Trends in Agricultural Practices and Water Quality in NW Ohio, 1975-1995: and an Update to 2005

or: Lessons We Thought We'd Learned?

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Road Map...

- Lake Erie Agricultural Systems for Environmental Quality (LEASEQ) study:
  - Study area
  - Trends in agricultural land use and practices
  - Trends in water quality
  - Cause and effect?
- Preliminary Update: the last 10 years

LEASEQ team:

David Baker	HCWQL	Ken Krieger
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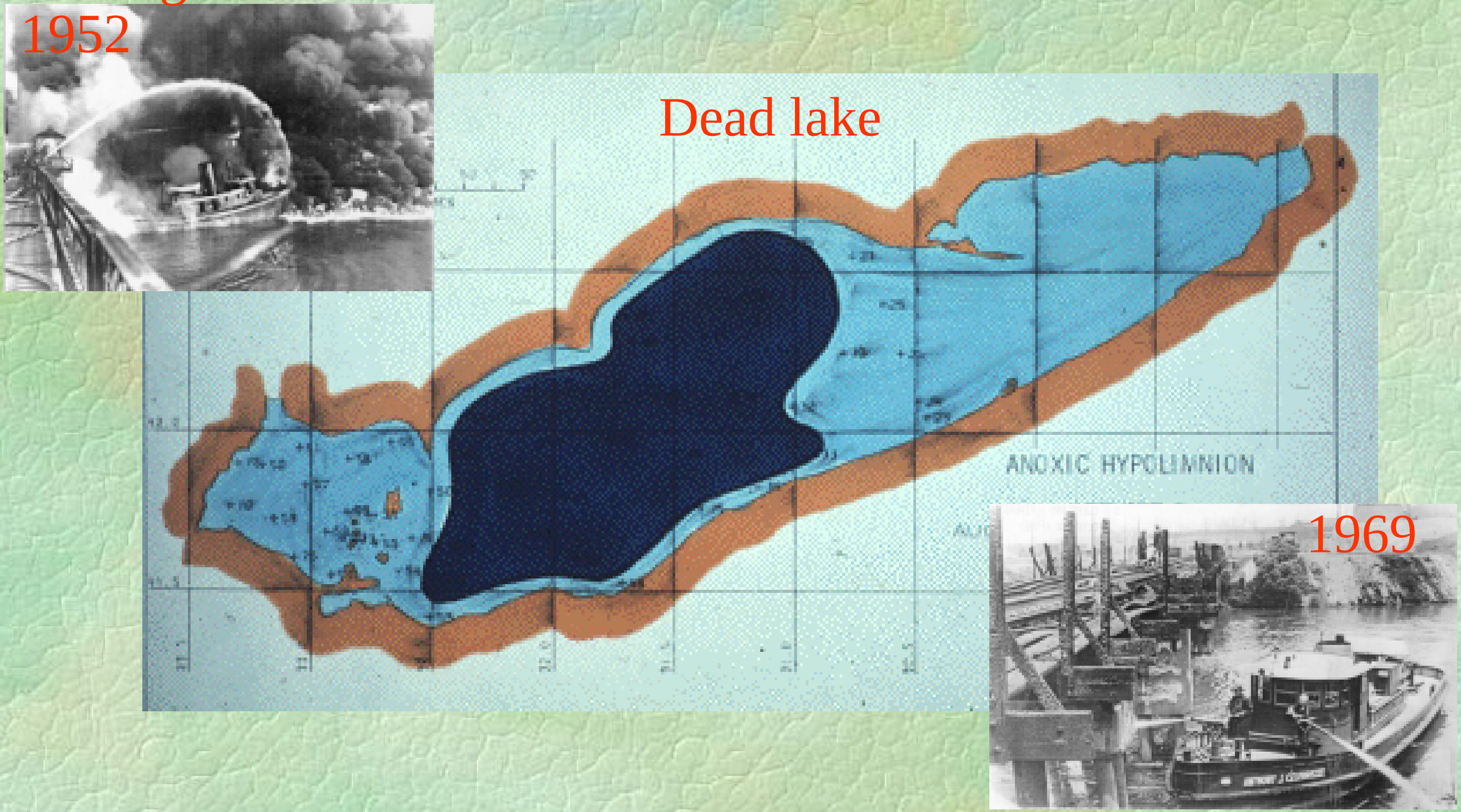
Gerry Matisoff	CWRU	Doug Moog
Peter Whiting		Chris Bonniwell
		John Stamm
Frank Calhoun	OSU	Brian Slater
Lynn Forster		Joan Nichols
Don Eckert		Phil Levison
Jerry Bigham		Jonathan Rausch

The LEASEQ project was funded by a grant from USDA-CSREES

Background: water quality in Ohio

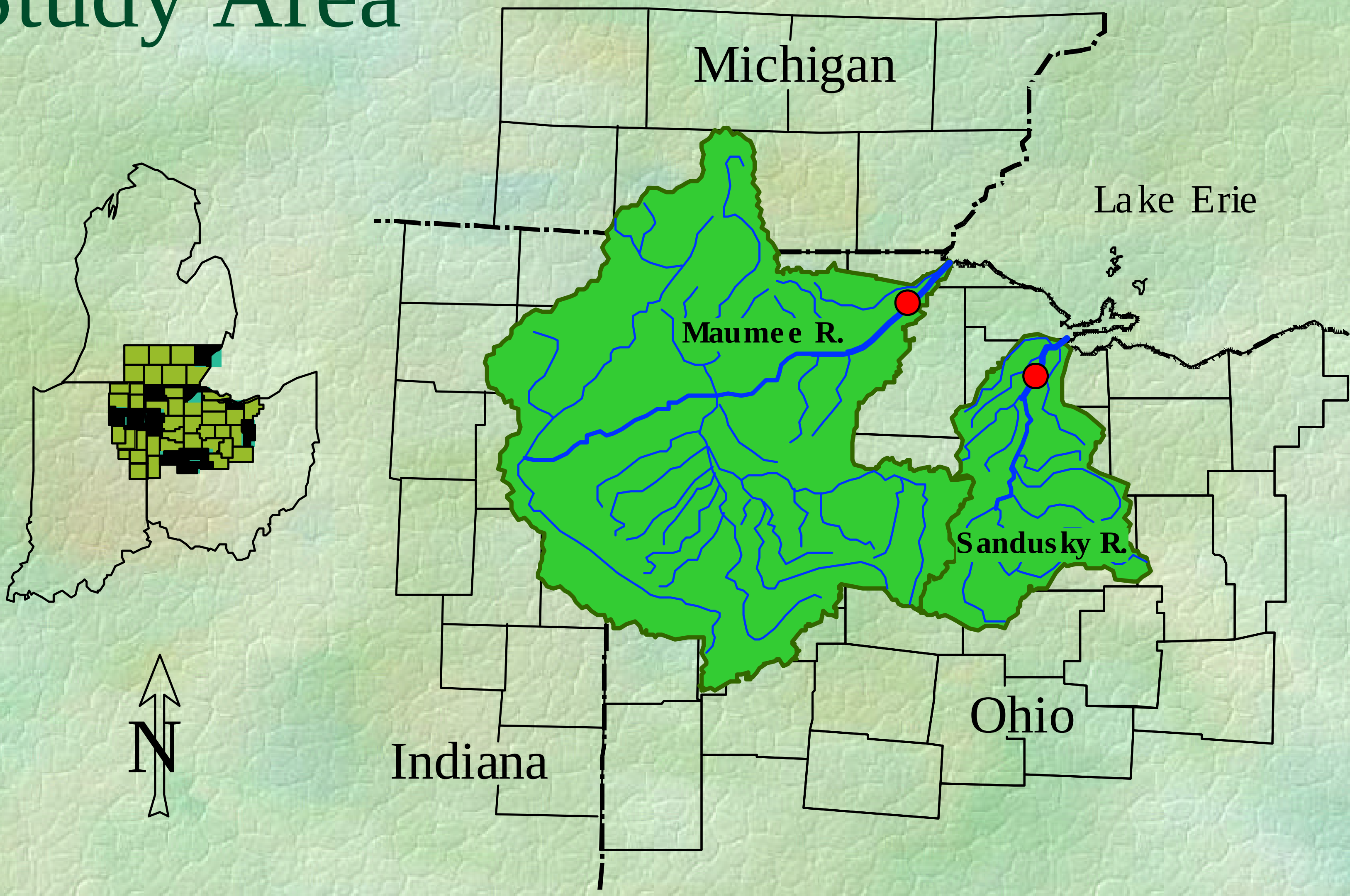
Burning river



Fixing Lake Erie

- Point source controls for phosphorus
- PLUARG
- Nonpoint management = ag management
- BMPs aimed at sediment and phosphorus:
  - Conservation tillage
  - Buffer strips, riparian corridors, CRP
  - Fertilizer management
  - More recently, CREP
- A pre-TMDL TMDL!
- LEASEQ project was a retrospective evaluation of nonpoint programs in the Lake Erie basin and their success

