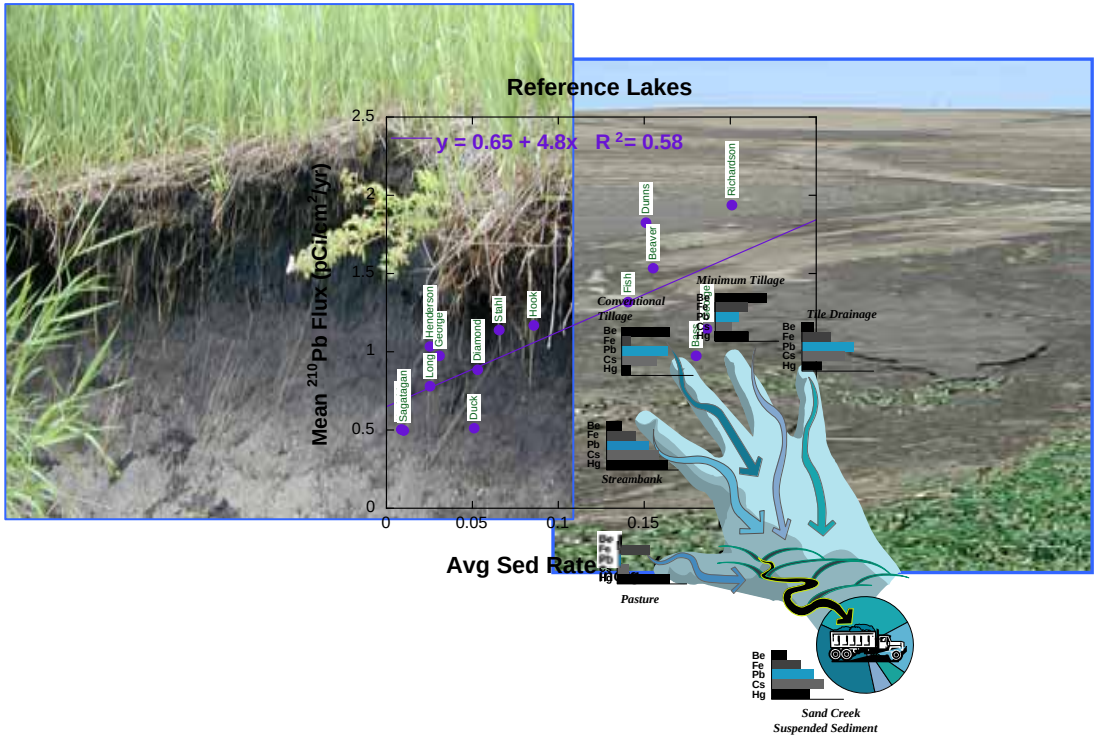
Fingerprinting Sources of Suspended Sediments



…the path to studying tile drainage

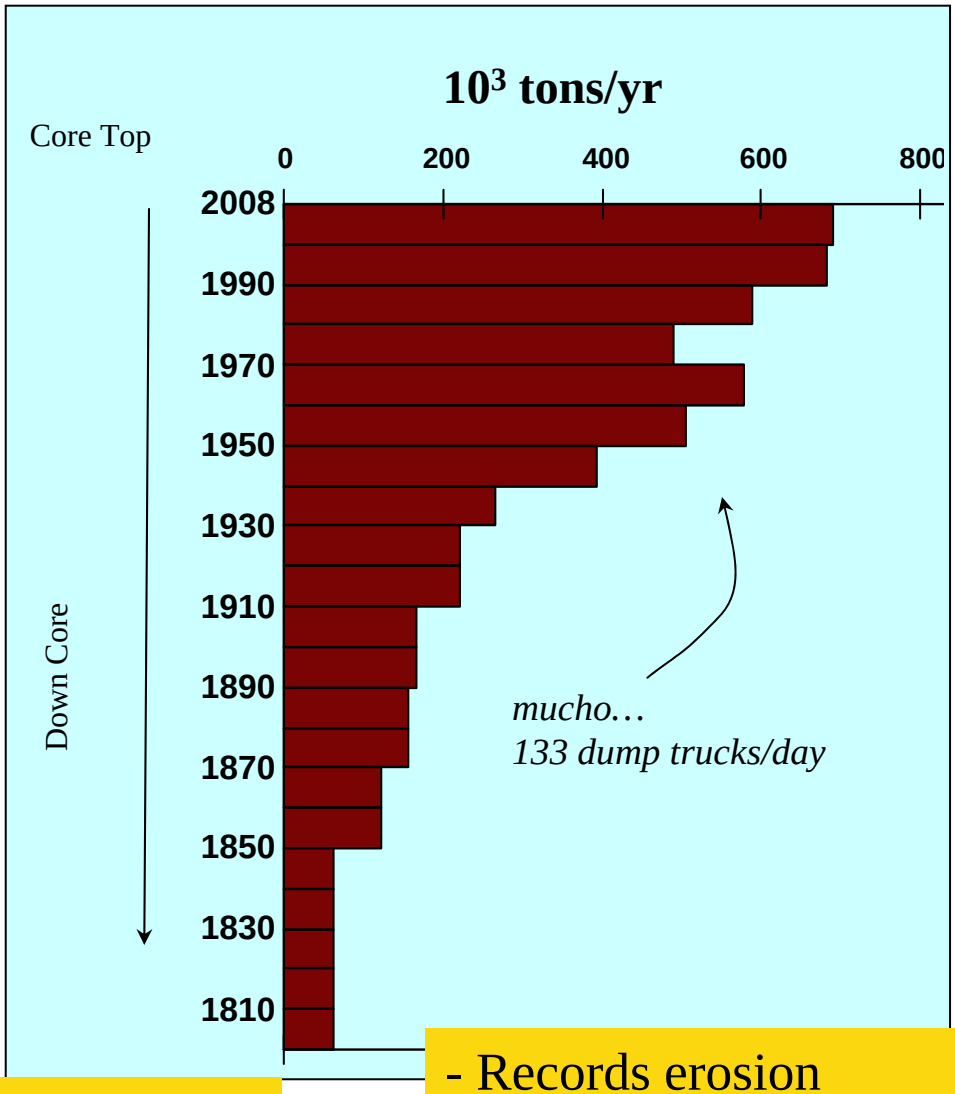
Shawn Schottler, Dan Engstrom and Dylan Blumentritt
St. Croix Watershed Research Station--Department of the Science Museum of Minnesota

Lake Pepin Sediment Accumulation History

"Hey, Brain what are we going to do today"

"Same thing we do every day Pinky…

…try to figure out where the sediment comes from, and why it changes"

