Detecting Water Quality Responses to Land Management Changes:

Why Is It So Difficult?

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I. Desirable aspects of field research

- Manipulation, not just observation
- In control of all aspects of experiment
- No extraneous influences (weather, soils, topography)
- Various levels of treatment
- A control (null experiment)
- Replication

Desirable aspects of field research

- Manipulation, not just observation
- In control of all aspects of experiment
- No extraneous influences
- Various levels of treatment
- A control (null experiment)
- Replication
- Minimize the (unexplained) Variance!

Research at the plot scale

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- √ Various levels of treatment
- √ A control (null experiment)
- √ Replication

Research at the field scale

- √ Manipulation, not just observation
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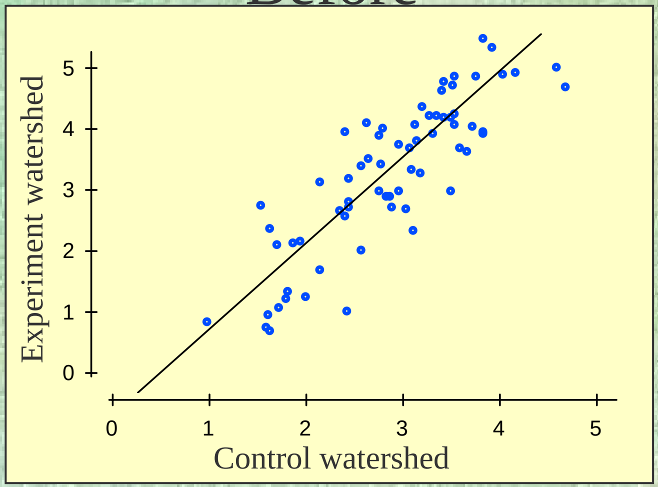
Research at the watershed scale

- ~ Manipulation, not just observation
  - In control of all aspects of experiment
  - No extraneous influences
  - Various levels of treatment
- ~ A control (null experiment)
  - Replication

Inferring cause & effect

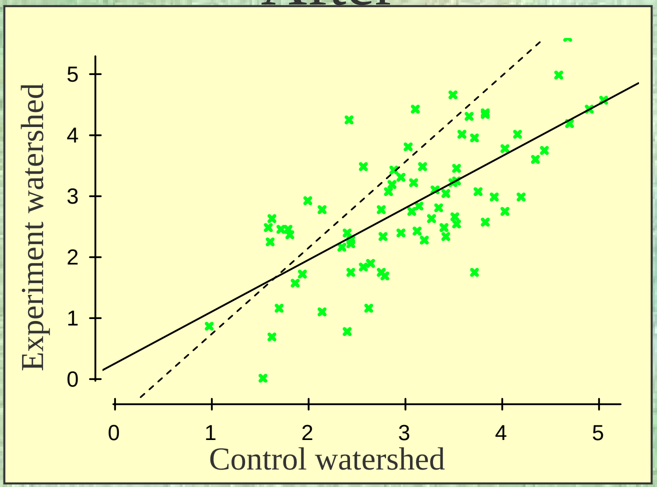
- Controls, treatment levels, replication build confidence that your manipulation *caused* the observed change(s)
- At watershed scale, before-after, paired design is often the best we can do

Before



Apply Treatments

After



Research at the watershed scale

- Long lag time between management action and water quality response
- Little control over the control watershed
- Limited, untargeted implementation
- Rarely have adequate funding for “before” monitoring
- Other things going on confound the signal
- Often we just observe, rather than experimenting

Research at the watershed scale

- With such marginal control…
  - If we see a change in water quality, how can we be sure it is because of what we did?
  - If we don't see a change in water quality, how can we be sure what we did was not helpful?

Watershed research as a lab experiment

- A large beaker in a lab with no door
- Several experiments already going on in the beaker
- Impure reagents
- No distilled water
- Experiment takes 3 hours but you're only allowed 15 minutes

- The CSI Miami analogy: you find the beaker after the experiments are done, and you have to figure out what happened in the beaker and why!