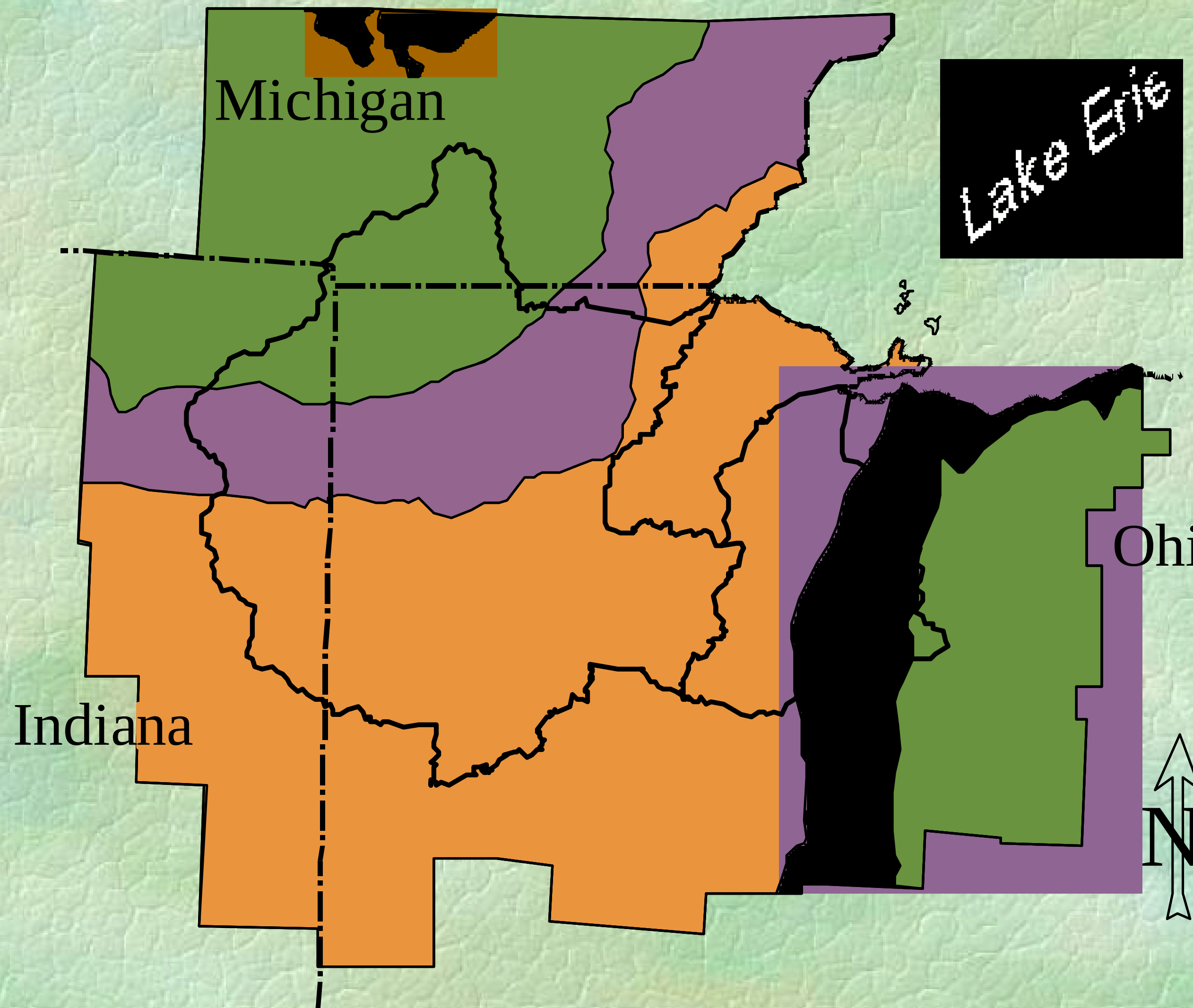
Study Area



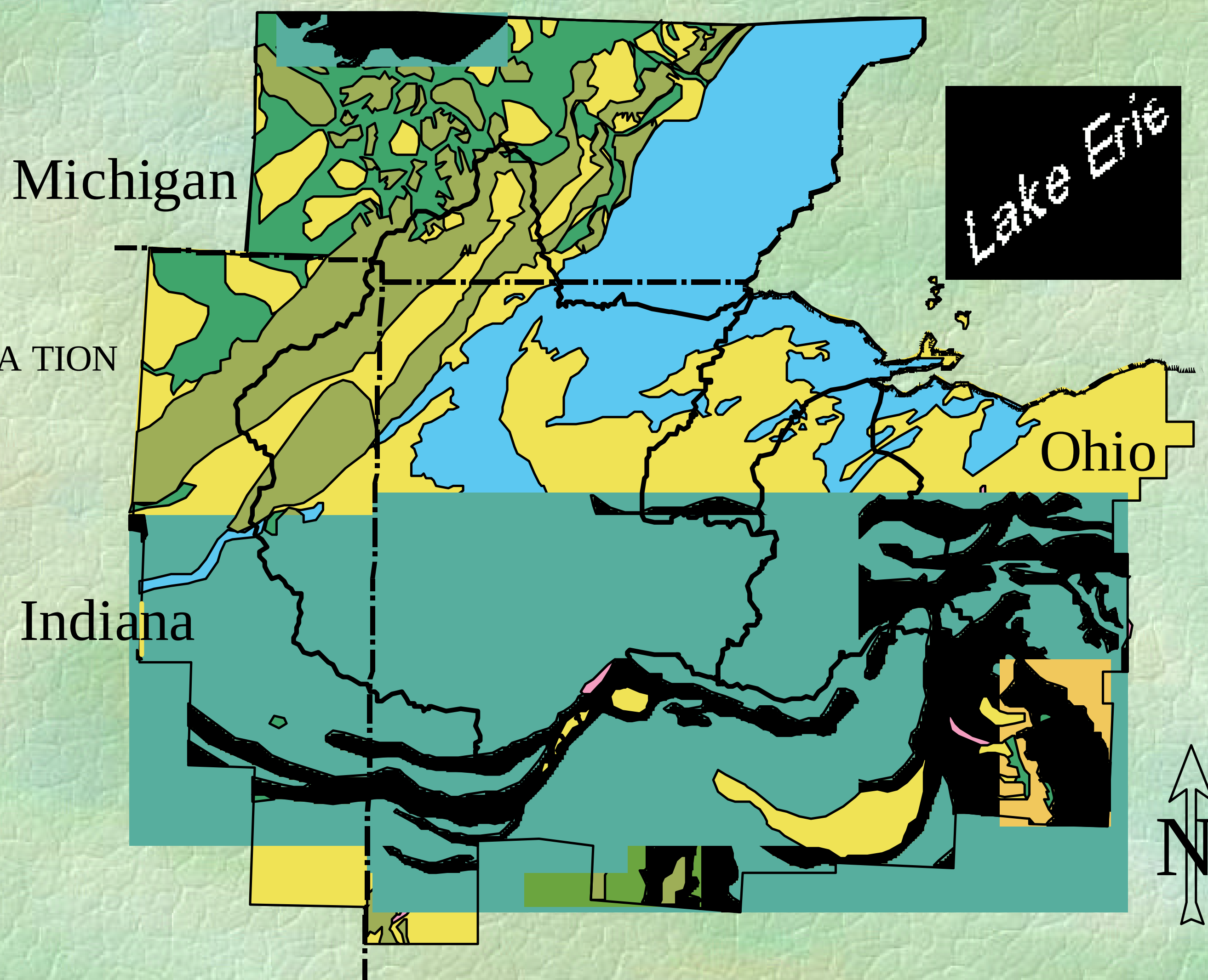
Bedrock Geology

GEOLOGIC SYSTEM
(million years before present)

- Pennsylvanian (320-286)
- Mississippian (360-320)
- Devonian (408-360)
- Silurian (438-408)



Glacial Geology



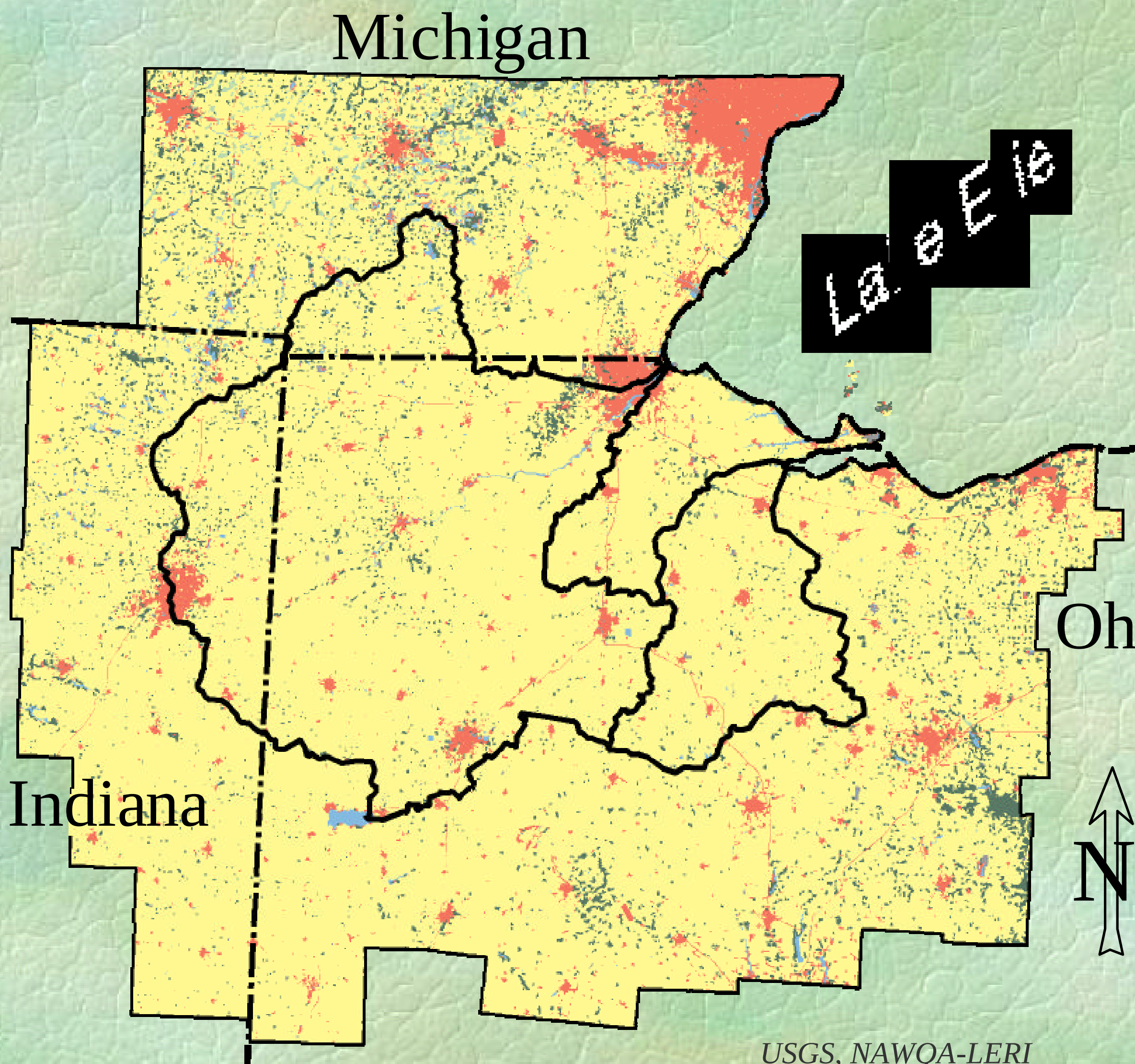
WISCONSINAN GLACIA TION
(14,000 to 24,000 years ago)