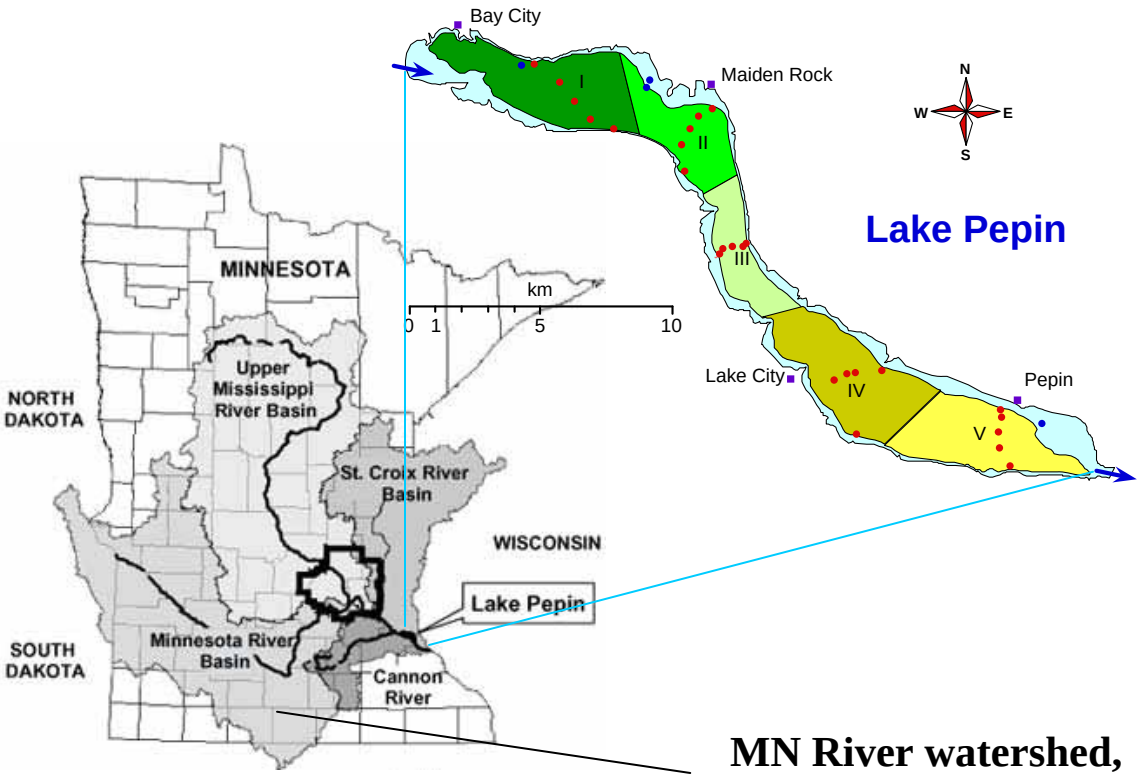


- 10 X faster than pre-settlement

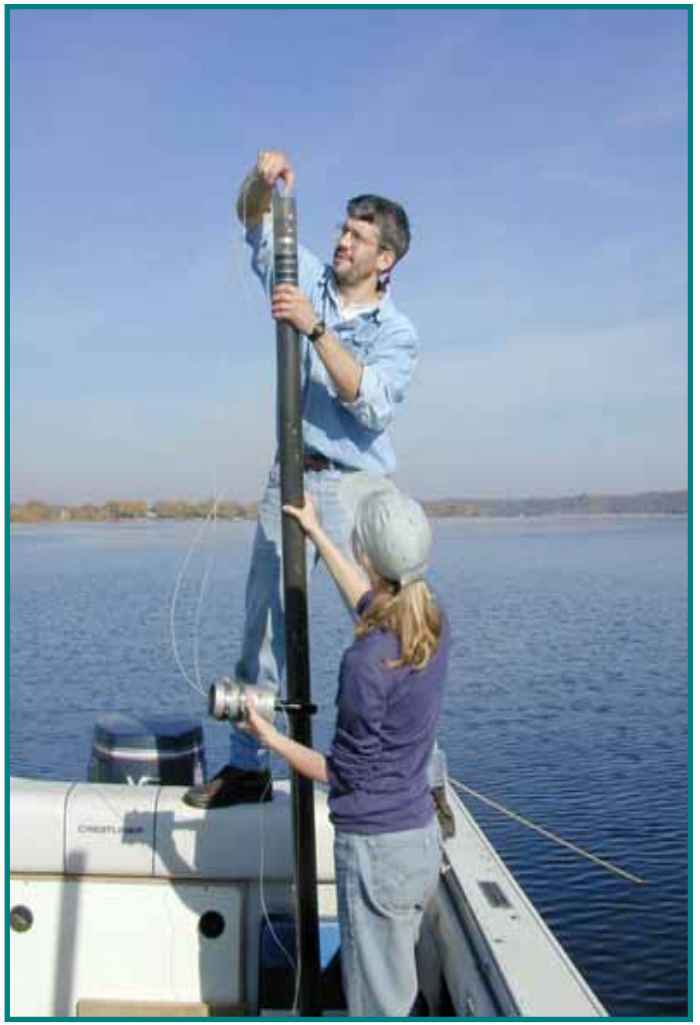
- Records erosion history of Minnesota's ag lands

Lake Pepin: Integrator of watershed scale erosion processes

- Sediment cores = window to the past
- Record erosion history of MN Watershed

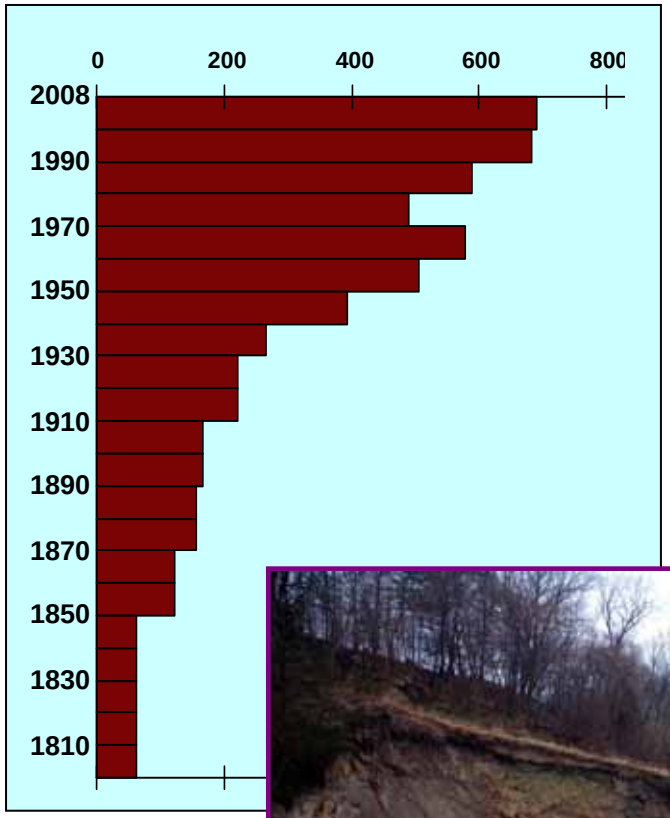


MN River watershed, ~85% cultivated



What is the source of the sediment ?

Lake Pepin Sediment Accumulation History



Field Erosion

Non-field

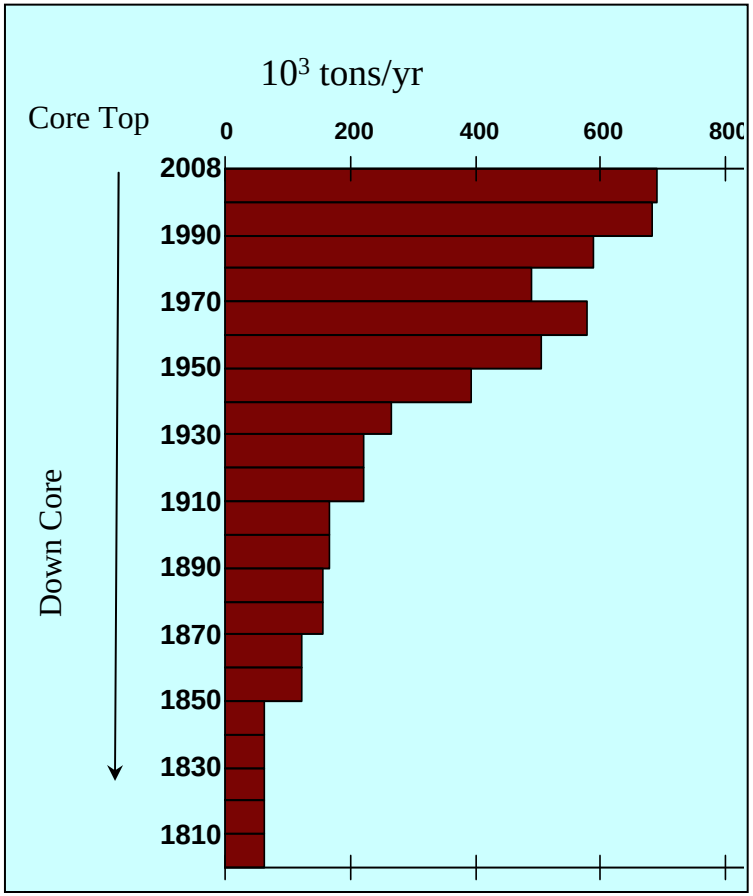
So What….

- ❖ Sediment a serious pollutant
- ❖ Ag Fields assumed to be major source
- ❖ Spend many $$$$ to keep soil on fields
- ❖ BMP's designed for fields

- ❖ Can't solve the problem unless we understand the problem

Why does it change over time…?

Lake Pepin Sediment Accumulation Rate

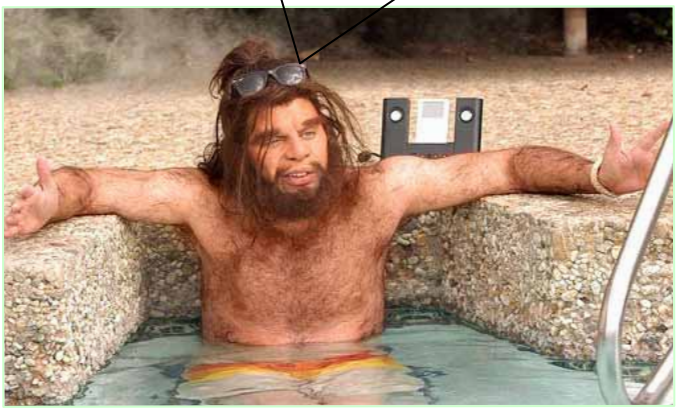


-It's possible the reasons are related

-Why does the rate change the way it does?

- Do the sources also change?

We can't solve the problem until we understand what is causing the changes.



