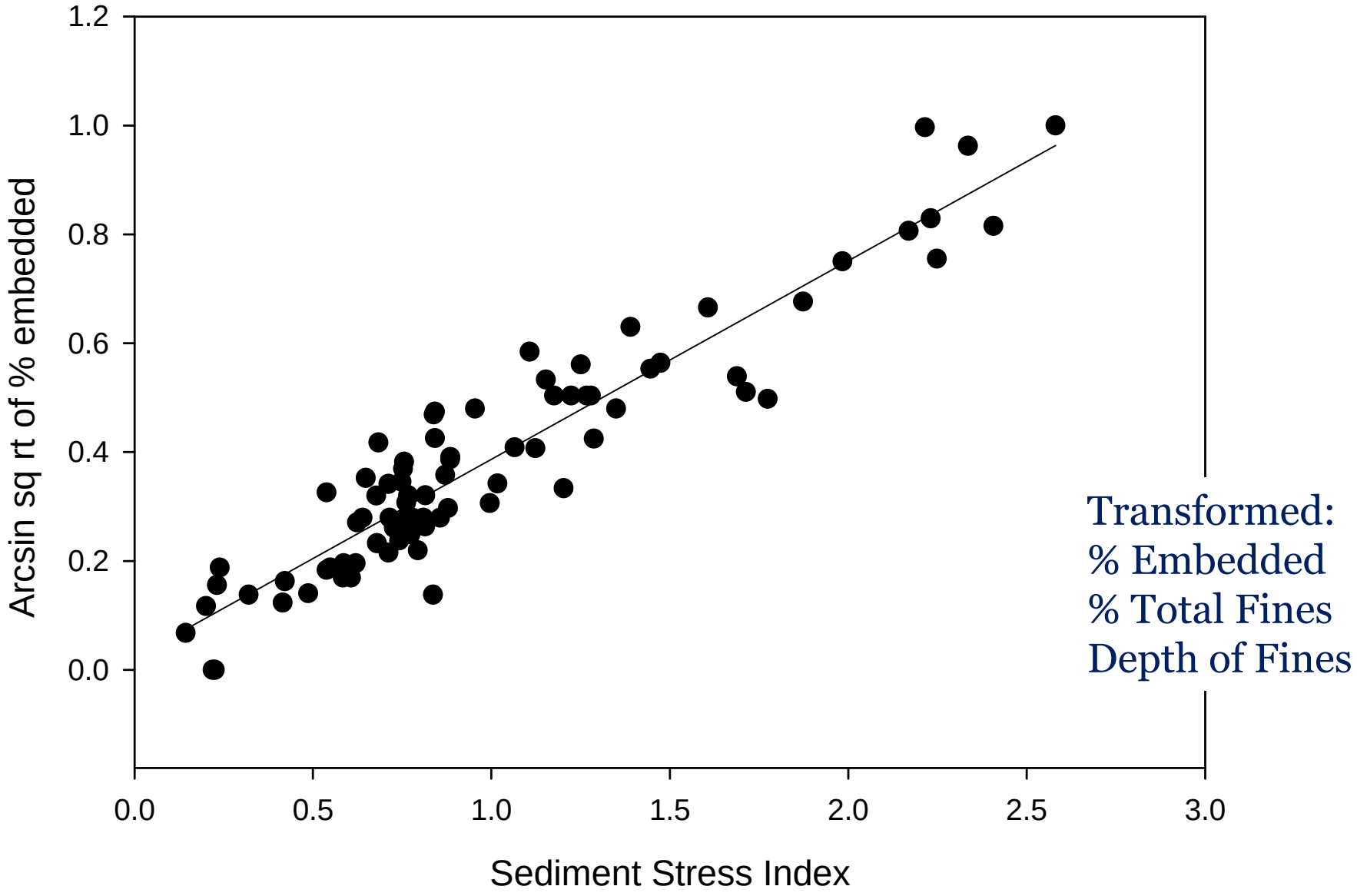
- Sensitive taxa (black) appear to decrease at approximately 15% embeddedness while tolerant (grey) appear to increase at approximately 15% embeddedness
- Community threshold in 10 to 20 % embeddedness range



Credit for graph: Dr. K. Kovalenko


Percent Embeddedness
90
80
70
60
50
40
30
20
10
0
N = North shore
S = South shore