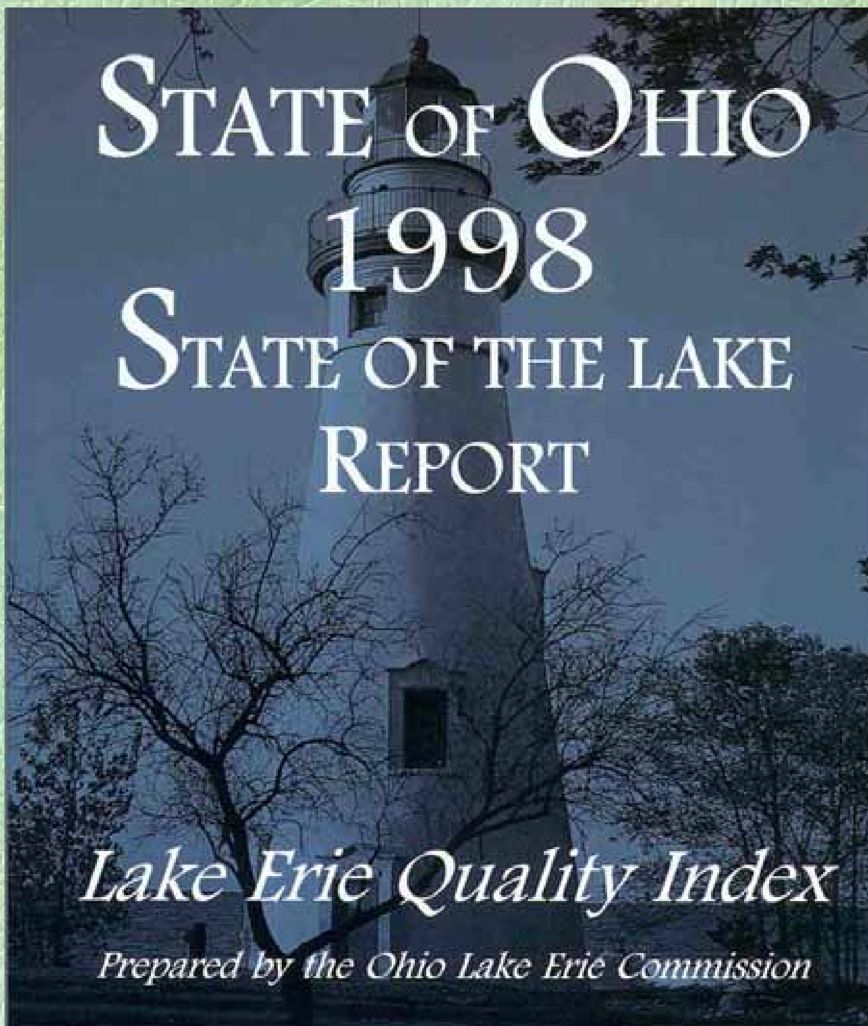
Research at the watershed scale

- So there are good reasons it's hard to do!
- In spite of these considerable problems and drawbacks, we need to keep trying to provide evidence of success at the watershed scale!
- Managers need to come to understand how hard this is, and not have unrealistic expectations!
- SWCS Workshop in Kansas City, October 11-13, "Managing Agricultural Landscapes for Environmental Quality", one theme is "Realistic Expectations"…