…Fingerprinting Sediment Sources with ^{210}Pb

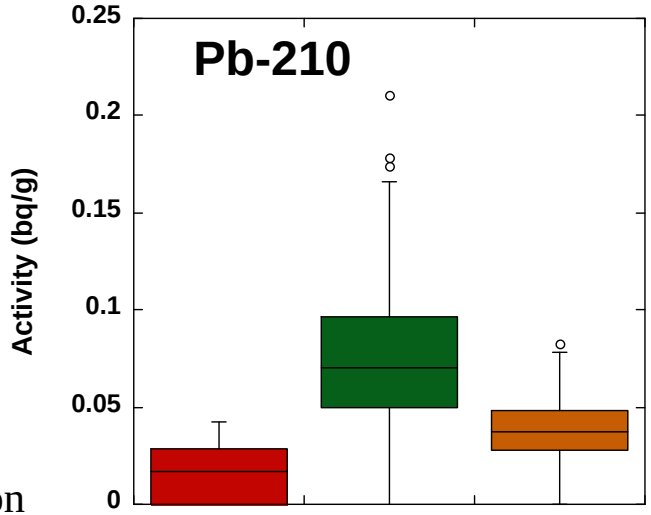
Constant Exposure to Atmosphere and Rain

Cultivated Field

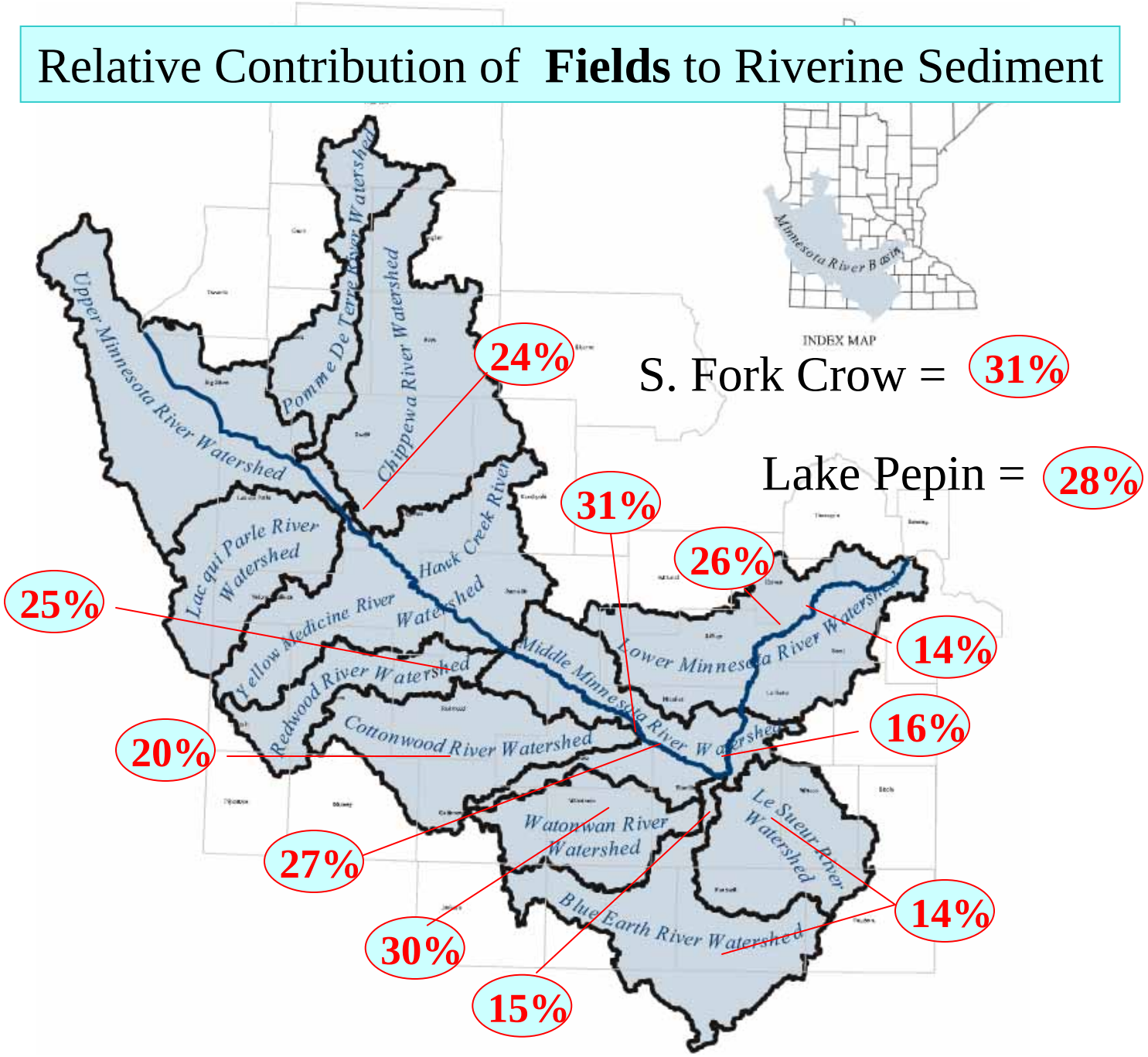
Suspended Sediment

Non-field Erosion

Minimal Exposure to Atmosp. and Rain



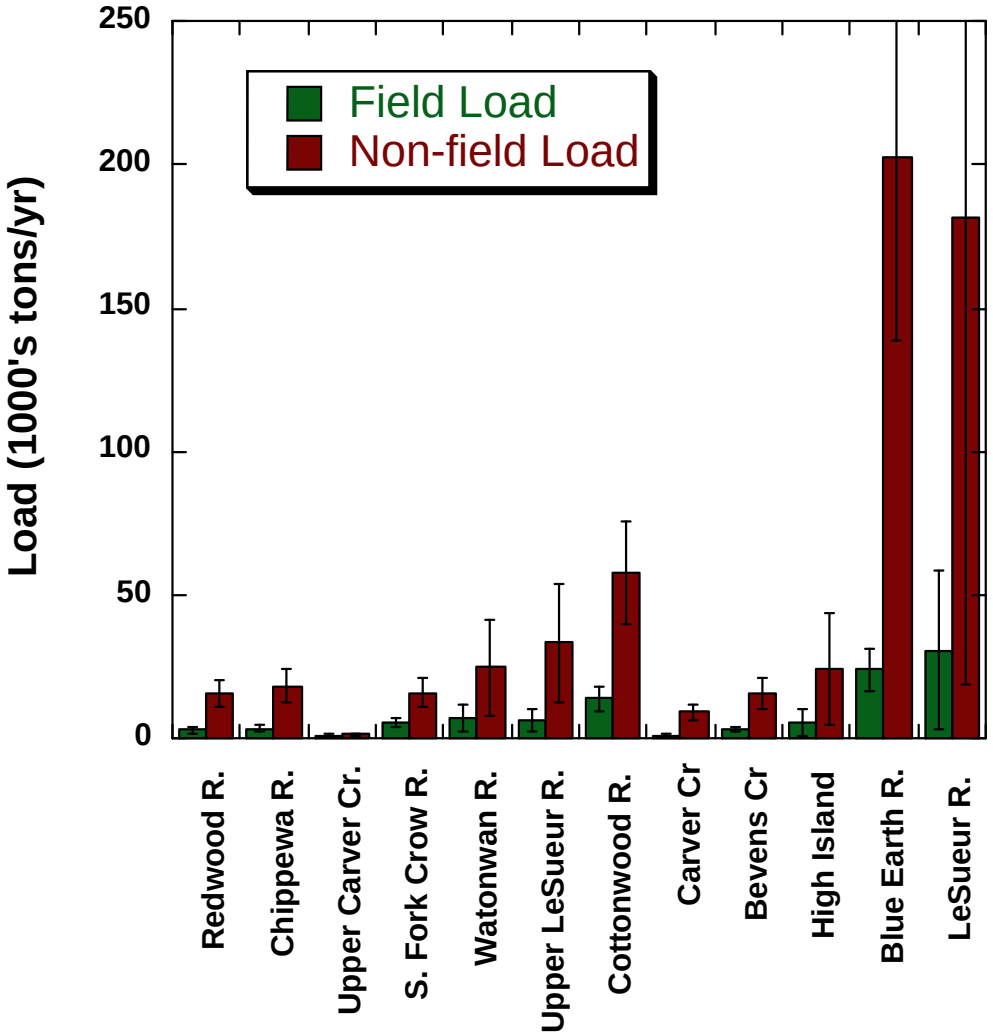
Relative Contribution of **Fields** to Riverine Sediment