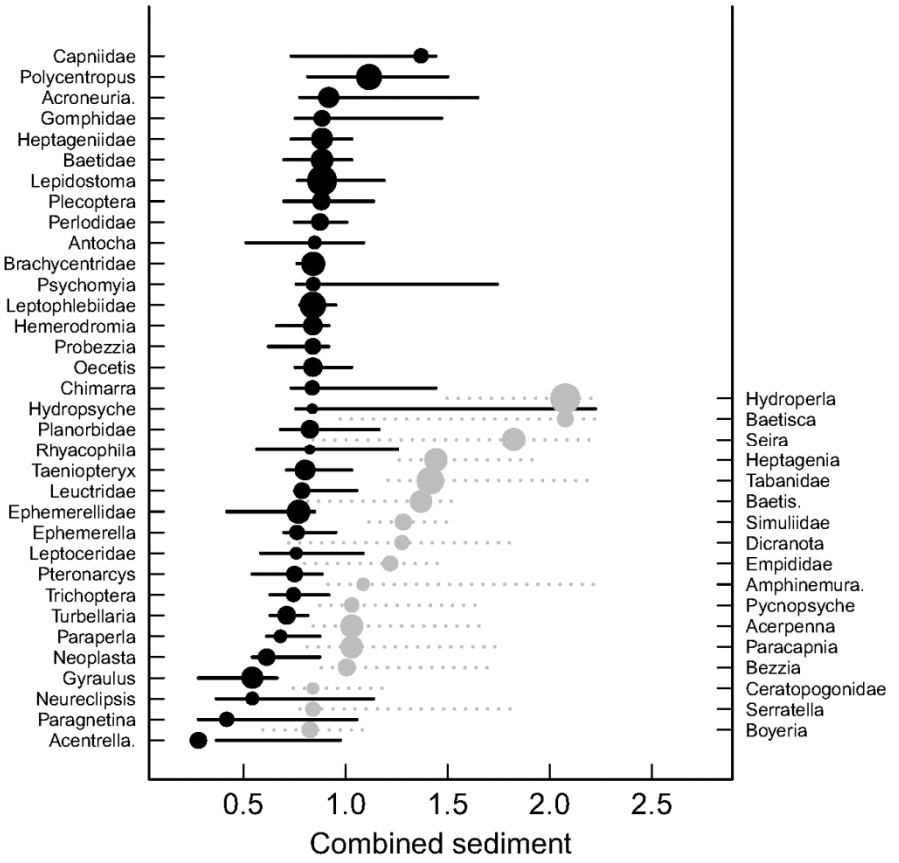
Combined Stress Index



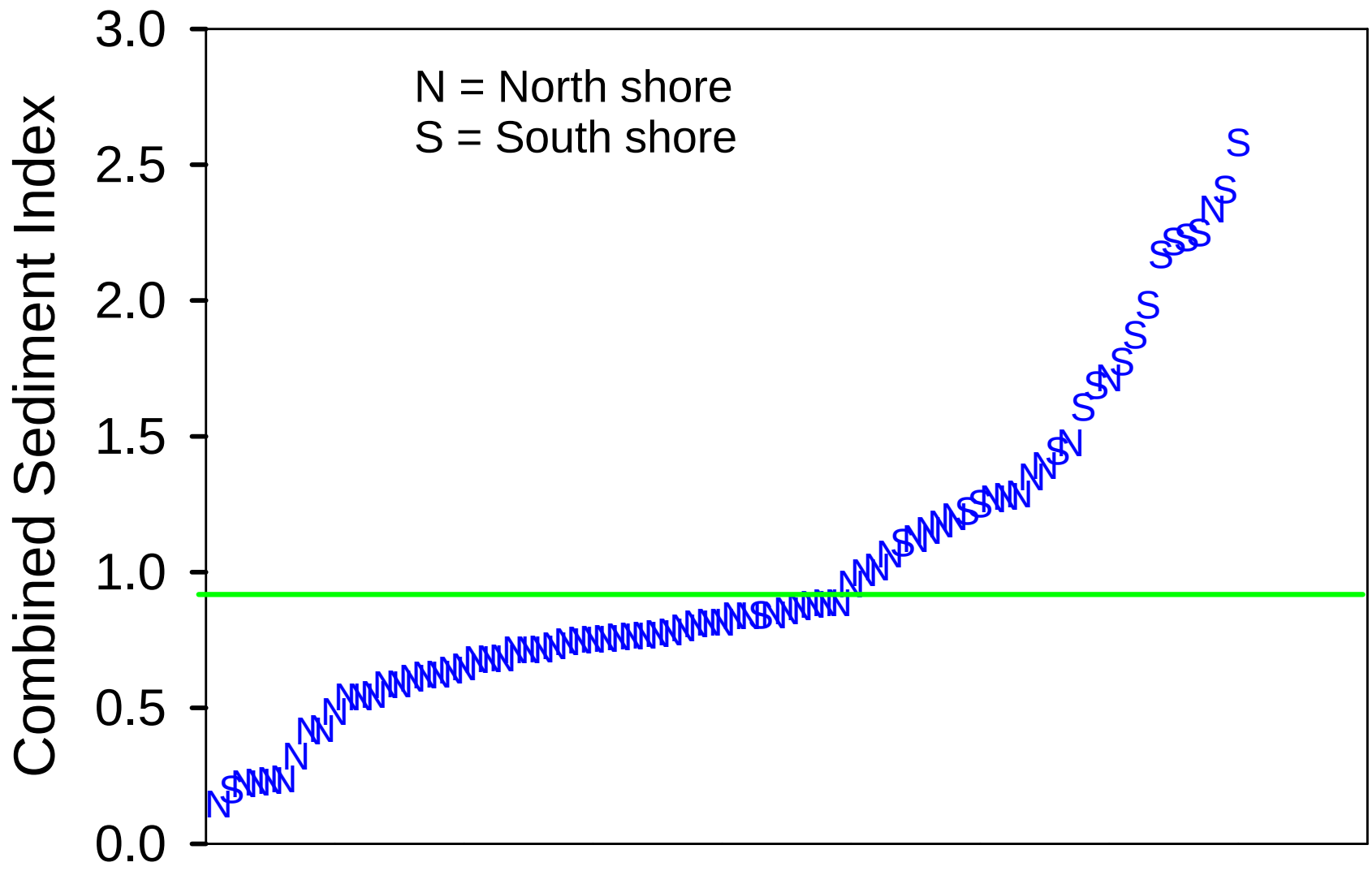
Transformed:
% Embedded
% Total Fines
Depth of Fines