II. Case Study: Lake Erie CREP

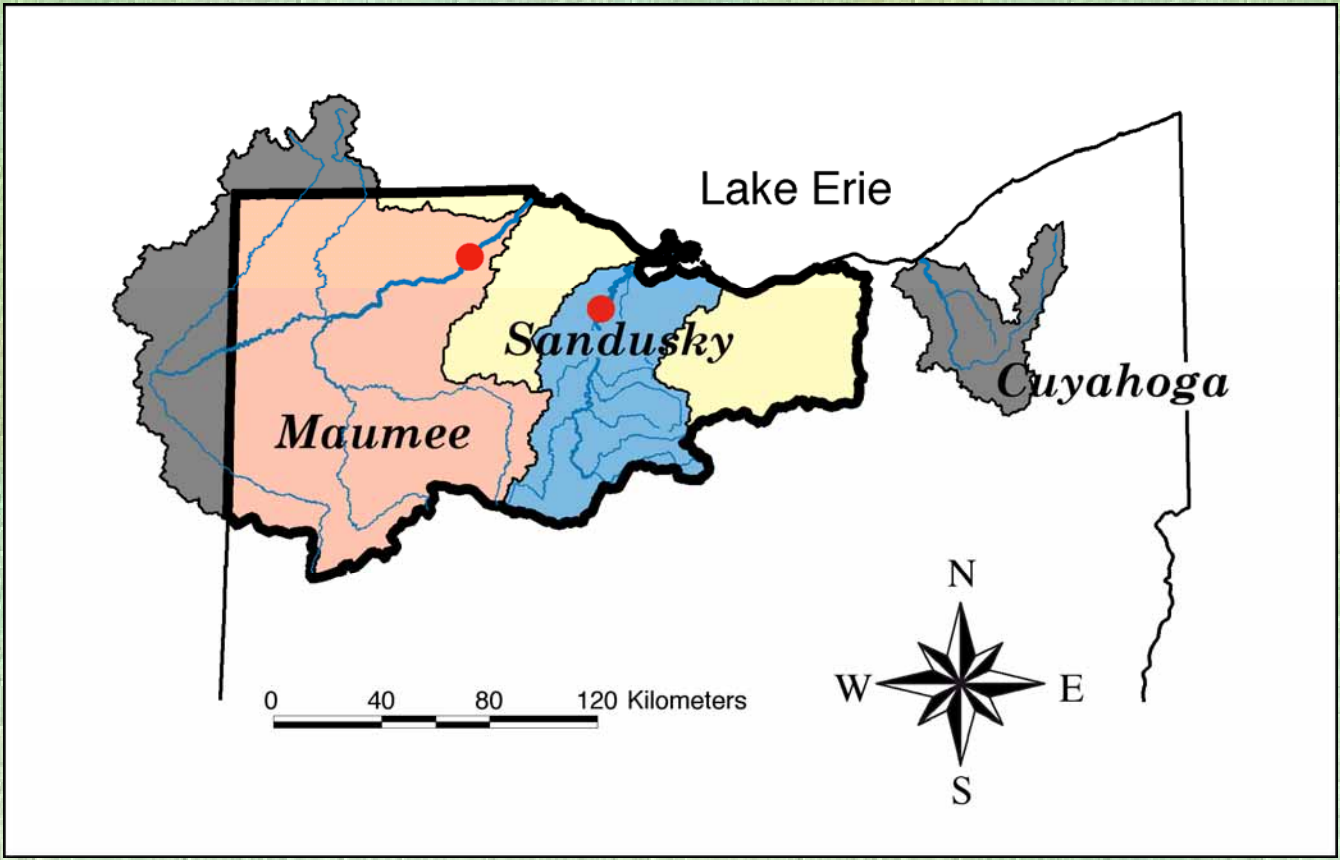
- Derivation of WQ Goal
- Approach to evaluation
- Where do we stand with meeting the goal?
- Recent work on longer term trends

Setting the water quality goal



- One Index of Lake Erie Quality is tributary sediment loads.
- For 1991-1996, the average annual sediment load from the Maumee, Sandusky, and Cuyahoga Rivers is 1,500,000 metric tons
- Reduce this by 67%(!)

Lake Erie CREP Project Area



Setting the water quality goal

- Lake Erie CREP Implementation Goal: Protect 10% of farmed riparian acres
  - Protect 10% of riparian corridor => reduce loads by 10% or by 150,000 metric tons annually
  - Gradual implementation, assumed uniform over 10 years
  - Thus save 15,000 metric tons the first year, 30,000 the second year, etc.

Setting the water quality goal

Year of program	Sediment load reduction in this year	Total sediment saved to date
1	15,000	15,000
2	30,000	45,000
3	45,000	90,000
4	60,000	150,000
5	75,000	225,000
6	90,000	315,000
7	105,000	420,000
8	120,000	540,000
9	135,000	675,000
10	150,000	825,000