S. Fork Crow = **31%**

Lake Pepin = **28%**

Field vs Non-field Sediment Loads



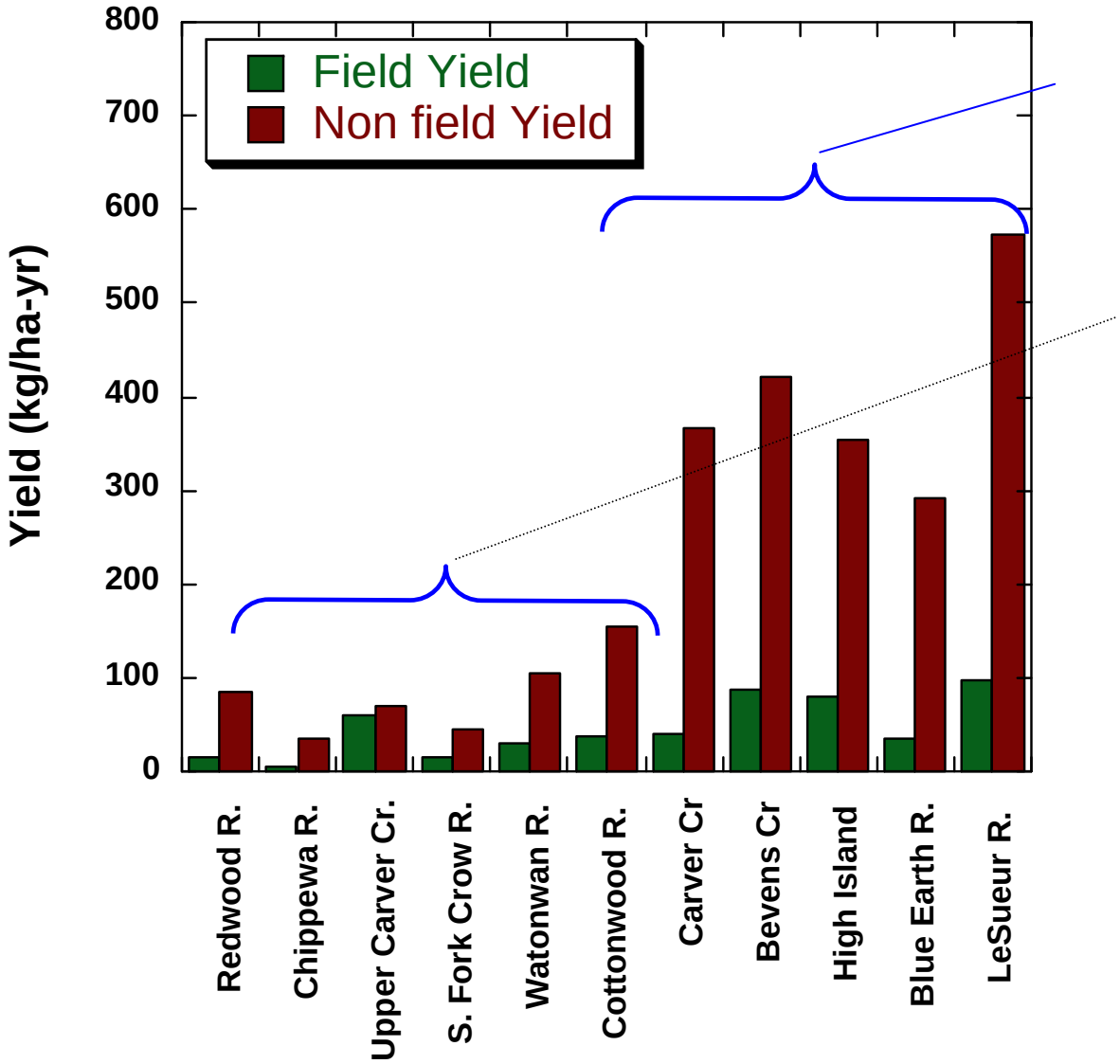
Between Watersheds:

- Non-field vary by: 400,000

- Field Load Vary only: 20,000

- Non-field highly variable!

Yields---

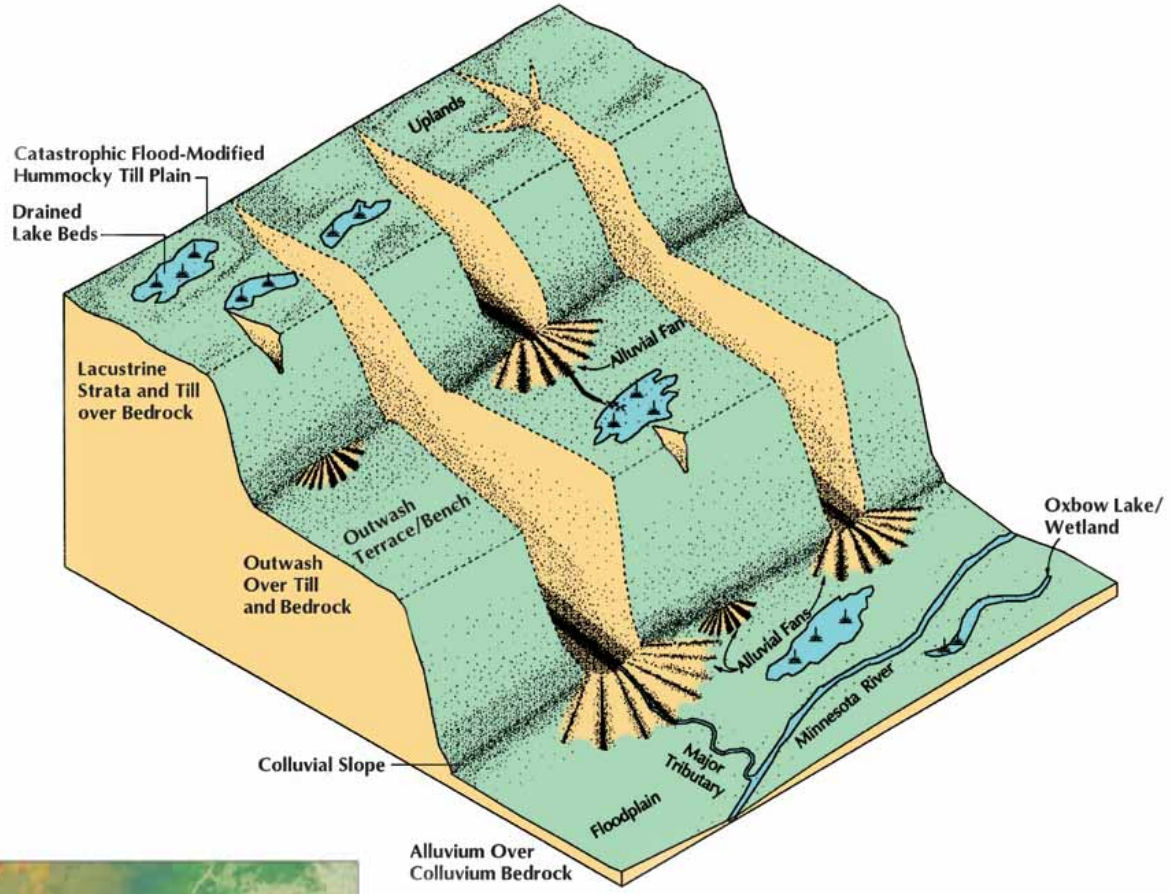


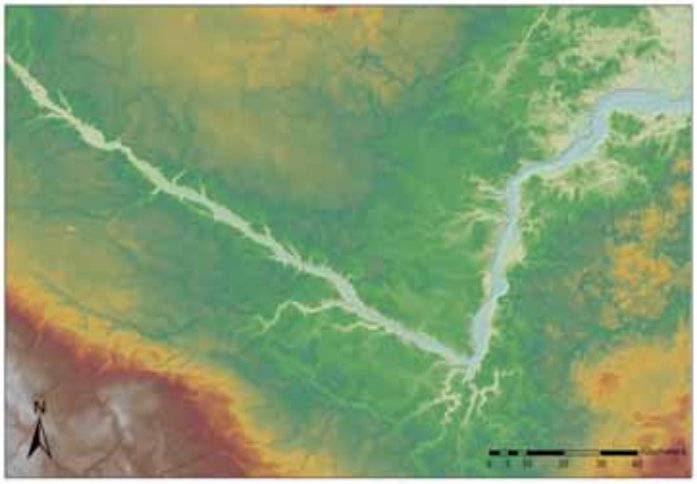
Steeply Incised Watersheds

Less Incised

Field Yield <u>Vary</u> by 60 kg/ha

Non-field <u>Vary</u> by 500 kg/ha



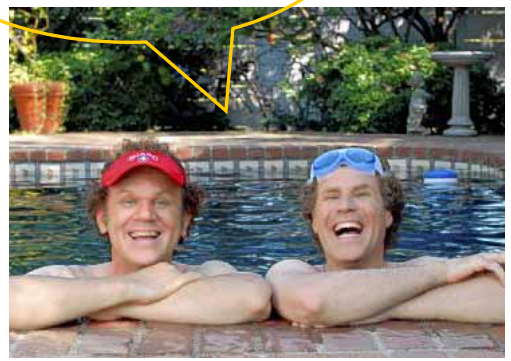


From Hudak and Hajc, 2005

..and now for Lake Pepin (= field + non-field)