- Ground moraine
- Lake deposits
- End moraine
- Outwash
- Kames and eskers

Land Use

LAND USE
CLASSIFICA TION
(Anderson, Le vel I)

- Urban
- Agriculture
- Forest
- Open w ater
- Wetlands
- Barren land



USGS, NAWQA-LERI

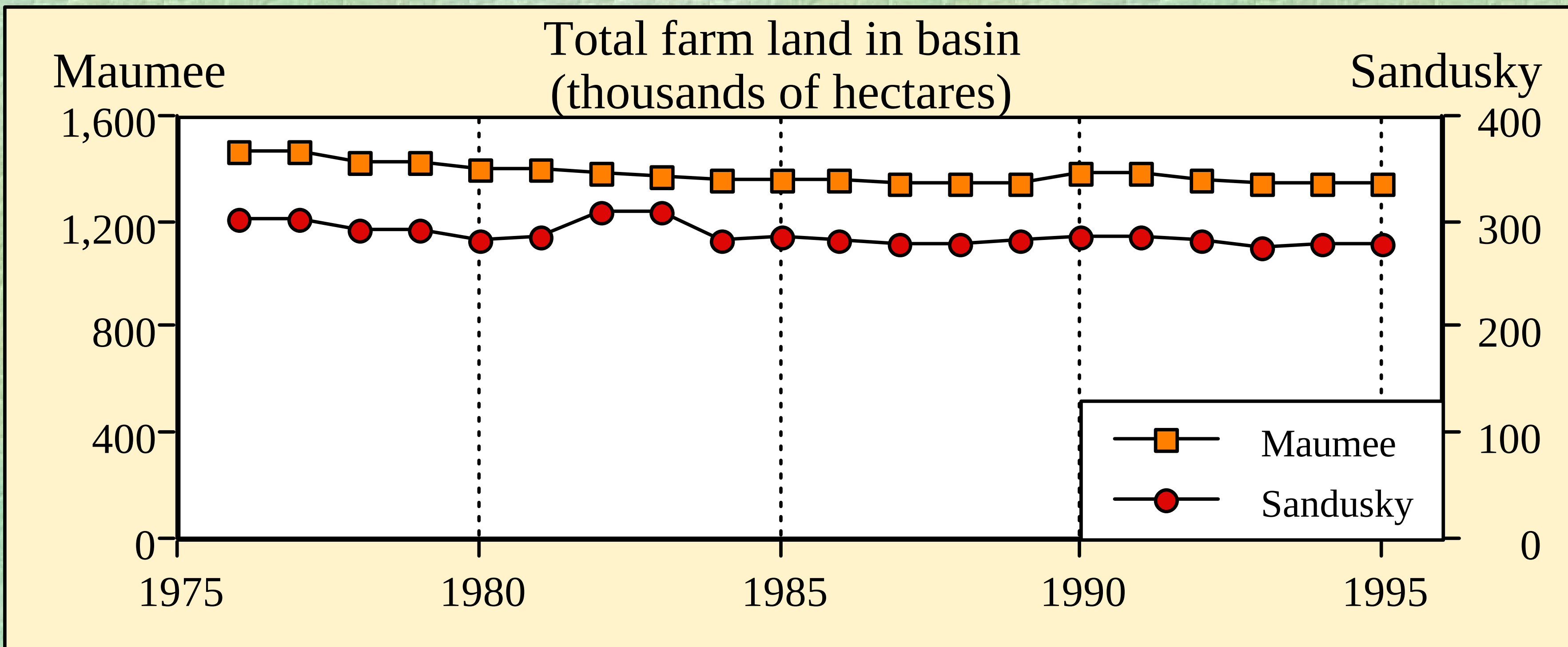
Trends in Agricultural Land Use

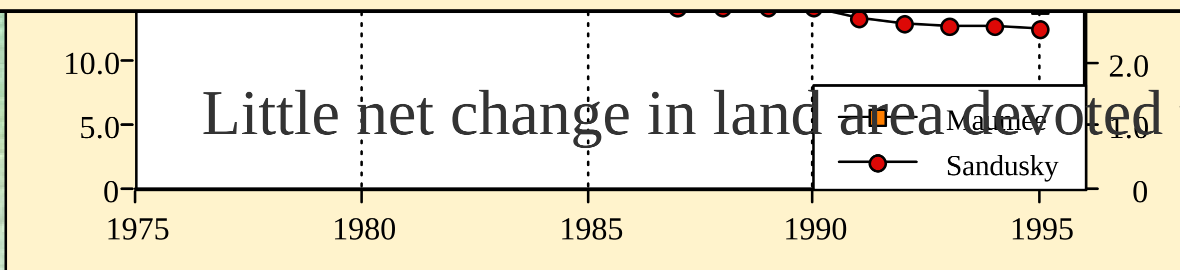
How have land use and farming practices changed in NW Ohio, 1975-1995?

Land use trends - approach

- Mostly county-level data available from state ag statistics, CTIC, etc.
  - Some variables derived by simple “models”, e.g. animal counts => manure production => P & N content => assume applied to fields
- Assign county data to watersheds based on percent of county within the watershed

Trends in “farm geography”