Combined Sediment Index

- Sensitive taxa (black) appear to have a threshold response between 0.5 and 1.0

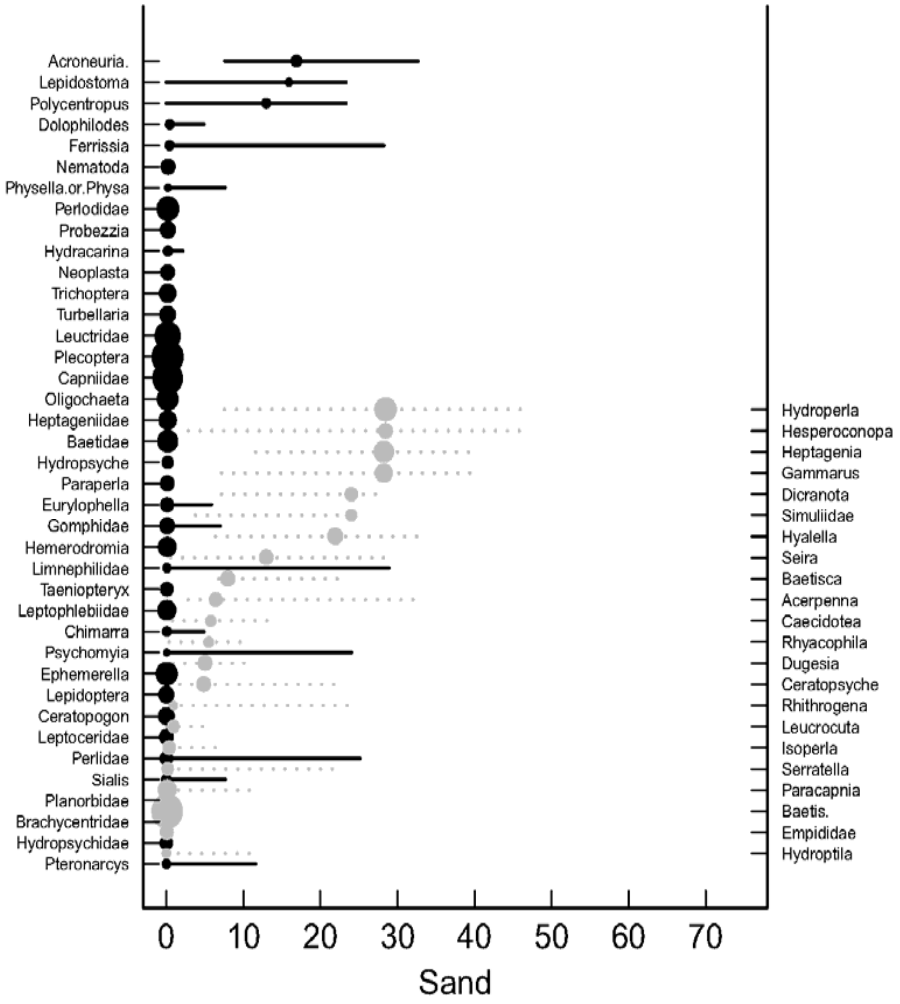


Credit for graph: Dr. K. Kovalenko


Combined Sediment Index
3.0
2.5
2.0
1.5
1.0
0.5
0.0
N = North shore
S = South shore

Sand

- Narrow quantile intervals, consistent change points indicate strong response to low levels of sand