	Field	Non-field
2007	25%	75%
1996	28%	72%
1964	35%	65%
1940	70%	30%

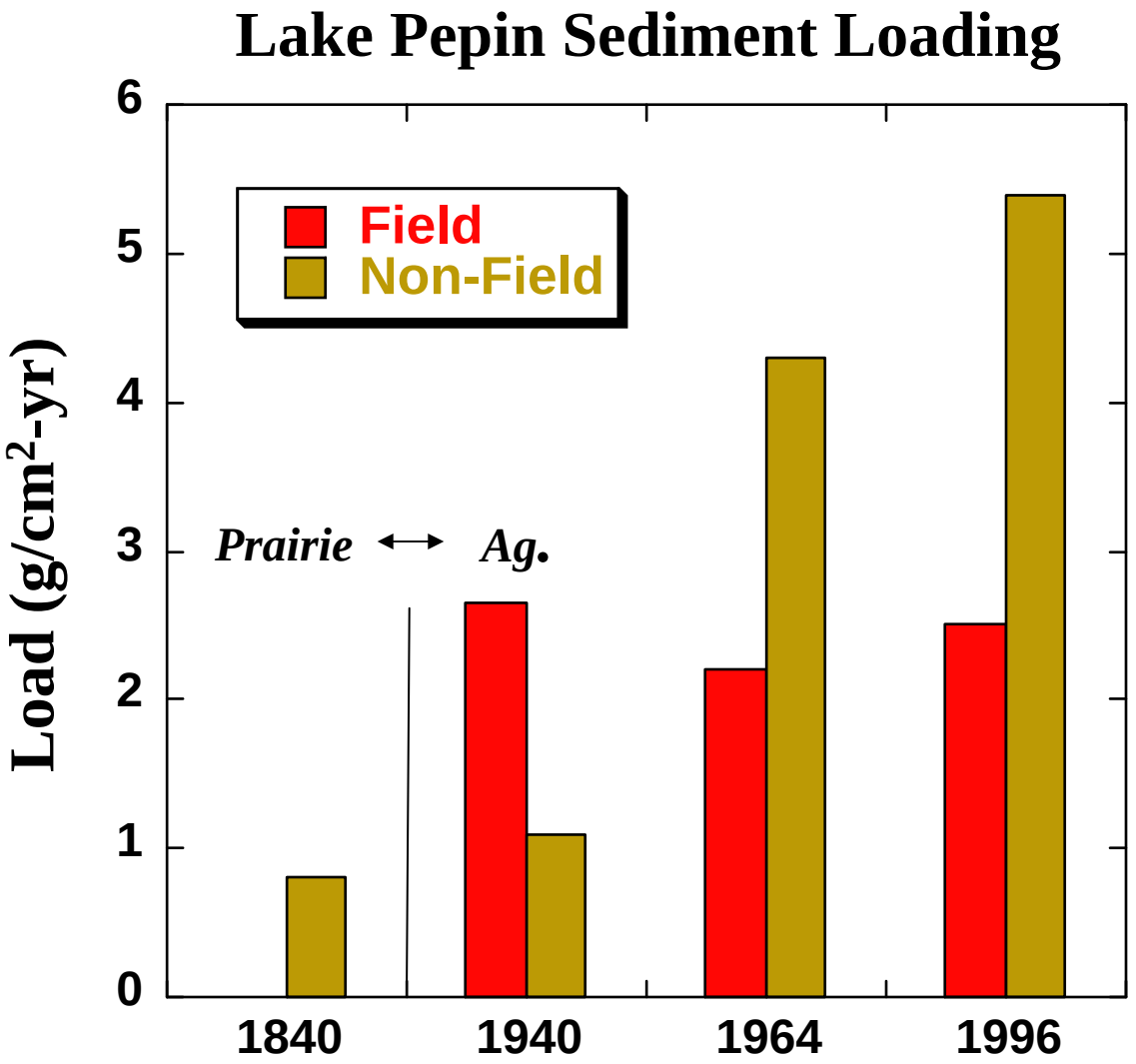
Neat-O, but why does it change



Non-field loading is increasing….

Field load ~ constant

Non-field accelerating & is now 6X "natural" rate

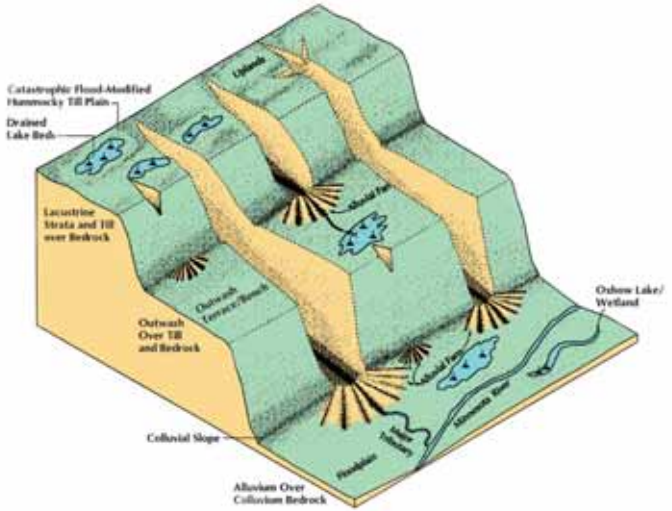


So…

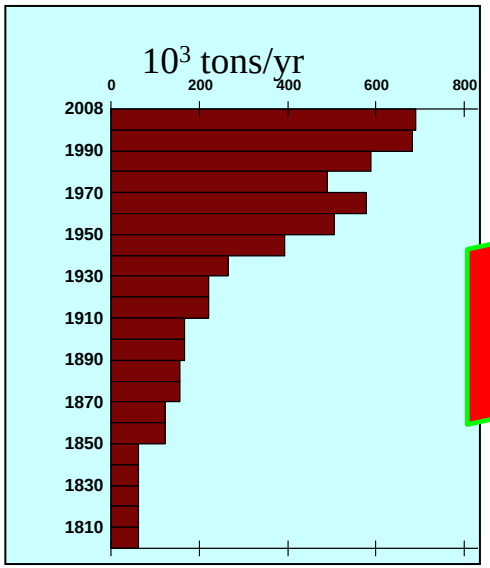
% Sediment from non-field sources

Ravens Creek =	70%
Kasota Pond & integrator sites =	60-80%
Lake Pepin =	65%
Event TSS samples =	>70%