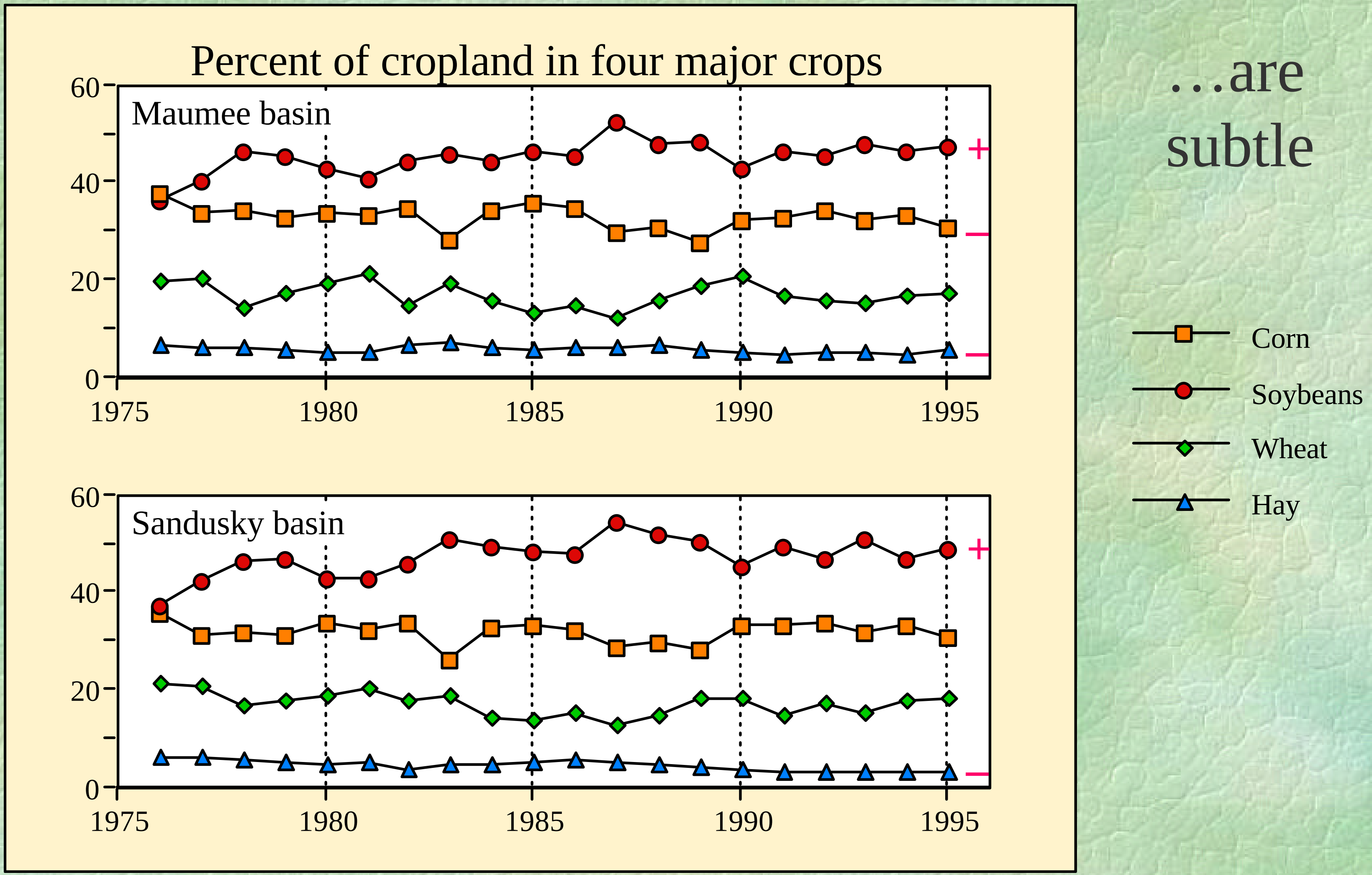




number of farms

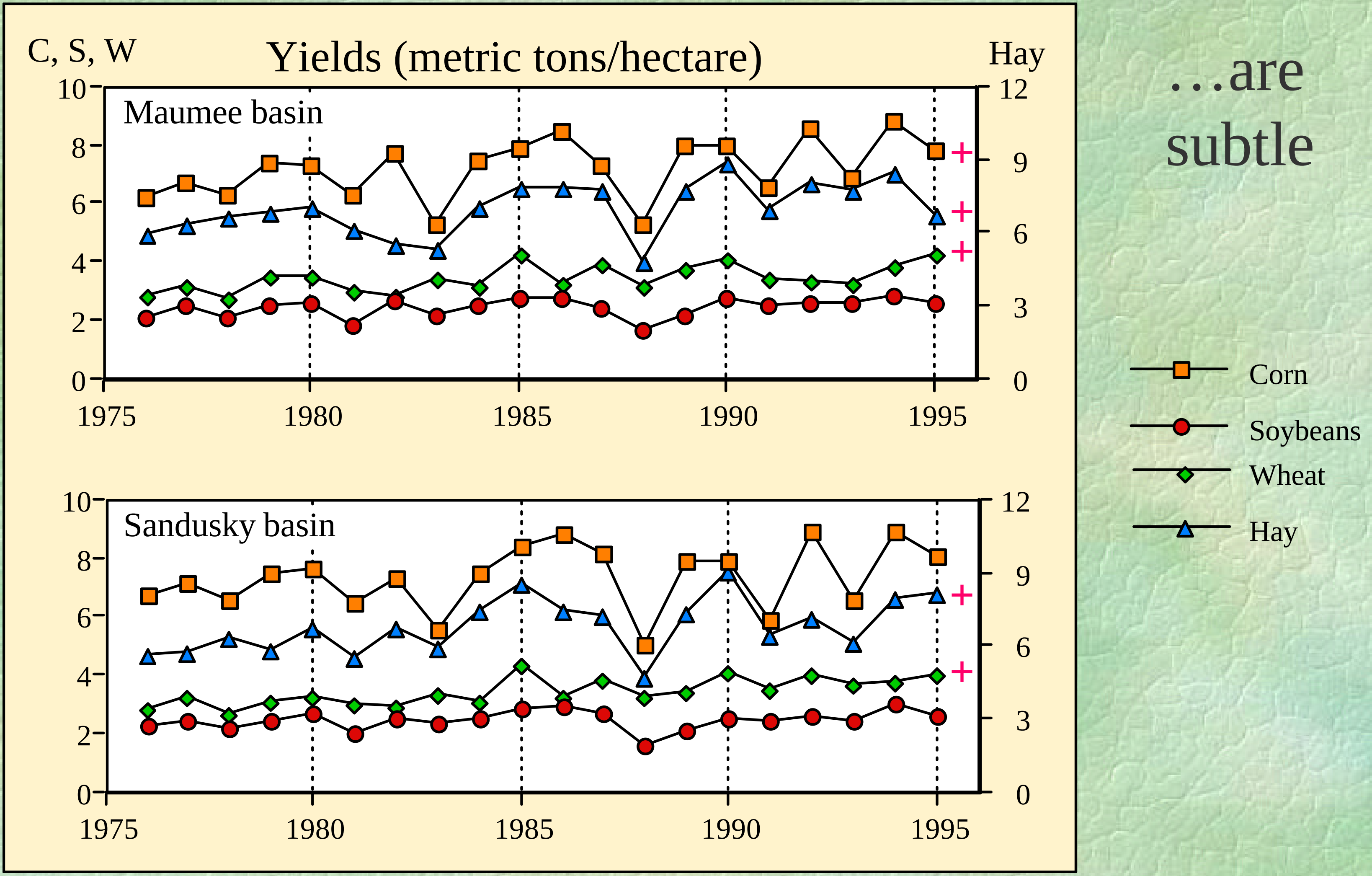
Little net change in land area devoted to agriculture