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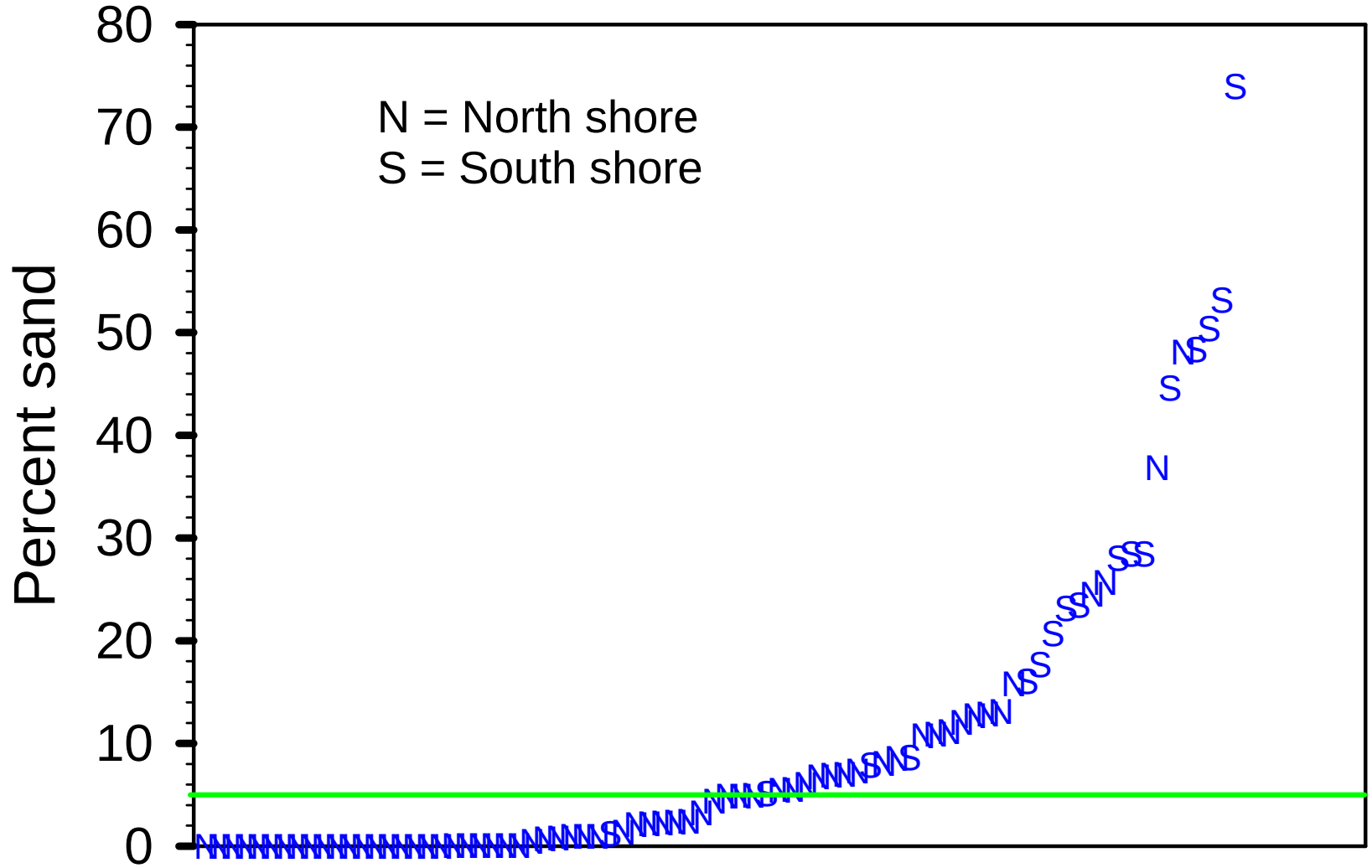