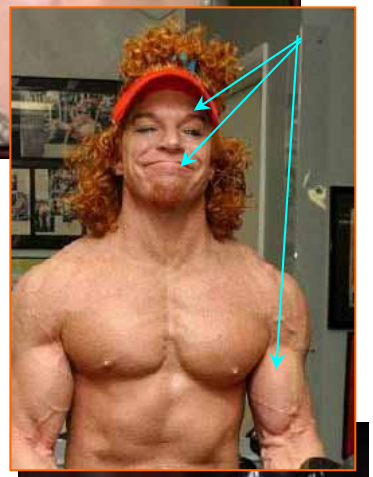
…and

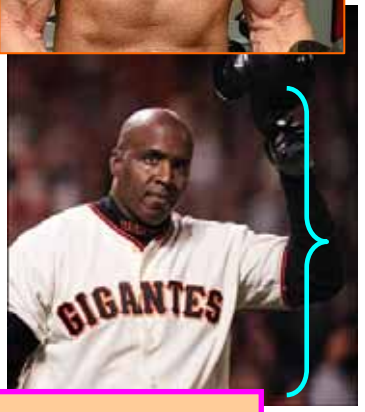


Symbols of the L. Pepin Sed. Accumulation Rate



NOT NATURAL



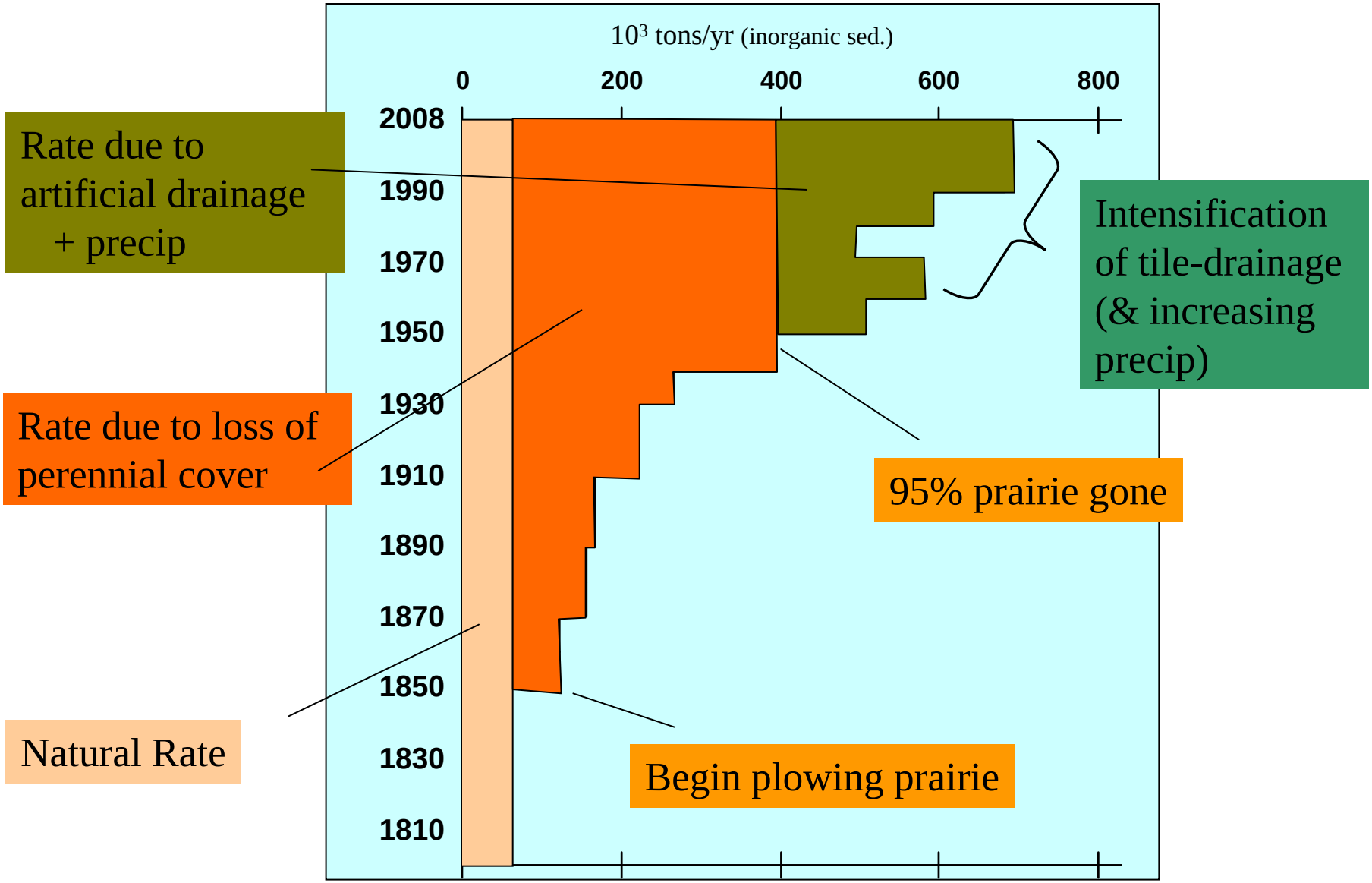


Sed Rate is 10X pre-settlement

>65% of sed is non-field

Therefore <u>RATE</u> of non-field is not natural

…why change: A hypothesis that needs testing




Blue Earth County,
slide from MPCA

Given that: Non-field inputs are significant and increasing

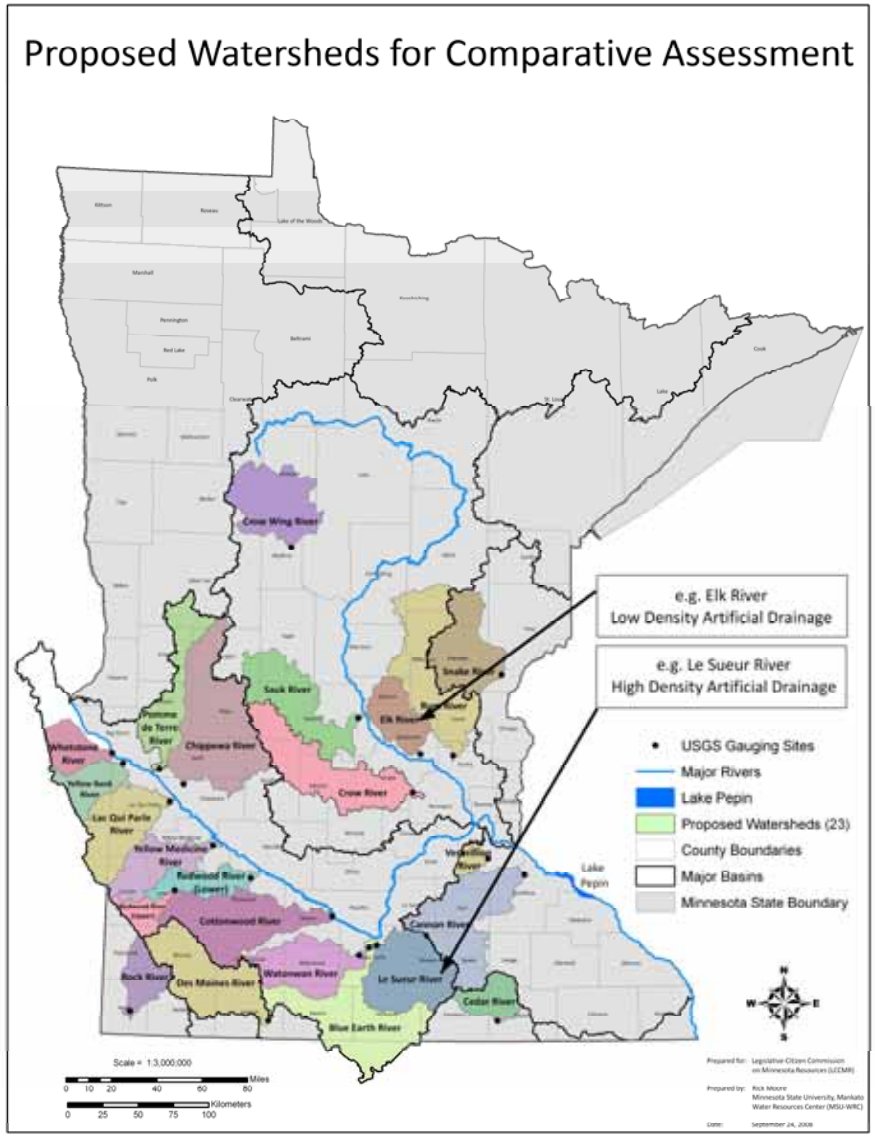
Hypothesize that: changes in riverine hydrology are mechanism for non-field inputs.

? Has tile drainage changed riverine hydrologic conditions

? Are changes in precipitation responsible

These two are linked--how do we disentangle them?

Compare watersheds ‘with’ and ‘without’ drainage



Hydrologic Changes

-over time

-between watersheds

-link to amount/density of drainage

-“normalize to climate”

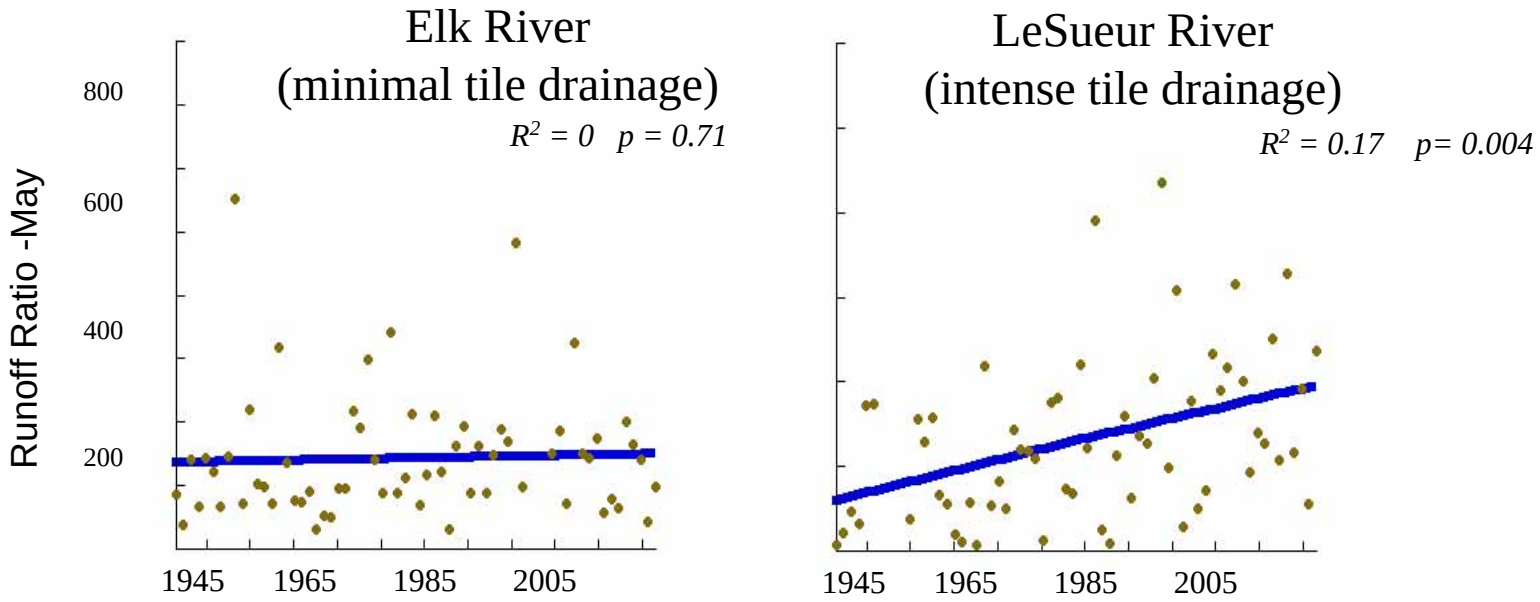
Relate magnitude and timing of:

-- hydrologic changes
-- installation of drainage

to Pepin sedimentation rate changes

Disentangling effects of climate from artificial drainage

Preliminary data--a hint at what we might find…



Runoff Ratio = flow/precipition (normalizes flow to rainfall)

Examine 14 other hydrologic parameters (monthly and seasonally)

e.g. runoff ratio, peak frequency, maximum flow, max flow duration, rate of increase, rate of decrease, flow:PDHI

- do they change over time
- how do watersheds compare
- are changes coincident with drainage, or climate
- how much can be explained by drainage v. climate
-Has drainage changed hydrologic conditions?

Model 2 Waterhsheds (1with, 1 “without”)
Swat model:
-calibrate to 1940-1970
-compare model predictions to actual 1970-2008

Summary

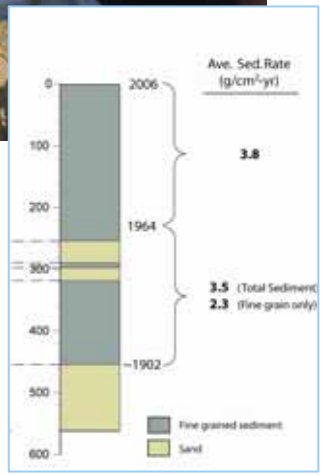
WHY?