Trends in distribution of crops



…are subtle

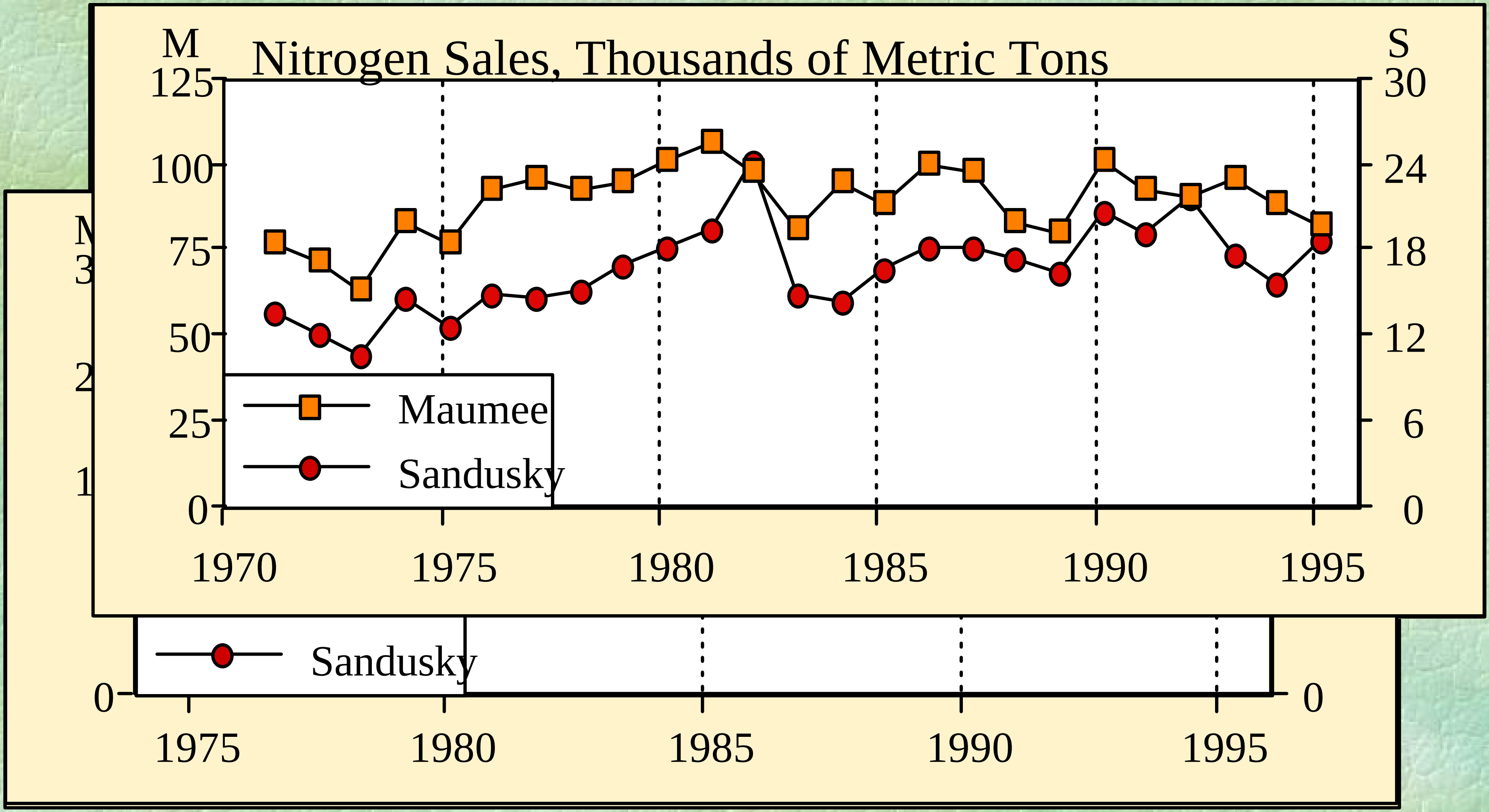
Trends in yields



…are subtle

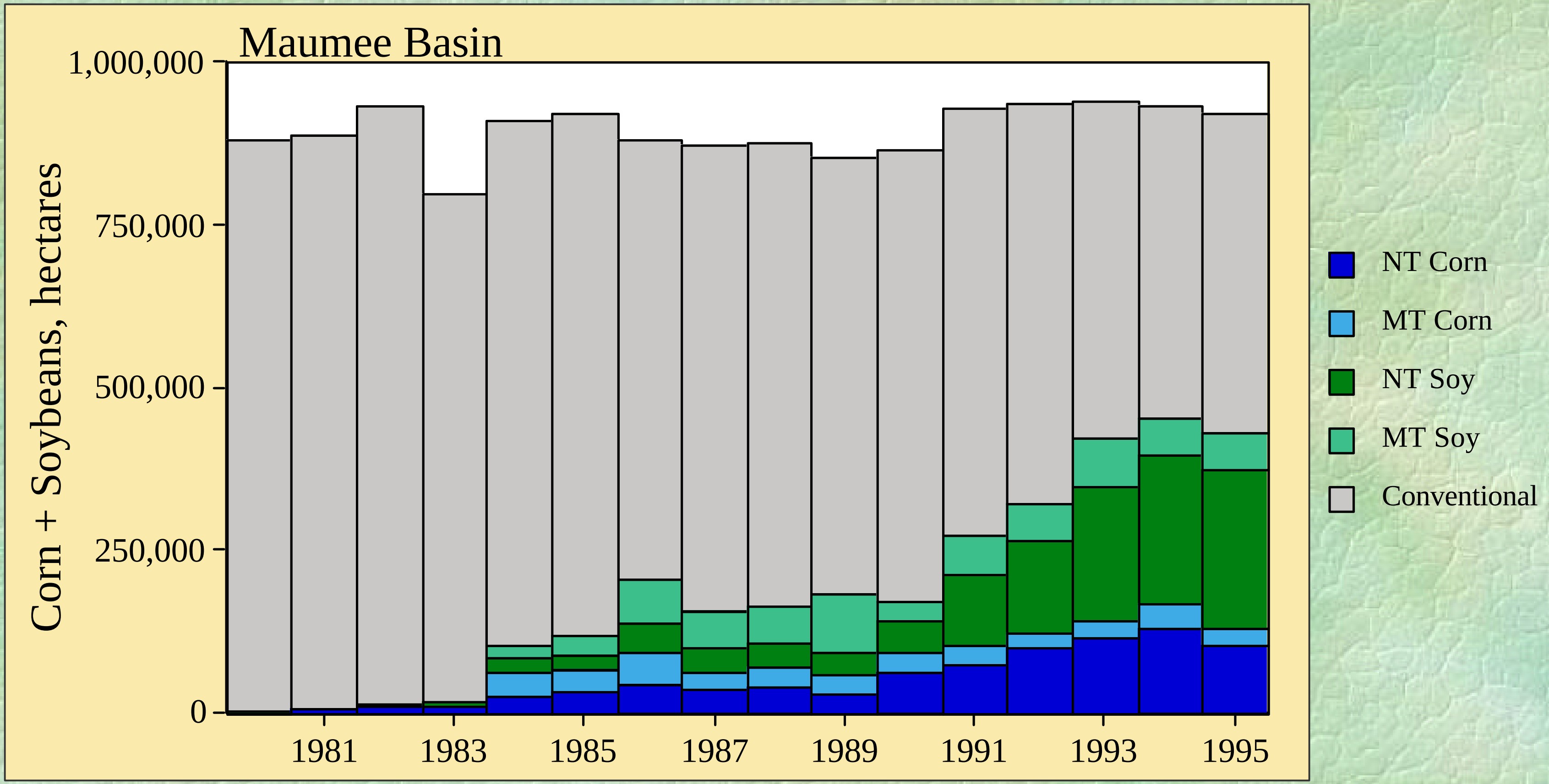
Trends in fertilizer and manure

…substantial decrease since about 1980



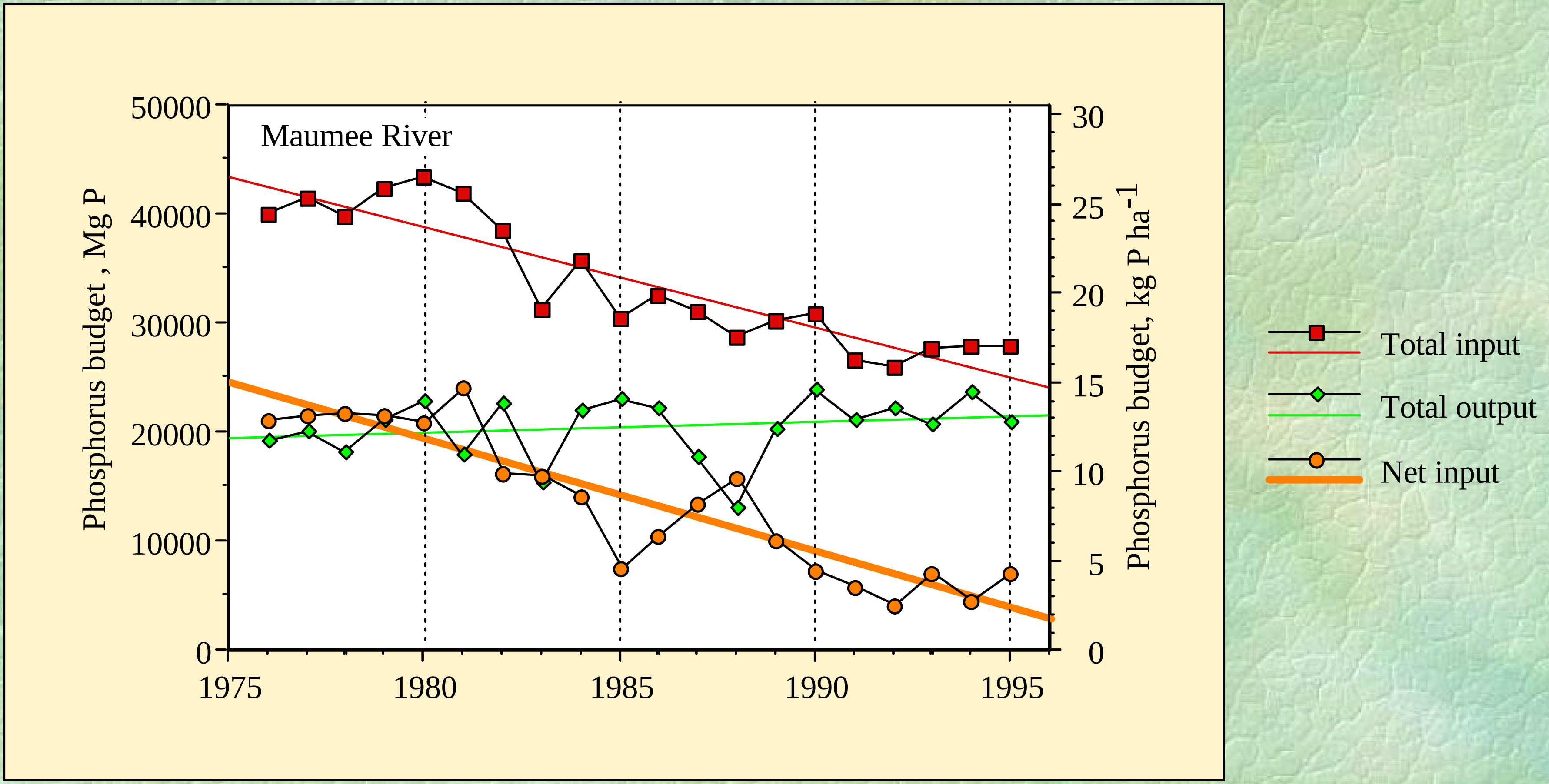
Trends in conservation tillage

…substantial increase 1990-1995



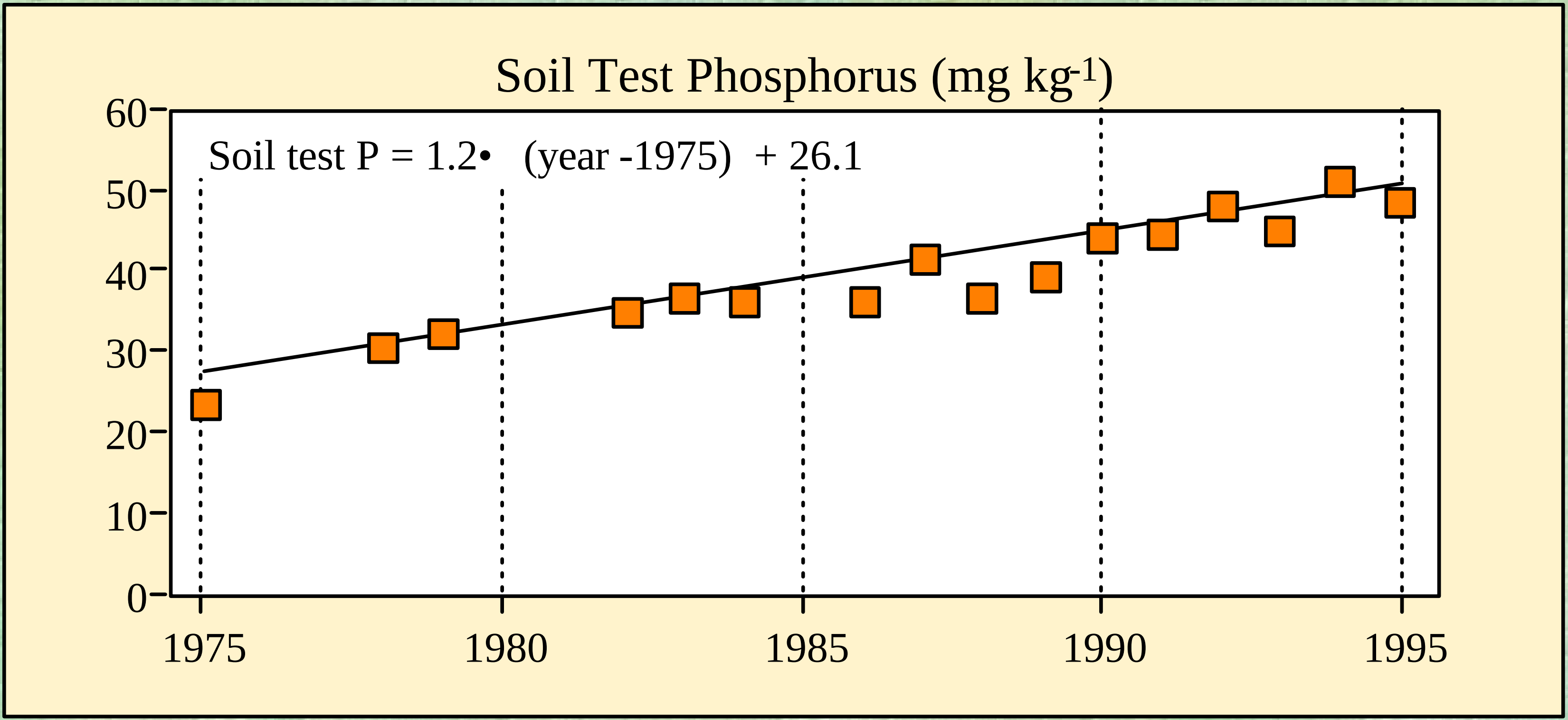
Trends in phosphorus mass balance

…substantial decrease, but always input>output



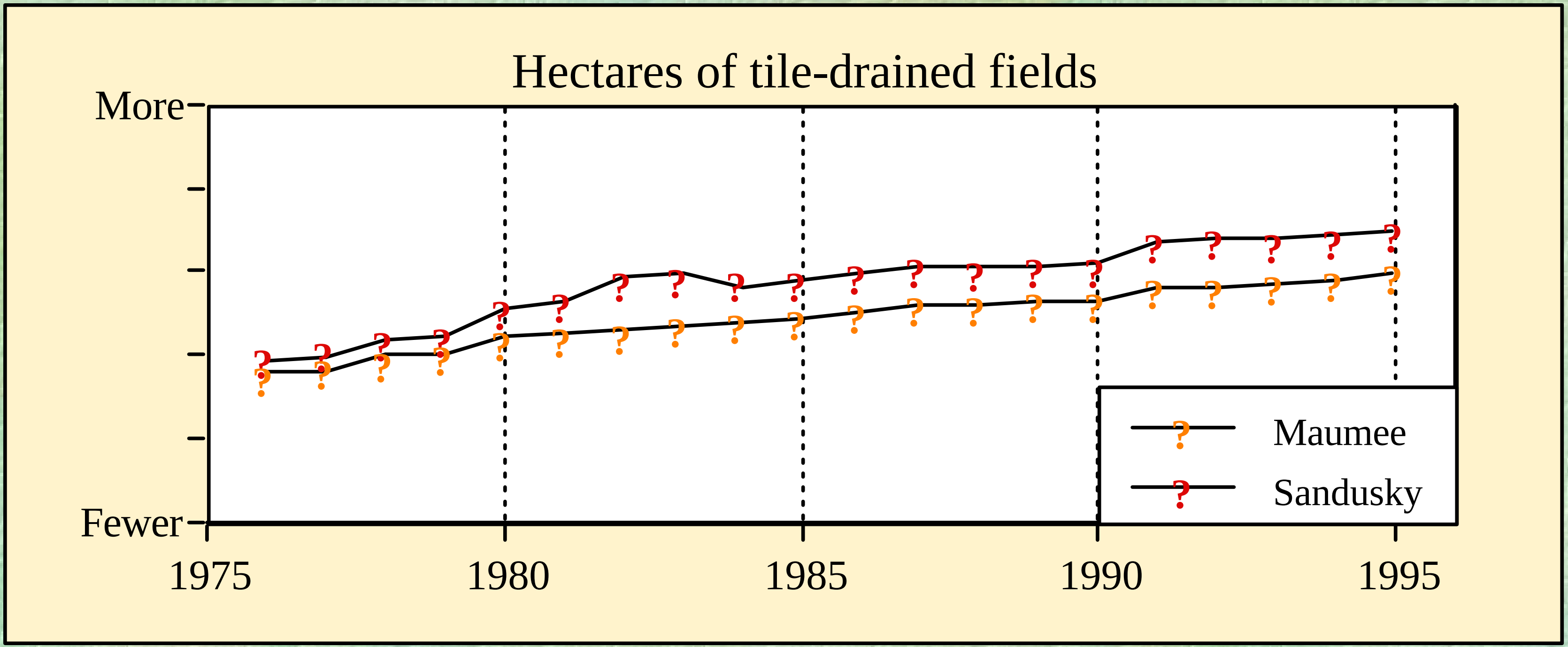
Trends in soil fertility

…nearly doubled between 1975 and 1995



Trends in tile drainage

…probably increased in extent and efficiency, but no data available



Trends in Water Quality

How has water quality changed? Are these changes a consequence of changes in agricultural land use?

Trends in Water Quality