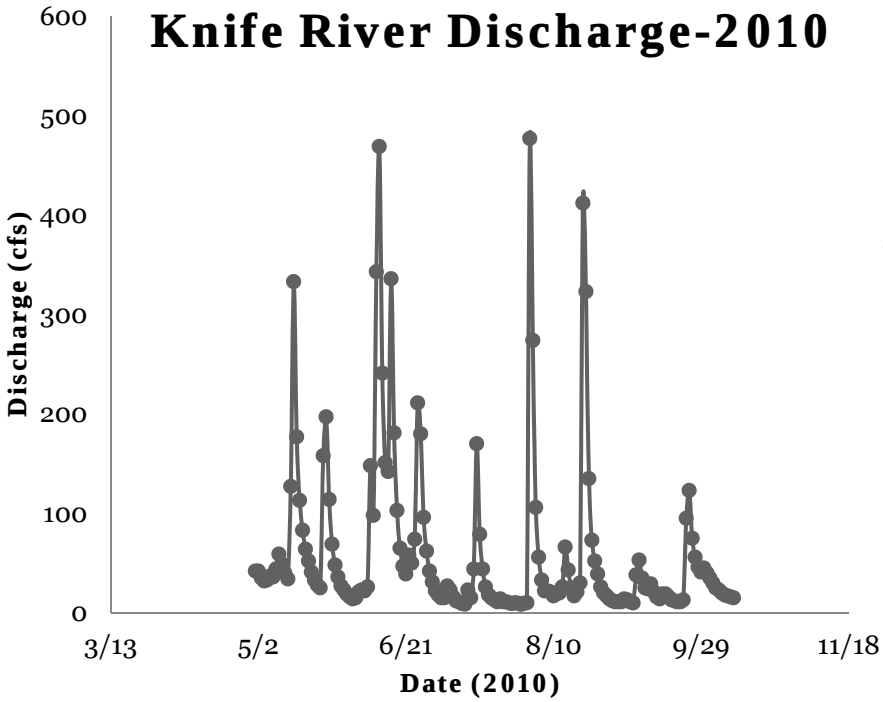
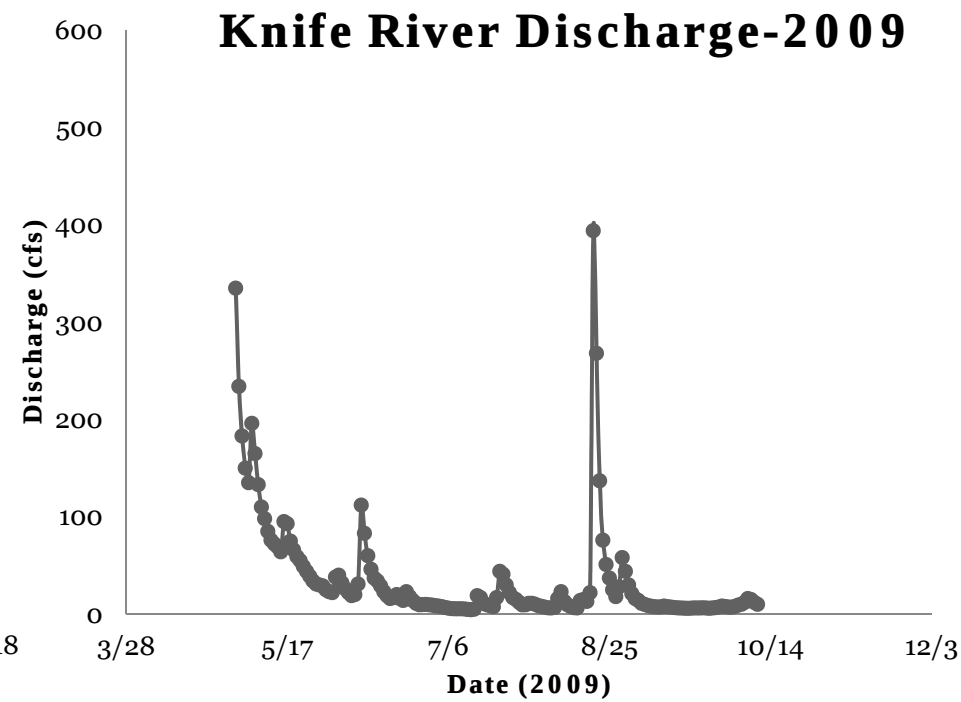