Not natural

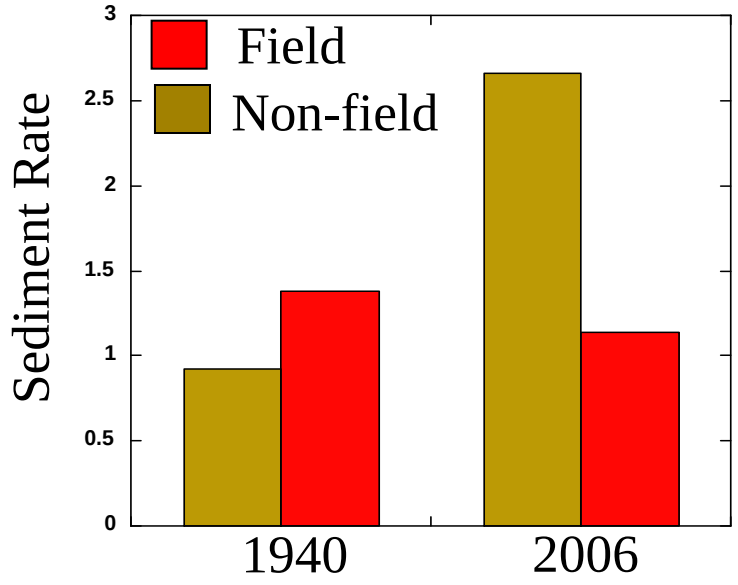
Why has non-field sediment loading increased

How much is related to intensification of artificial drainage and/or increased precipitation?

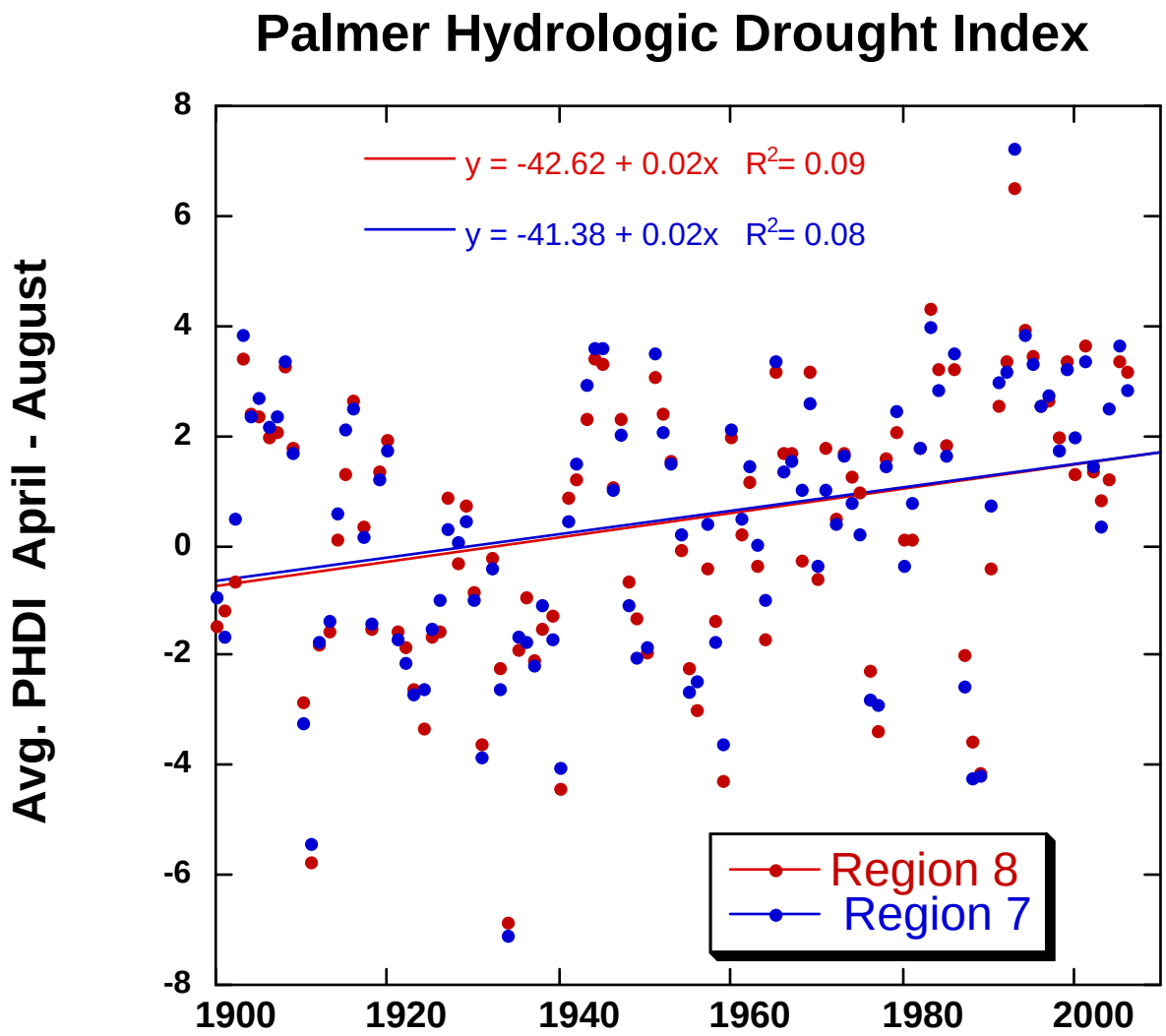
Redwood River Reservoir---different river, same story…



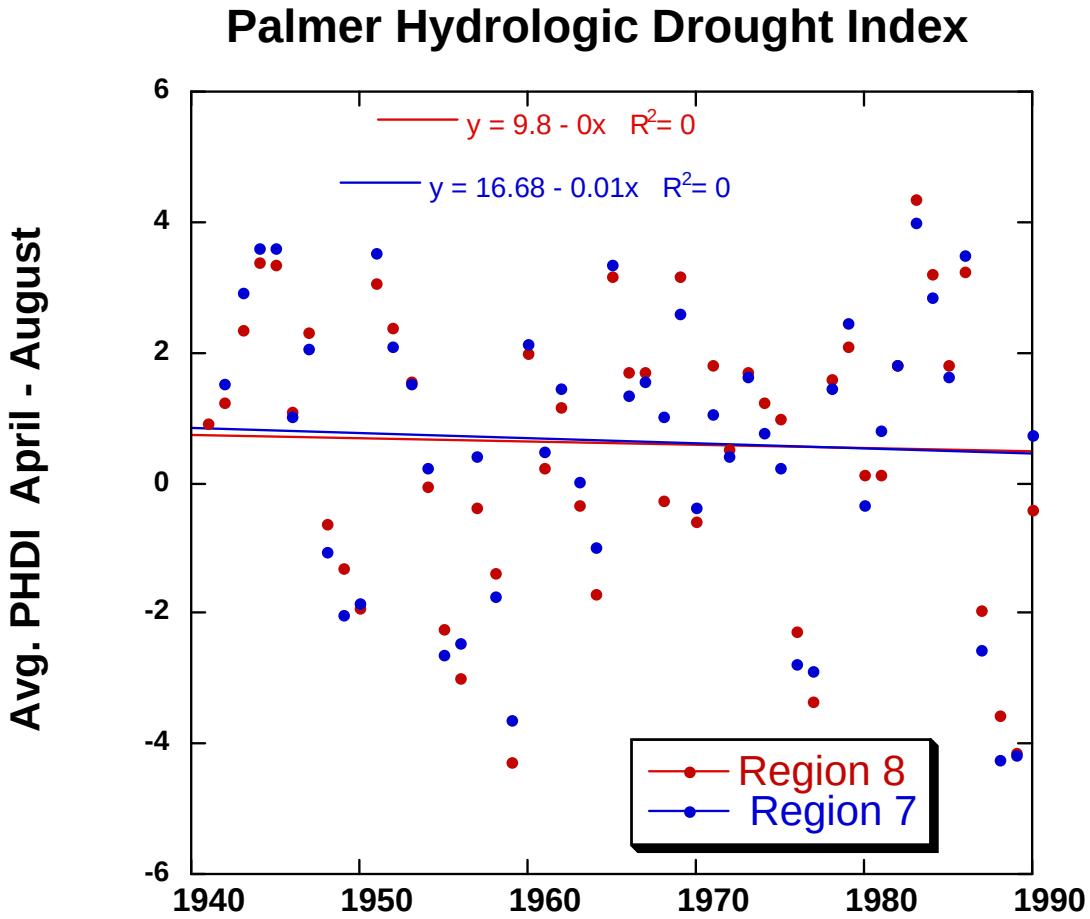
	Non-Field
2006	70%
1964	67%
1950	50%
1940	40%

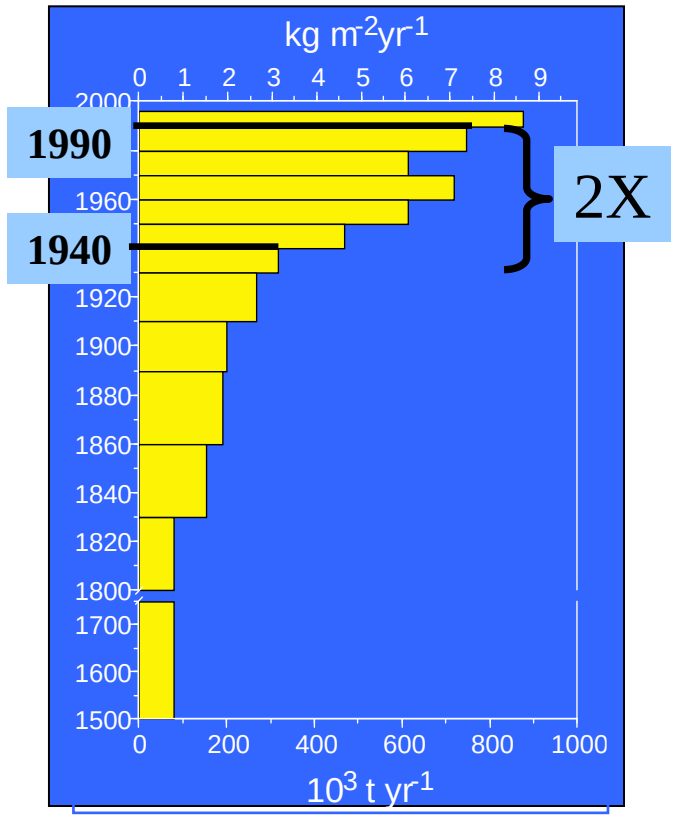


Climate is getting Wetter…



Sedimentation Rate and Climate ?