- Expectations based on land use trends
  - Decreases in fertilizer and manure, increase in conservation tillage suggest decreasing SS, P, increasing N?
  - (Suspected) increase in tile drainage suggests increasing N, perhaps decreasing SS and P
  - Increase in soil P suggests increasing P losses to surface waters

Trends in Water Quality

- Data to work with (WQL)
  - Daily and more frequent samples at stations on Maumee and Sandusky and several tribs
  - …since 1975. Up to 12,000 records per station!

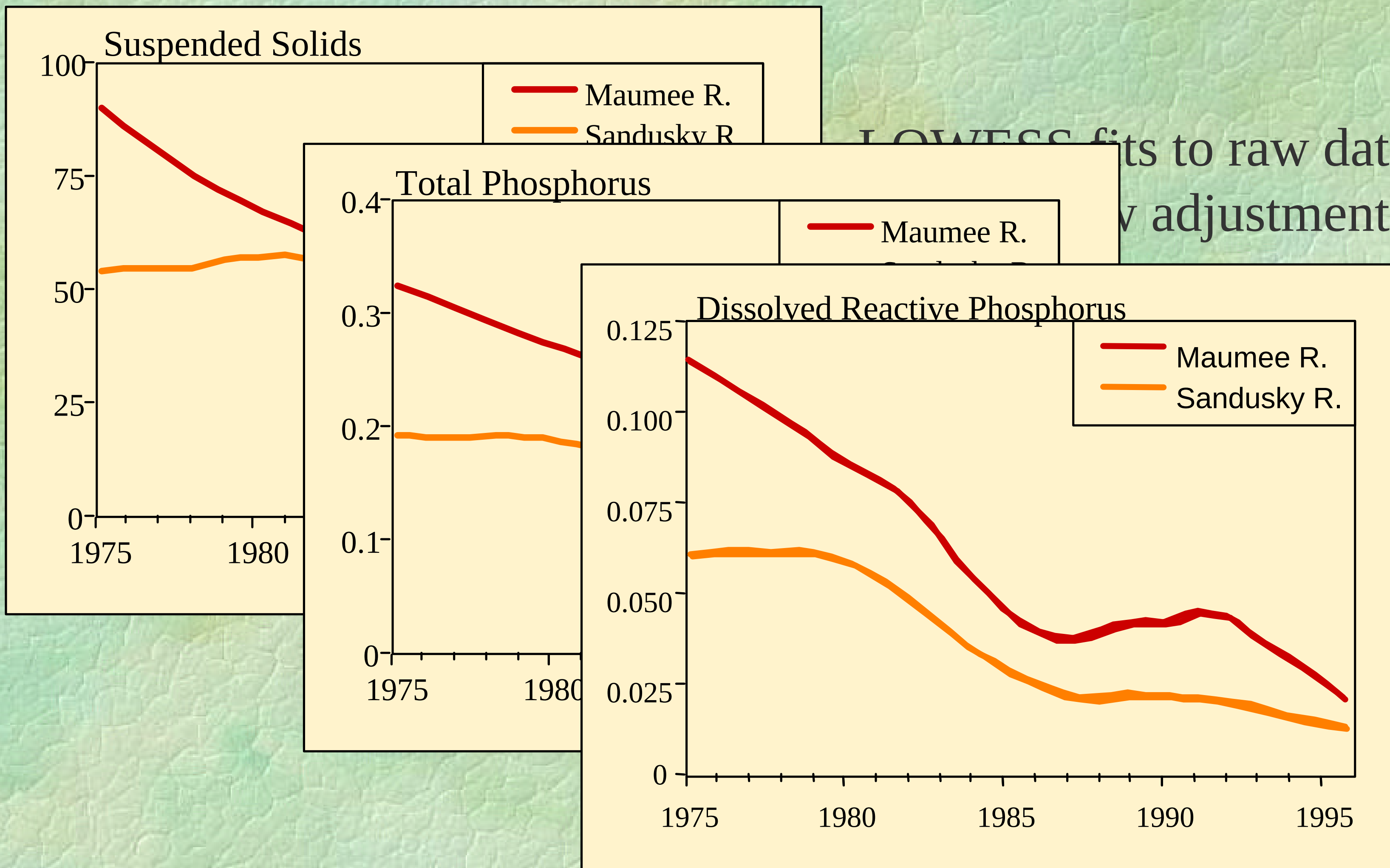
Trends in Water Quality

- Methods
  - Adjust concentrations for flow, after...
  - Removing any trends from flow
  - Calculate both as the rough (“residuals”) from LOWESS fit
  - Analyze trend on flow-corrected, log-transformed concentrations using regression, LOWESS