…plus 10 more years of loads reduced by 150,000 m.t./yr

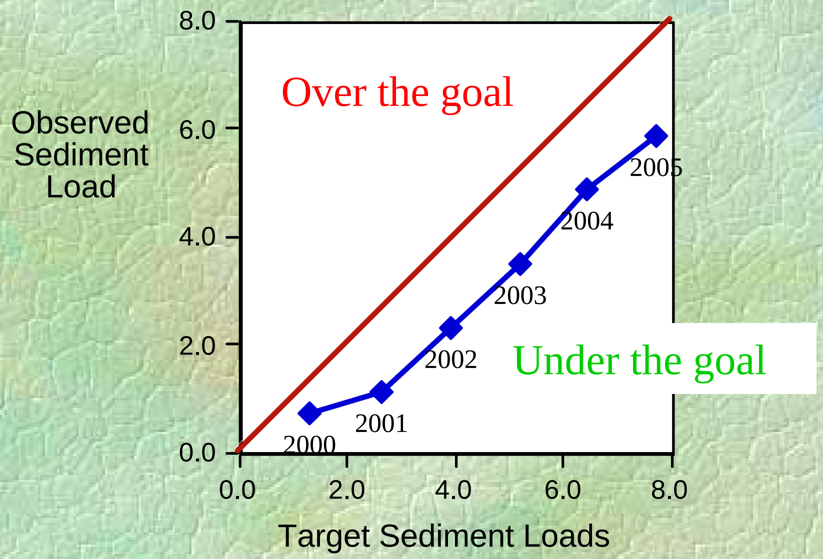
The water quality goal: notes

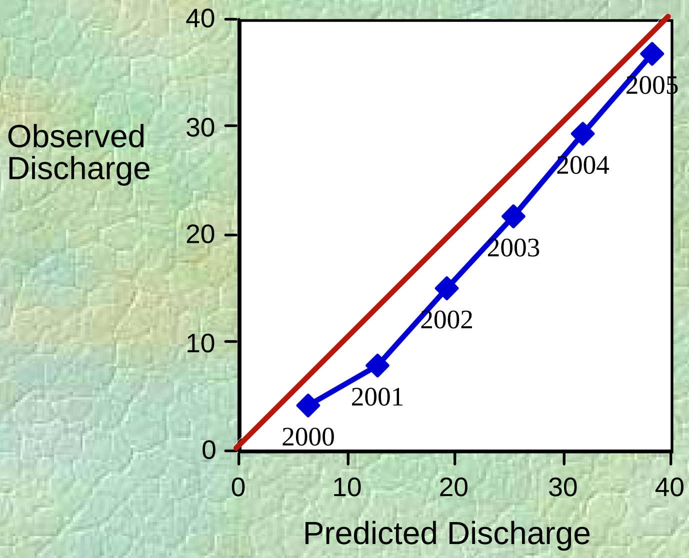
- We have no control watershed - just before and after in the CREP implementation area
- We don’t really know what WQ response to expect from 10% implementation of BMPs
- We don’t know anything about lag times
- The goal amounts to only a 1% change per year
- If we meet the goal, how do we know it’s not just because of weather?

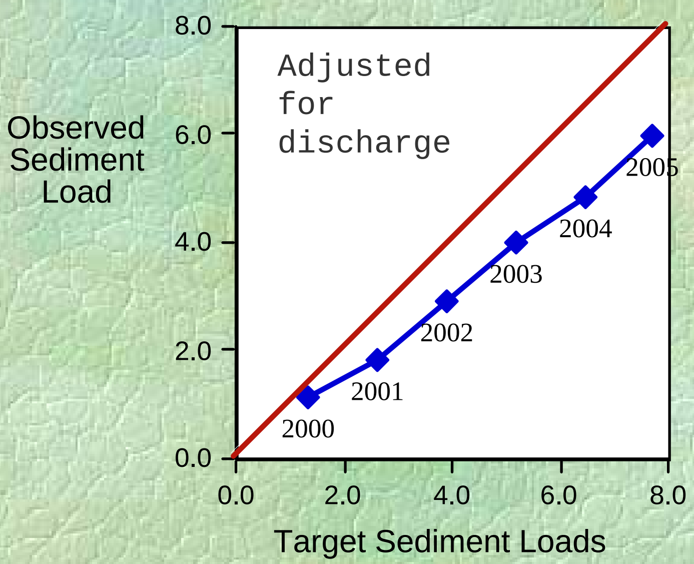
Initial results

- Total sediment "saved" after six years: 2.1 million metric tons.
- We weren't supposed to have saved that much until sometime in the year 2018!
- Unfortunately, a lot of the "savings" are associated with years of low discharge, which reduces the loads as well.
- After proportional adjustment to average discharge, still 1.9 million metric tons ahead.