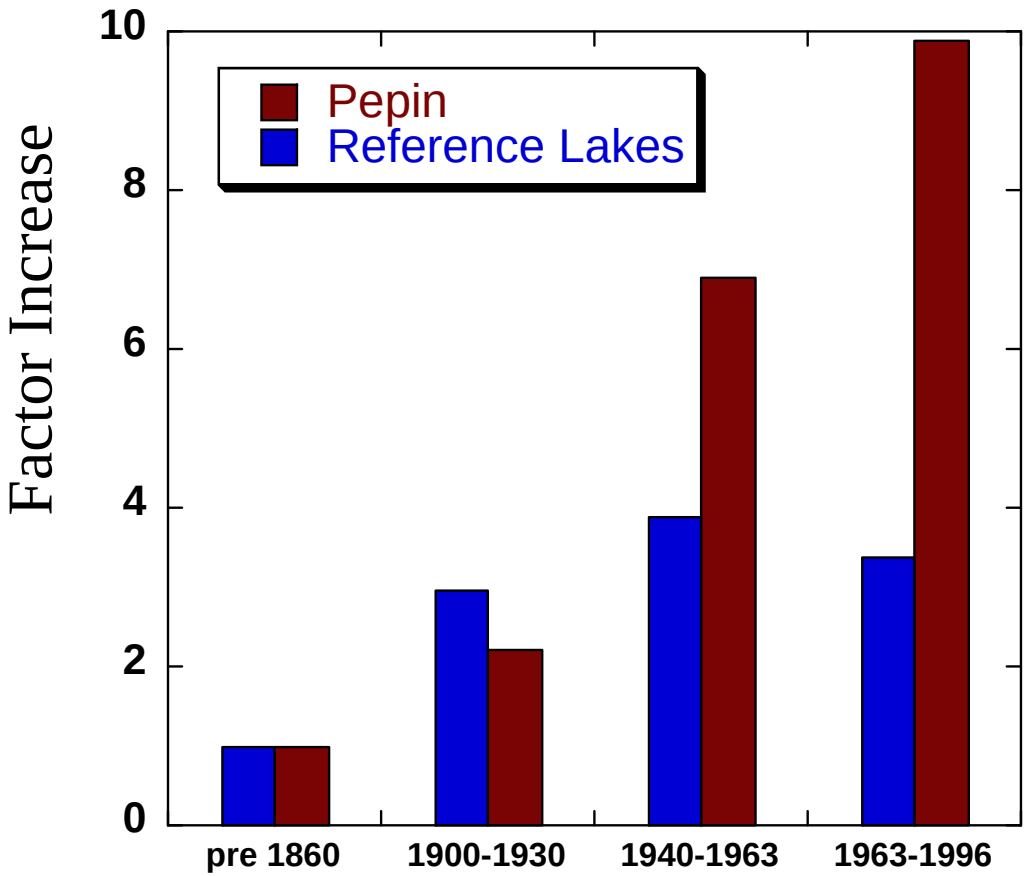


Trends in Sediment Accumulation Rates-- in Different Systems

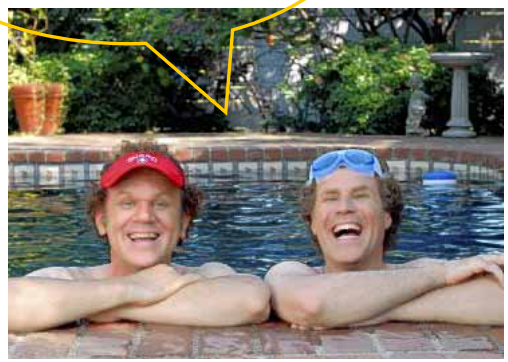
Riverine systems

Field + Non-Field

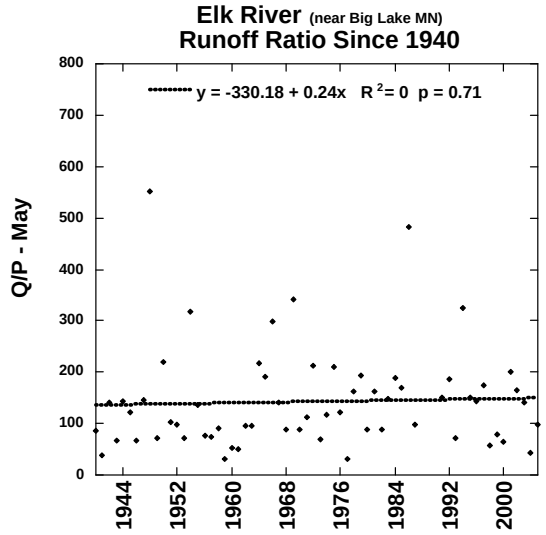
Field Source Only



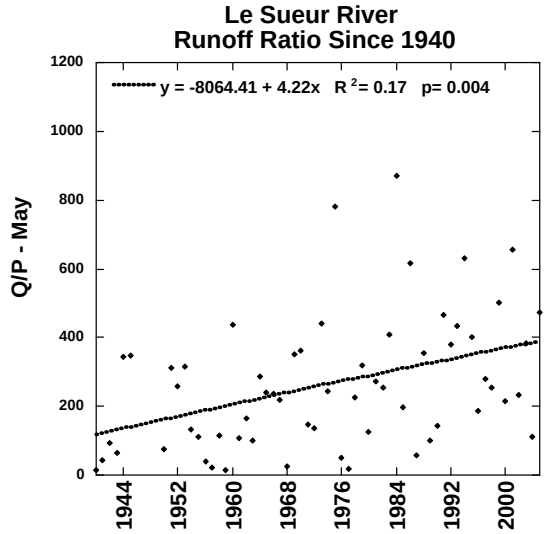
Neat-O,
but why are they different?



Effect of artificial drainage on flow and non-field erosion ??



Watershed with minimal artificial drainage



Watershed with dense artificial drainage

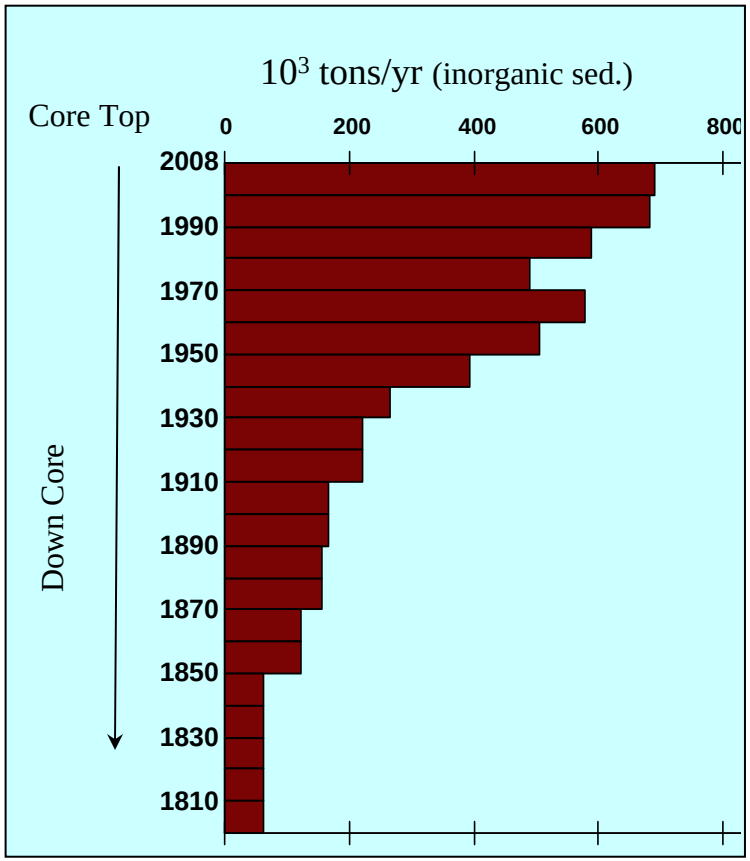
Need to quantify and understand this difference

"Hey, Brain what are we going to do today"

"Same thing we do every day Pinky,

Try to figure out where the sediment comes from, and why it changes"

Lake Pepin Sediment Accumulation Rate



Tracing Sediment Sources with Radioisotope Fingerprints.

1. ^{210}Pb and ^{137}Cs are deposited by rain

2. Different Sources = Different Concentrations

3. Fields have high concentrations

4. Non-fields sources have ~ 0
   Ravines, Streambanks, Bluffs Gullies

5. Suspended Sediment combination

6. Measure suspended sed. and compare to Source Fingerprints

"…why am I singing and what does it have to do with fingerprinting"