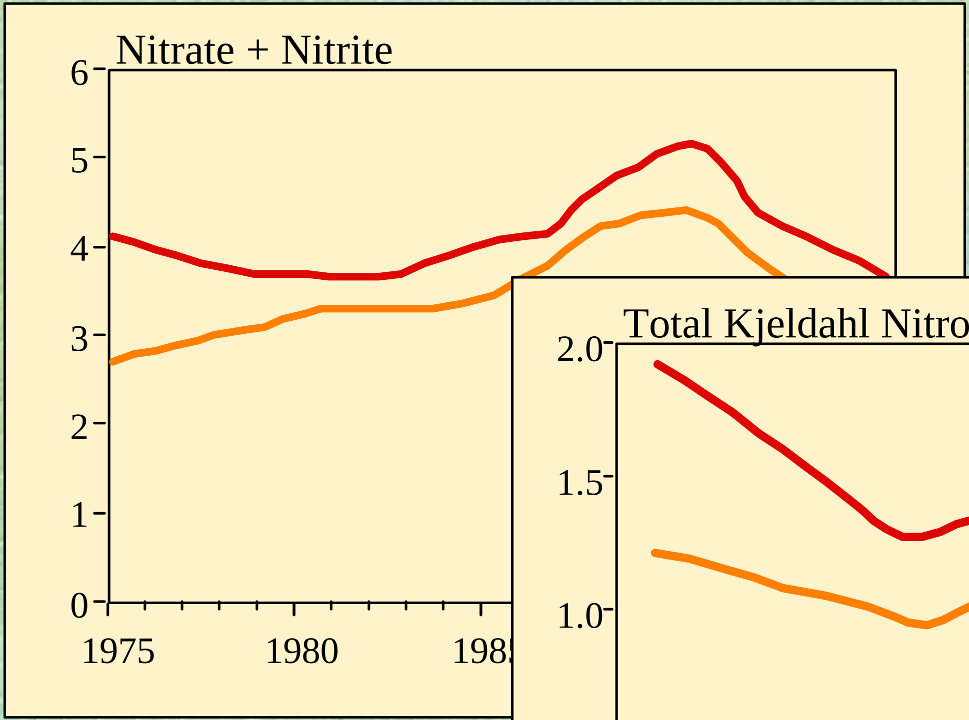
Trends in Water Quality

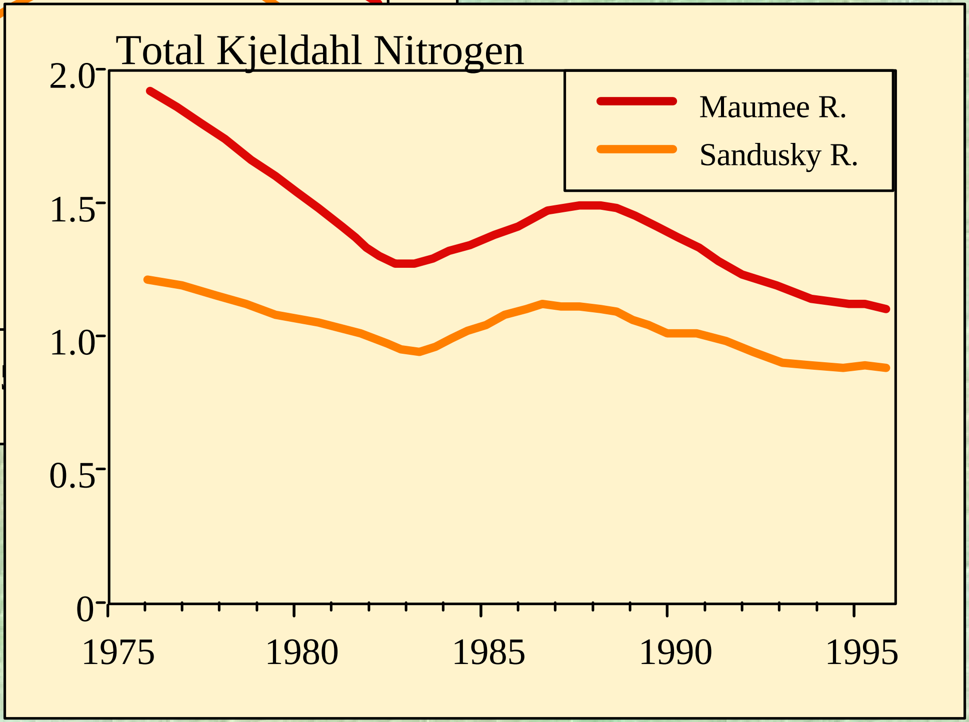
LOWESS fits to raw data

adjustment

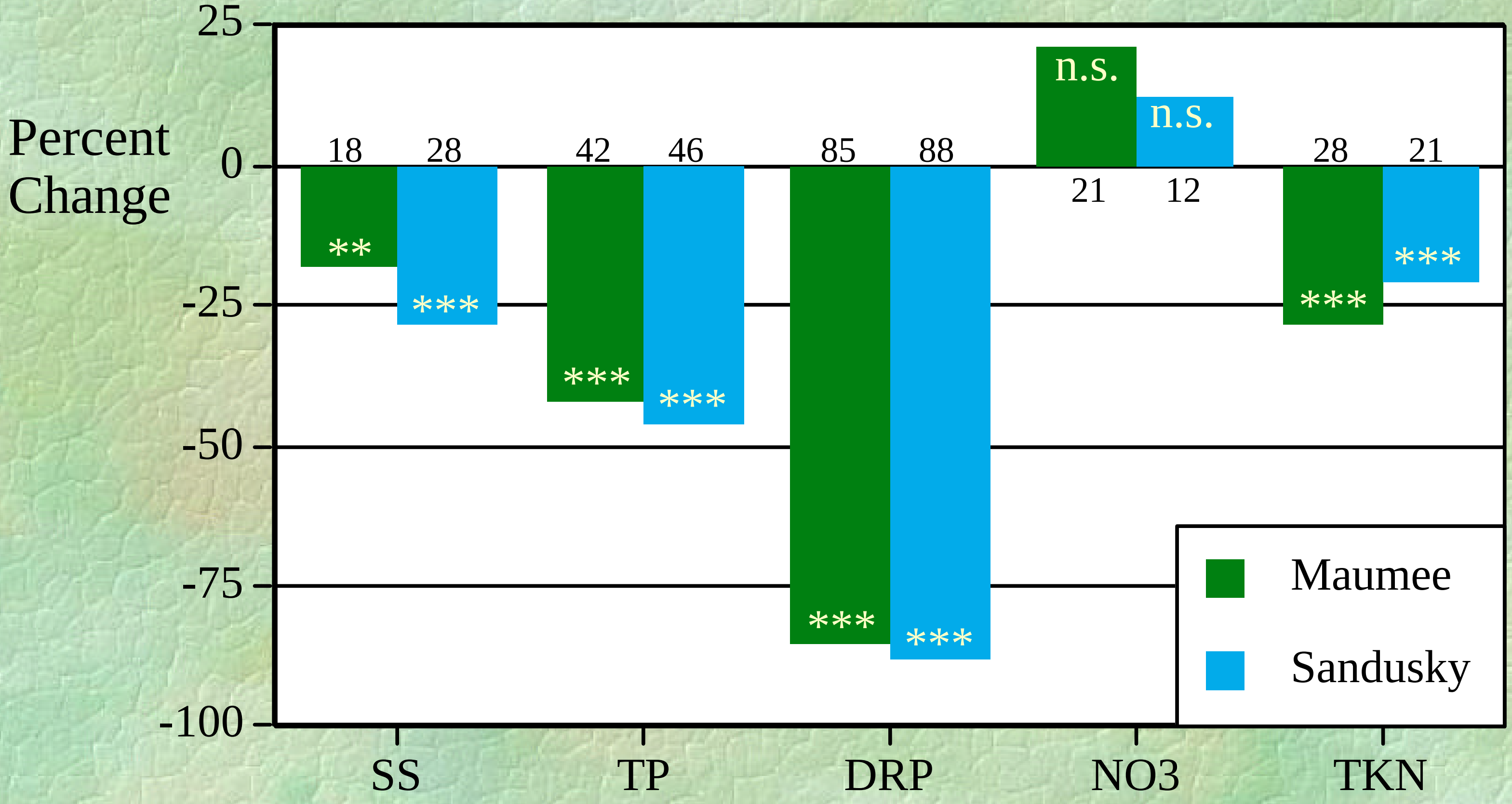


Trends in Water Quality





Trends in Water Quality



** p=0.01 *** p<0.001

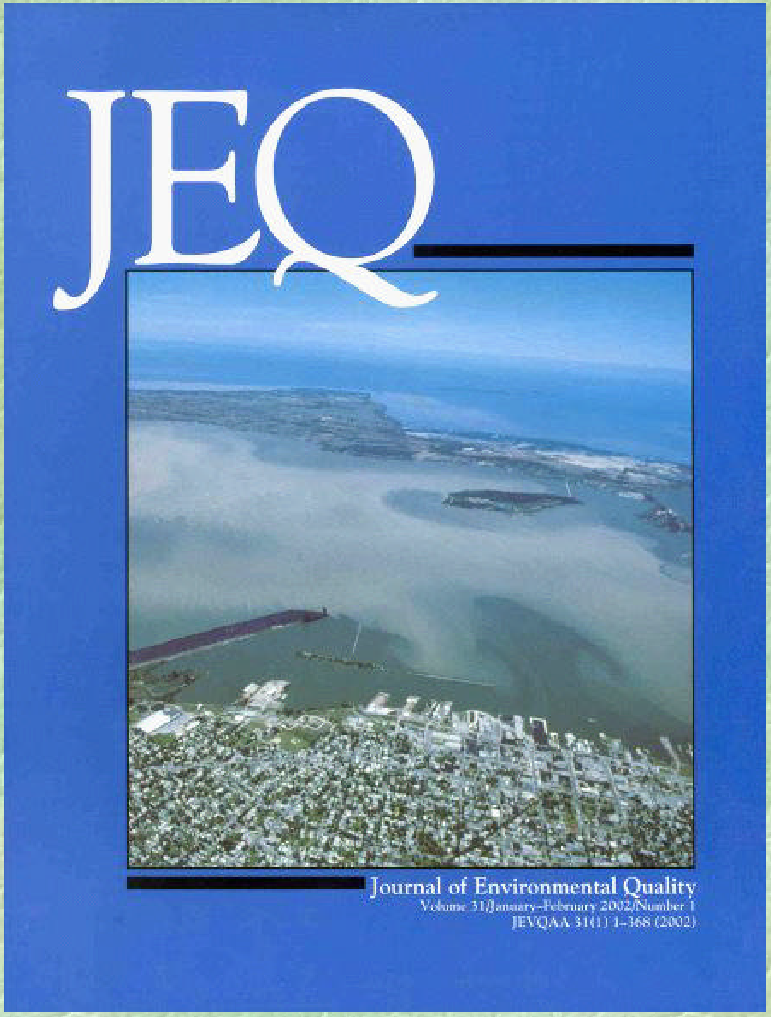
Are trends in water quality and land use linked?

- Water quality trends occur in parameters we would expect, based on land use changes
- Water quality changes occur at about the same time as the land use changes
- Water quality trends are of appropriate magnitude
- Other potential causes (e.g. upstream point sources) too small to account for changes
- Therefore we believe the linkage is cause-and-effect, though details are not well understood

Conclusions

- Water quality trends are toward improved conditions (except nitrate)
- Water quality trends result from intentional changes in use of the land
- A major victory for environmental science and management

For more information...



12 papers on the findings of the LEASEQ project can be found in the Journal of Environmental Quality, Vol. 31(1), January - February 2002.