Initial results







Note: these are cumulative loads and discharges

Indications

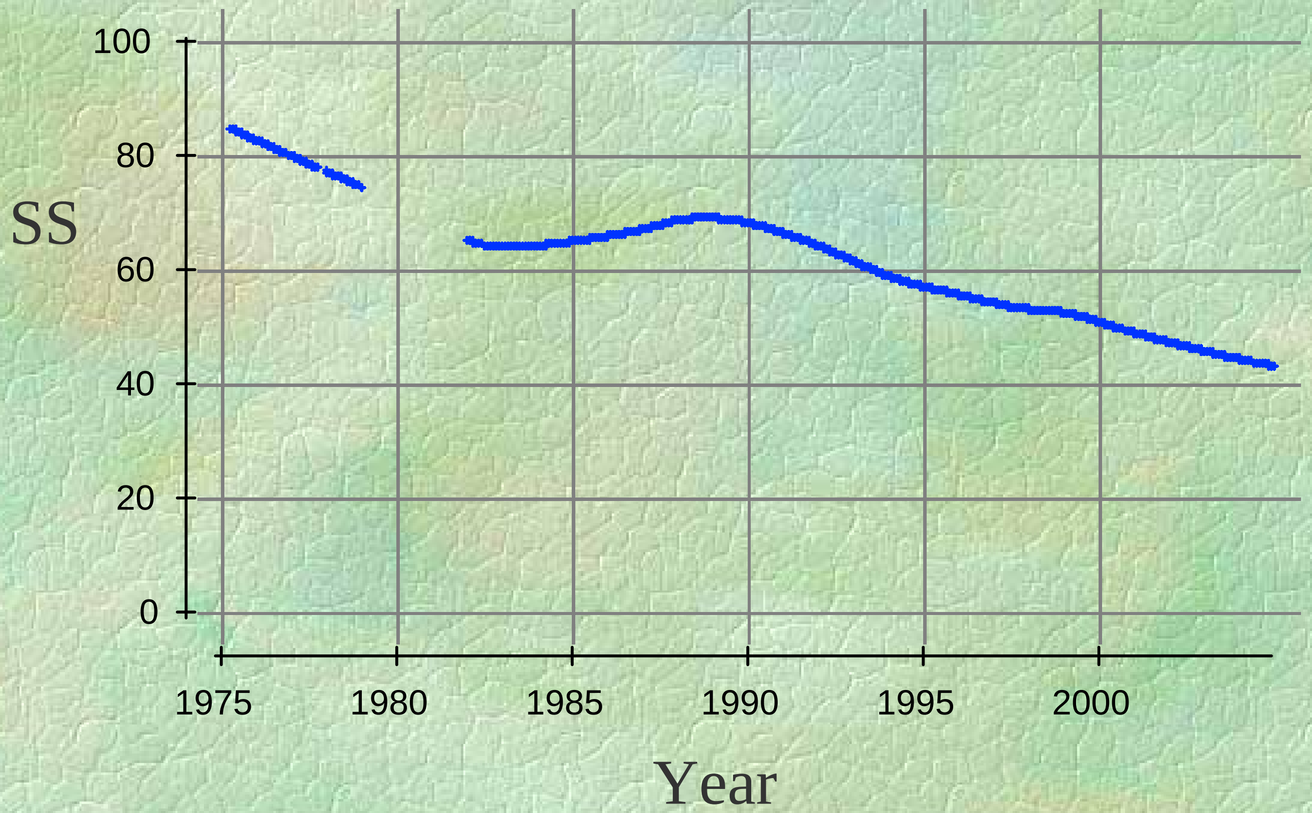
- We're looking good!
- But some or much of our "success" to date is due to weather effects that produced lower-than-expected flows….
- So keep your fingers crossed, and lets go for as much implementation as possible!