Percent sand
80
70
60
50
40
30
20
10
0
N = North shore
S = South shore

Discharge-Knife River





Conclusions

- Macroinvertebrate assemblages change at about 15-20% embeddedness, or < 5% of stream substrate dominated by sand.
- Many N shore stream sites are below these amounts.
- Invertebrates may be adapted to sediments moving through.

Caveats

- Based on data collected over 20 yrs
- Can't prove cause and effect
- Tracking exposure to sediment is time-consuming & expensive

Sponsors

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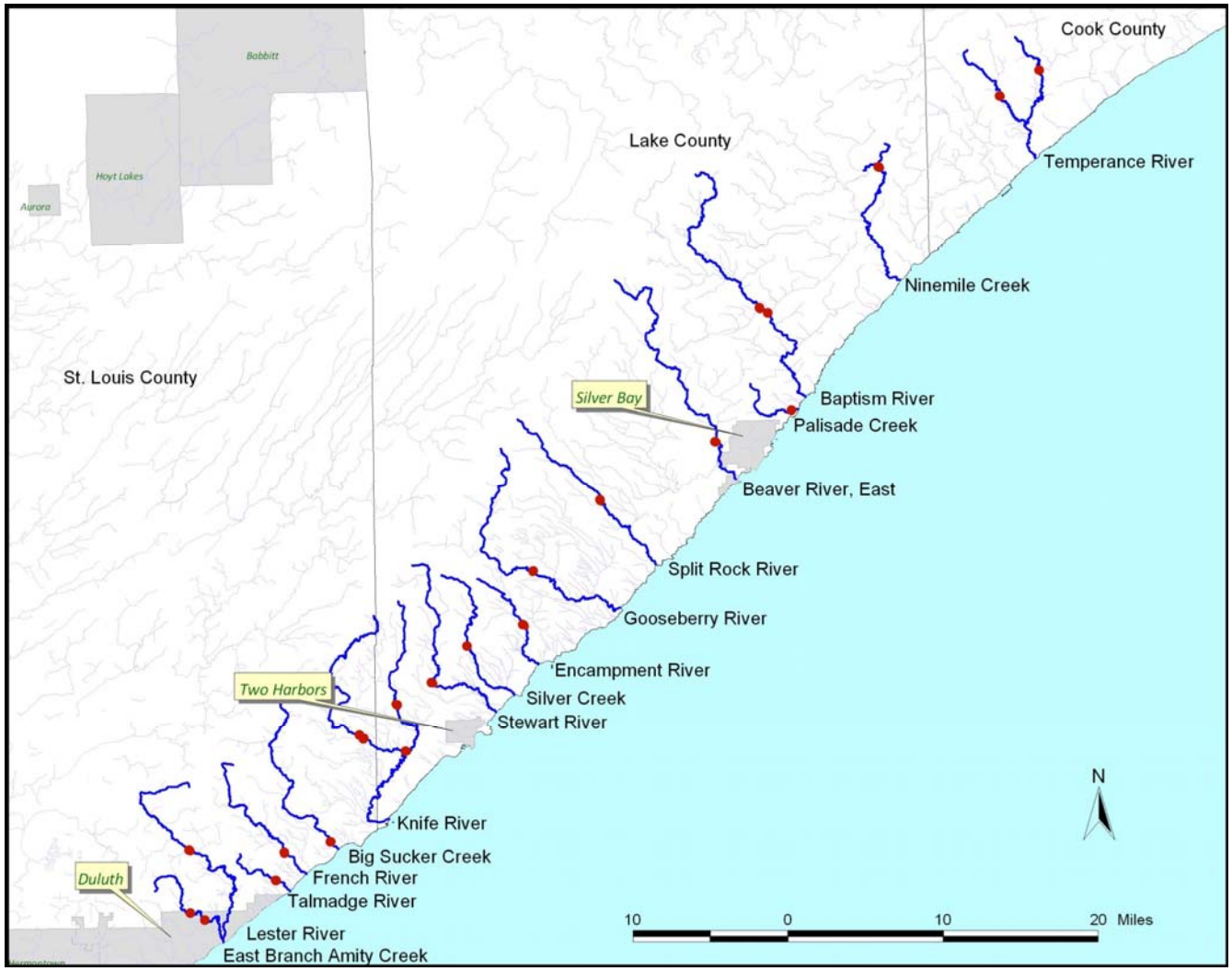
EPA

South St. Louis
SOIL & WATER CONSERVATION DISTRICT

Minnesota Pollution Control Agency

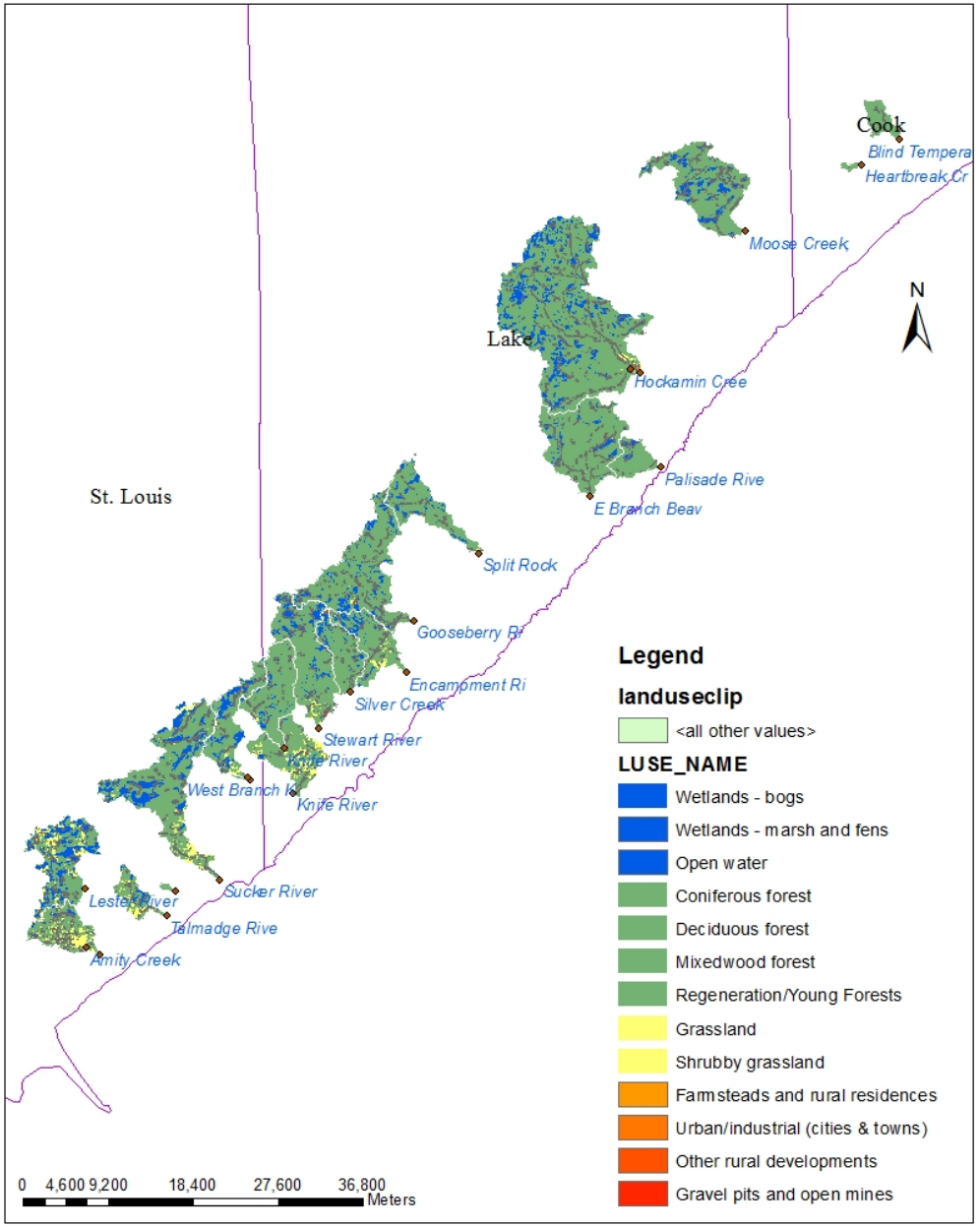
Study Sites



- 22 sites
- 19 separate streams
- Non-urban
- Non-agricultural
- 2nd to 4th order
- Watershed >1000 ha
- Reasonably accessible
- Several have previous data indicating low or high sediments