III. Weather Effects on Trends: A New Approach

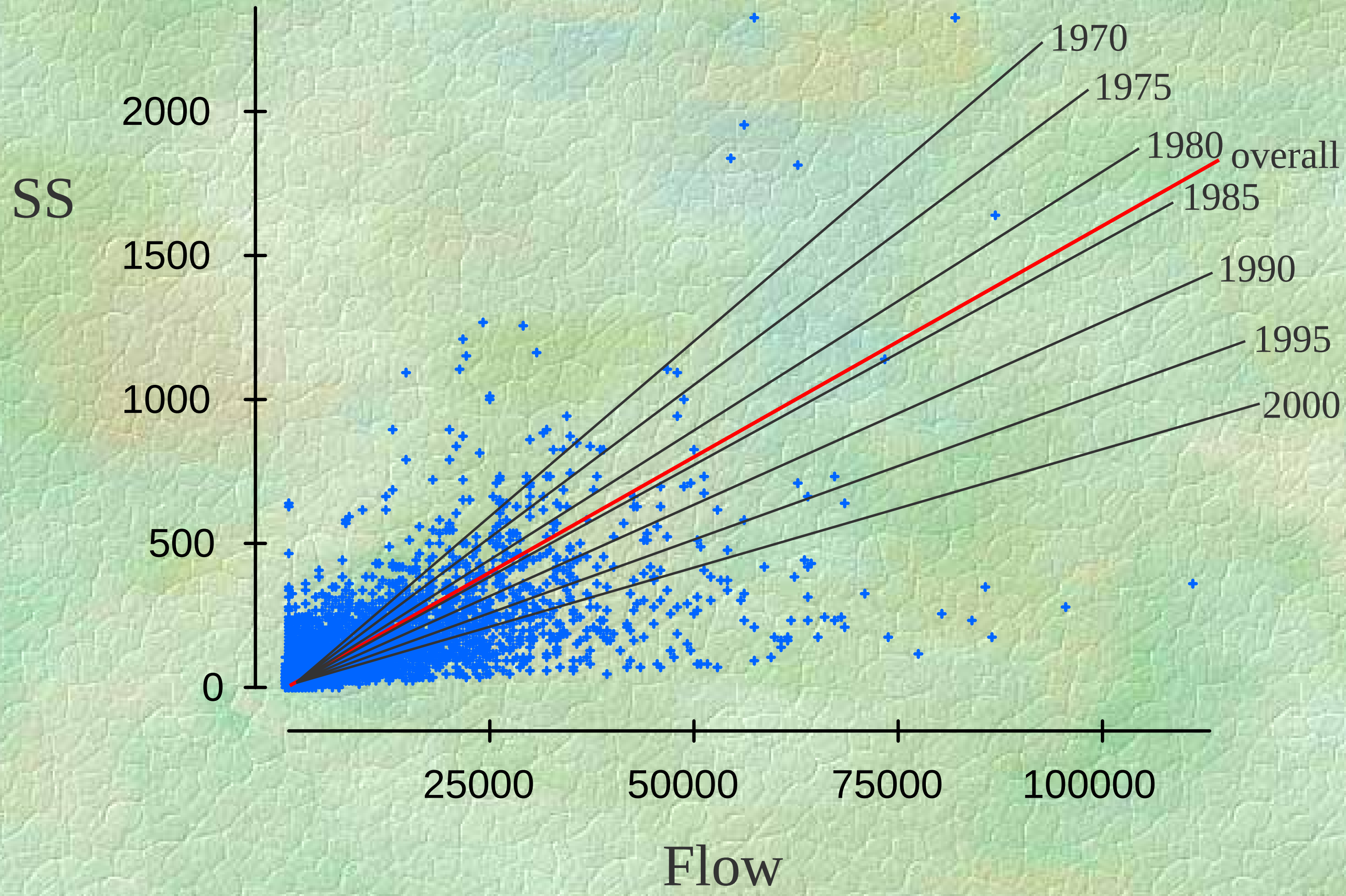
- Maumee only, not entire CREP area
- 30-period of record, not just CREP period
- Examine concentration-flow relationships in relationship to time

Weather Effects and Trends

- LOWESS smooth of Maumee SS:

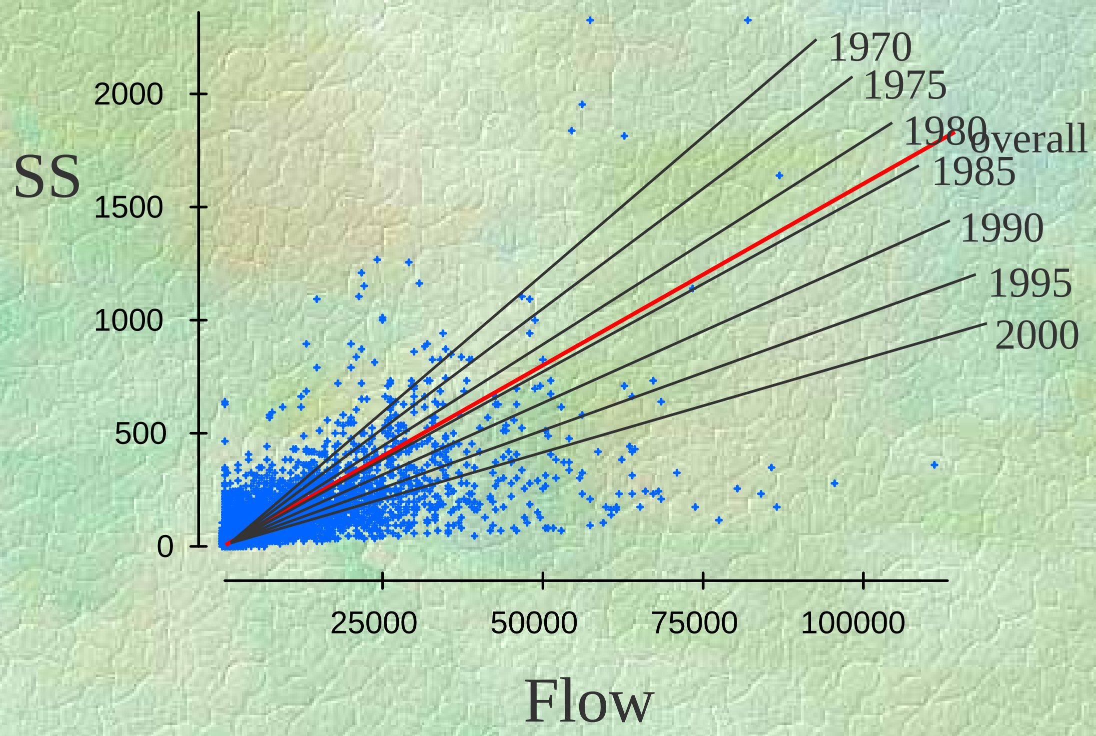


Weather Effects and Trends



Weather Effects and Trends

- Need to do the analysis in log-log space…



$SS = k_y * Flow$

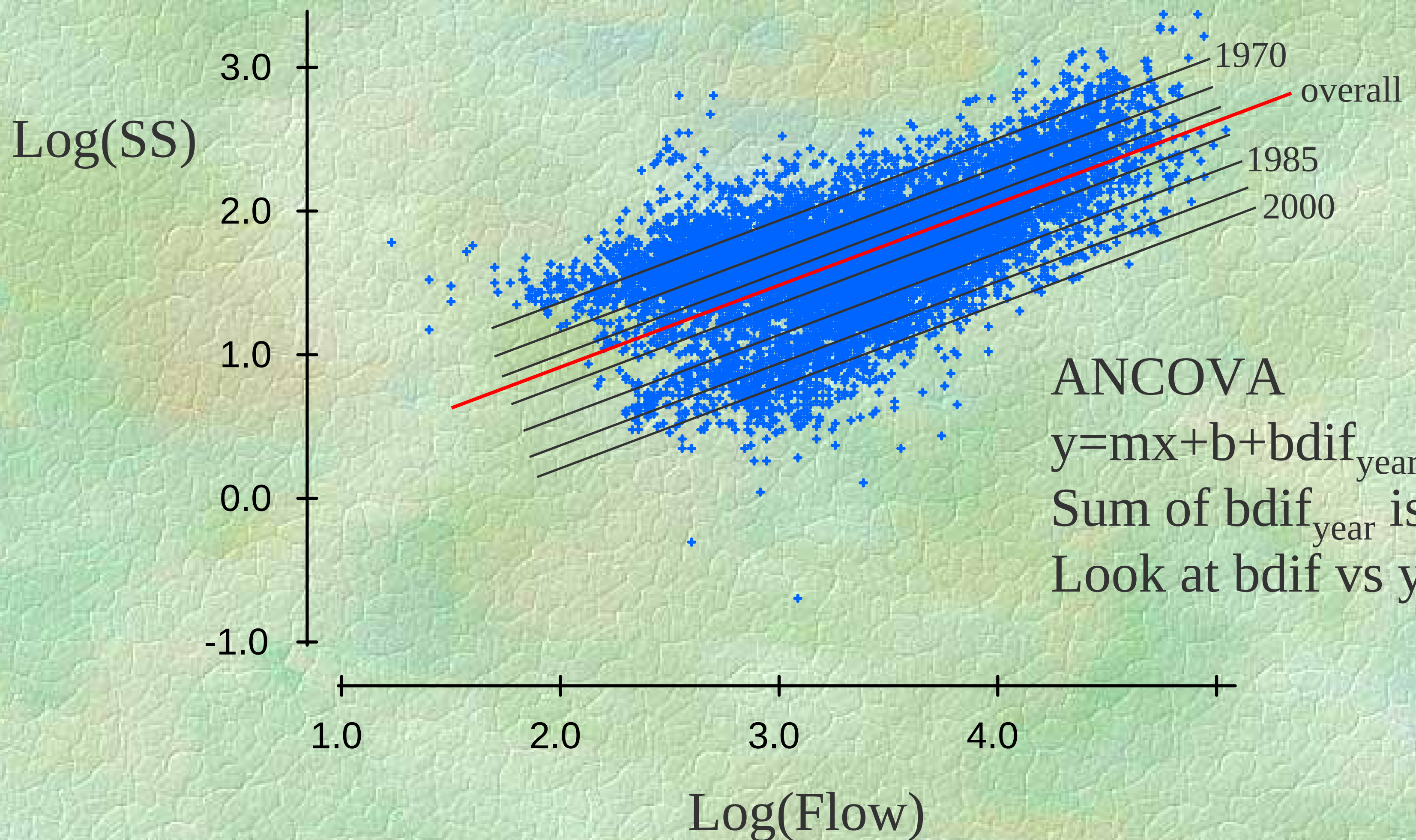
$\log(SS) = \log(k_y * Flow)$

$\log(SS) = \log(k_y) + \log(Flow)$

constant

(part of intercept term)