Land Use

- Delineated watersheds above sample points
- Dominated by wetland and forest
- No urban land or gravel pits
- Lack of development observed in field
  - Dirt roads used to access sites and very few houses/businesses



Discussion: Gills

Negative Response

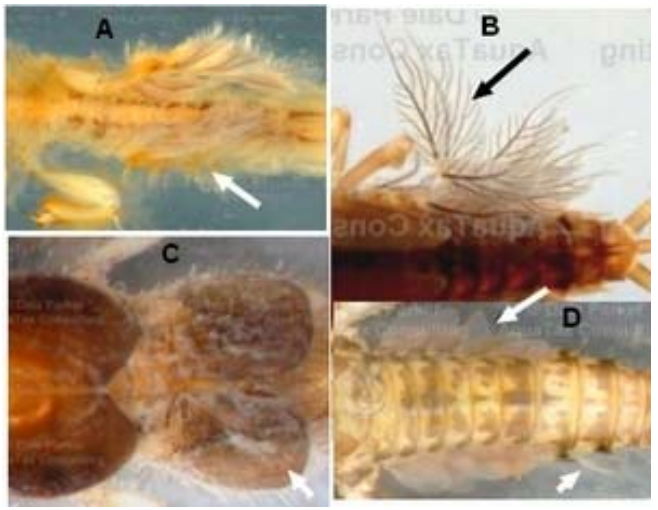
- Had a negative response to at least one of the four sediment stressor variables
- External gill richness
- Filamentous gill richness

- Of the sensitive TITAN taxa, 14 had filamentous gills while only 4 had lamellae gills

  - Gills subject to physical damage by abrasion and subject to clogging
  - Various gills may have different levels of fragility

Positive response

- Had a positive response to at least one of the four sediment stressor variables
- Proportion operculate gills
  - Operculate gills relatively uncommon
- Lamellar gill richness



http://www.aquatax.ca/TaxaKeyImages/MayflyGills.jpg

Discussion: EPT

- Mayflies, stoneflies, and caddisflies (EPT) taxa are known sensitive taxa for a variety of stressors
- In this study, EPT richness was significantly negatively correlated with increasing depth of fines, embeddedness, and combined sediment
- Proportional abundance of EPT was not significantly correlated with any of the sediment stressor variables indicating a decrease in species richness under increasing sediment conditions but potentially an increase in tolerant EPT species
- TITAN: 34 EPT were sensitive and 14 were tolerant

http://midge.cfans.umn.edu

Discussion: EPT

- Biggest question
  - What specific characteristics are driving the response of the EPT taxa
- EPT have been identified in numerous studies as sensitive to sediment
- Gill type may be a driving factor in vulnerability to excess fine sediment
- Predation was also significant correlation and many EPT are predators
- Refine characteristics
- Separate out EPT taxa in predator or other behavioral groups
- Look at genera within families with different gill types
- Macroinvertebrate data is already collected by many watersheds and agencies
- Teasing out specific characteristics could provide more information without additional sampling cost

Chosen Metrics

1. Proportion Coleoptera

http://midge.cfans.umn.edu/vsmivp/coleoptera/coleopteralarvae/elmidae/

http://midge.cfans.umn.edu/files/2012/09/Corydalidae_big.jpg

2. Proportion Acari
3. Proportion Predator

4. Predator Richness
5. Filamentous Gill Richness

Chosen Metrics

6. Sprawler Richness

7. Plecoptera Richness

8. Ephemeroptera Richness

9. EPT Richness

10. Taxa Richness

http://midge.cfans.umn.edu/vsmivp/

http://www.flycraftangling.com/index.asp?p=128

http://midge.cfans.umn.edu/files/2012/09/Ephemeridae_big.jpg

http://midge.cfans.umn.edu/files/2012/09/Helicopsychidae_big.jpg