Weather Effects and Trends



ANCOVA

$y=mx+b+bdif_{year}$

Sum of $bdif_{year}$ is 0

Look at bdif vs year

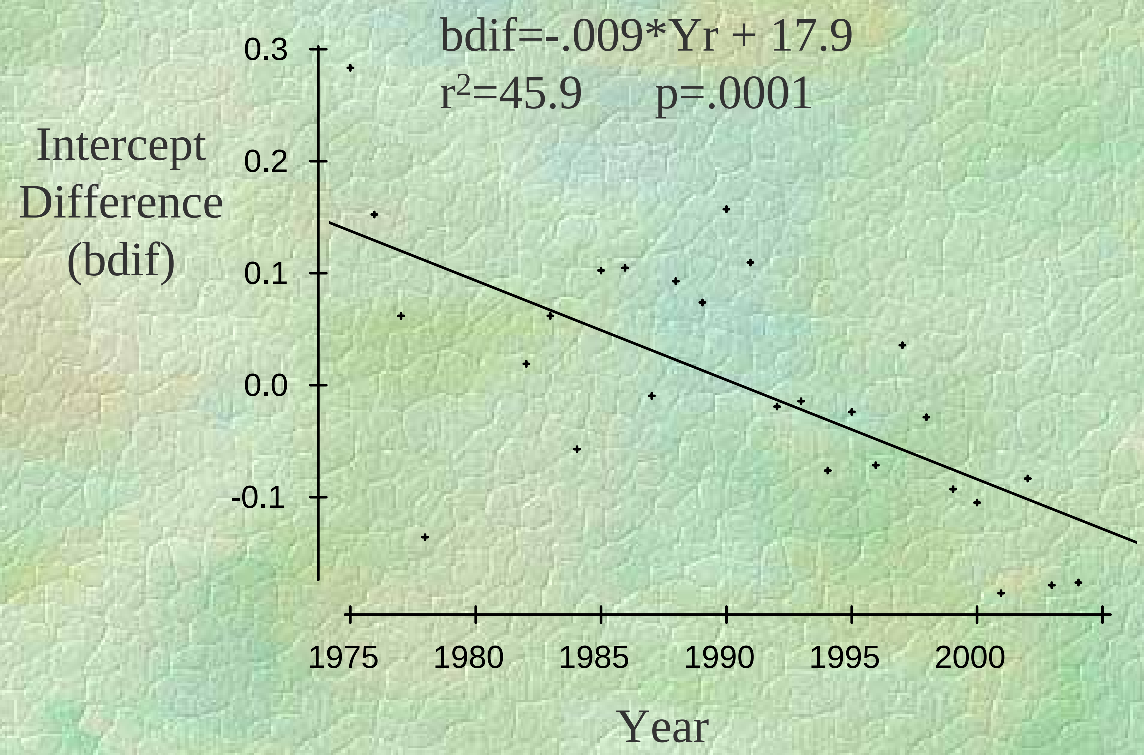
Weather Effects and Trends

Analysis of Variance For **LogSS**
No Selector
9102 total cases of which 62 are missing

Source	df	Sums of Squares	Mean Square	F-ratio	Prob
Const	1	26198.9	26198.9	234182	Š 0.0001
LgQ	1	565.480	565.480	5054.6	Š 0.0001
WY	26	105.821	4.07003	36.380	Š 0.0001
Error	9012	1008.21	0.111874		
Total	9039	1745.43			

Level of WY	Coefficient	Level of WY	Coefficient	Level of WY	Coefficient
1975	0.2831	1985	0.1021	1995	-0.0232
1976	0.1533	1986	0.1036	1996	-0.0708
1977	0.0616	1987	-8.924e-3	1997	0.0353
1978	-0.1354	1988	0.0931	1998	-0.0281
1979	no data	1989	0.0734	1999	-0.0931
1980	no data	1990	0.1569	2000	-0.1049
1981	no data	1991	0.1086	2001	-0.1853
1982	0.0202	1992	-0.0193	2002	-0.0822
1983	0.0620	1993	-0.0149	2003	-0.1774
1984	-0.0565	1994	-0.0767	2004	-0.1766

Weather Effects and Trends



Conclusion: highly significant decrease in sediment concentration as a function of flow over 30 years!

Weather Effects and Trends

- Further analysis shows:
  - Most of this change is associated with the “summer” months (May-October)
  - The Sandusky shows the same changes, though not as strongly

Conclusions

- Detecting water quality change at the watershed scale is difficult, for good reasons.
- Making a strong case that changes are responses to land management programs (cause and effect) is even more difficult.
- With good data and appropriate analyses, however, the case can (and should) be made.


Tune In Next Time...