Zoom Forward to 2005: A Preliminary Update

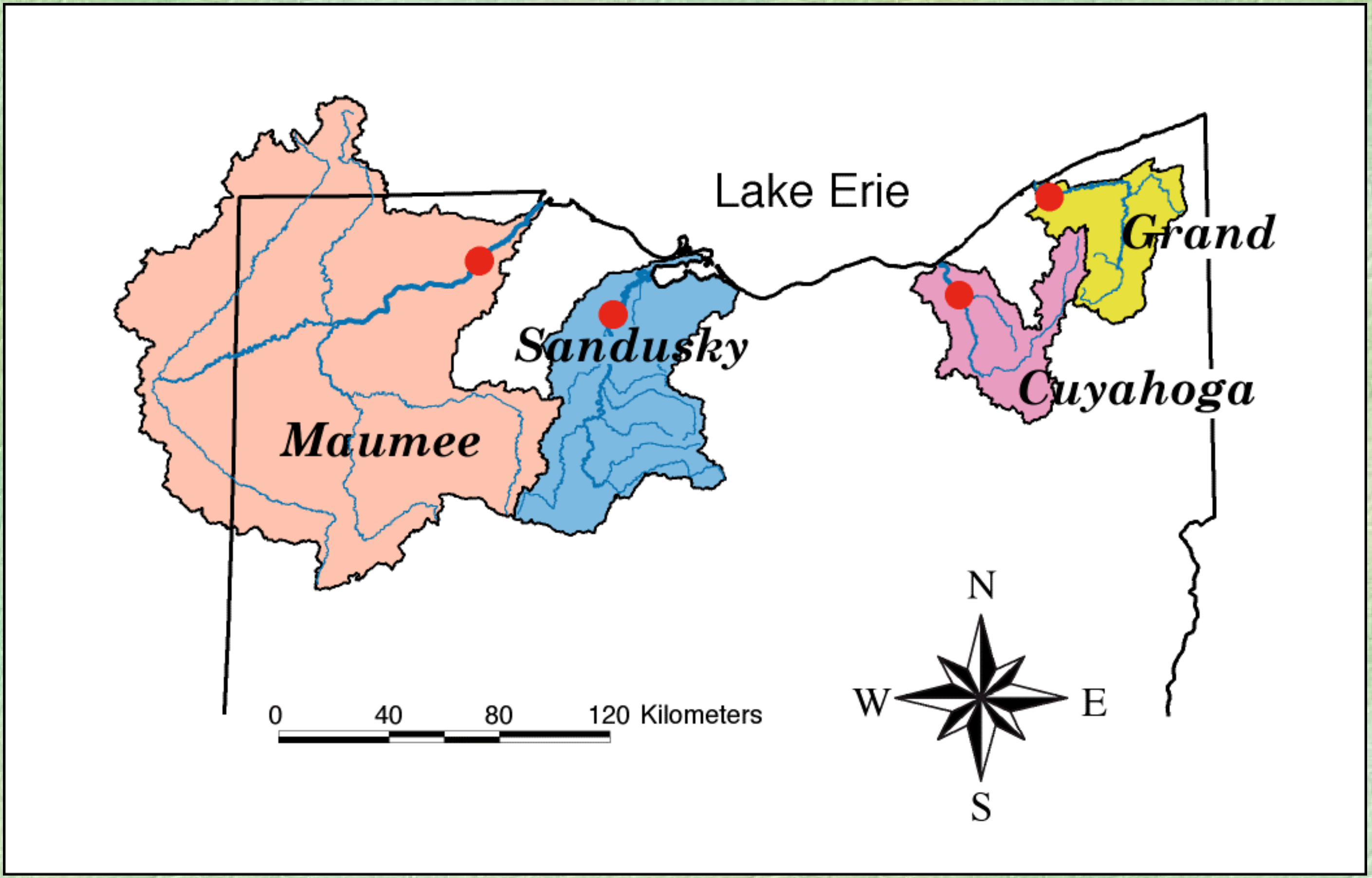
How do trends in the last 10 years compare with trends in the previous 20 years?

Also extend analysis to Cuyahoga and Grand

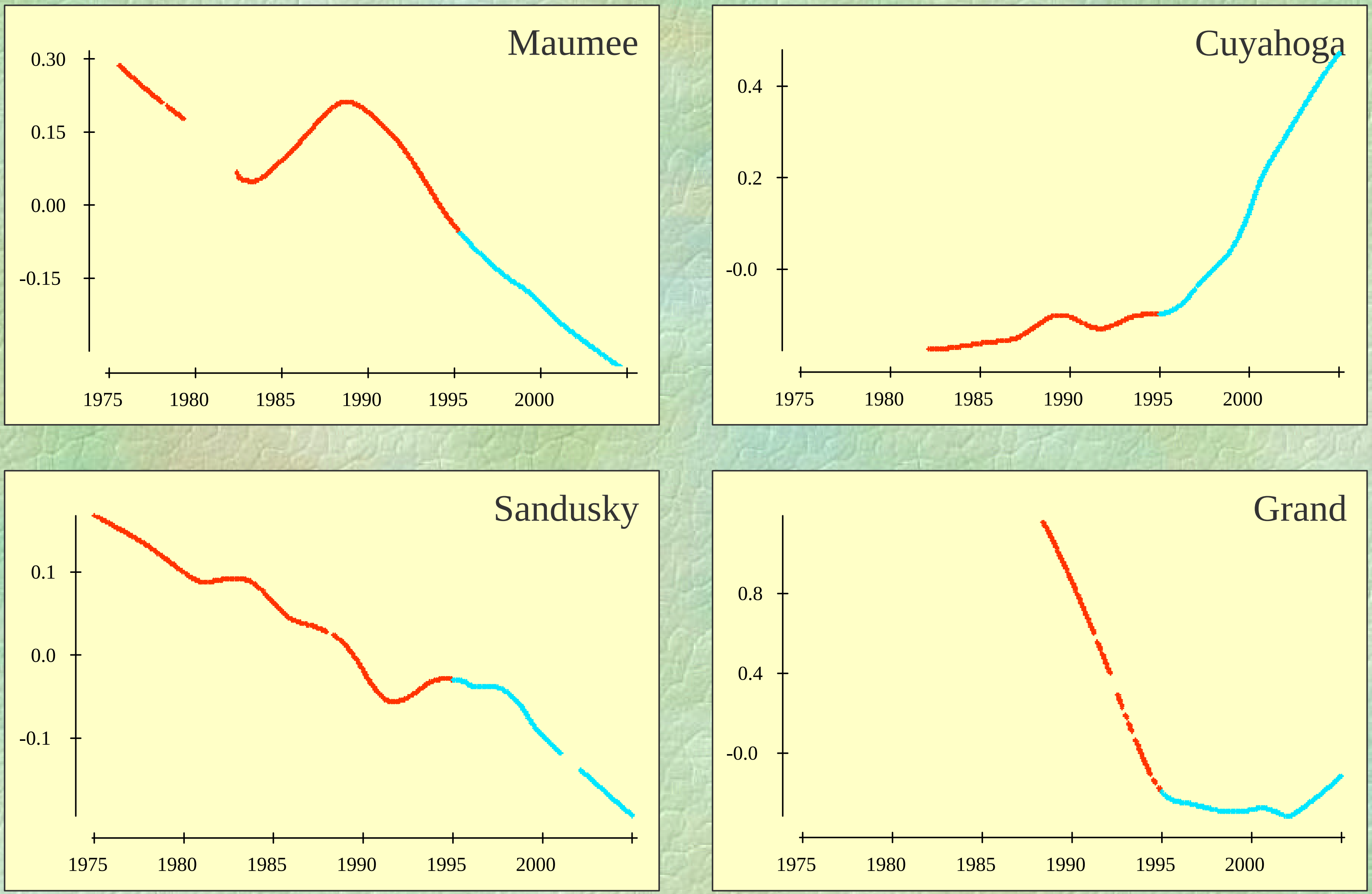
Approach

- LOWESS smooths of flow-adjusted natural-log transformed concentrations
- Color coded to indicate 1975-1995 and 1995-2005
- Trends for Maumee and Sandusky (agricultural), Cuyahoga and Grand (less so)

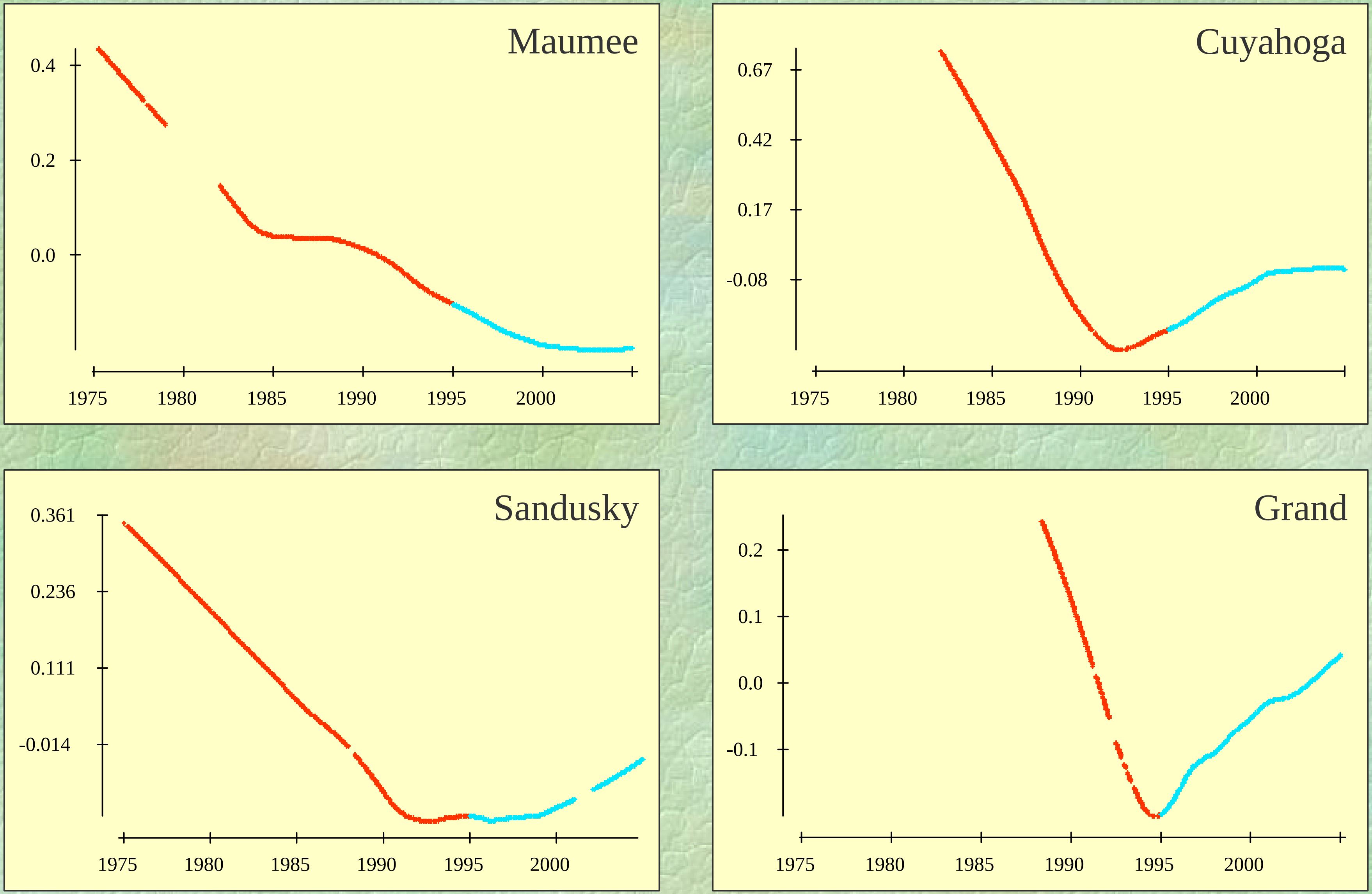
Station Locations



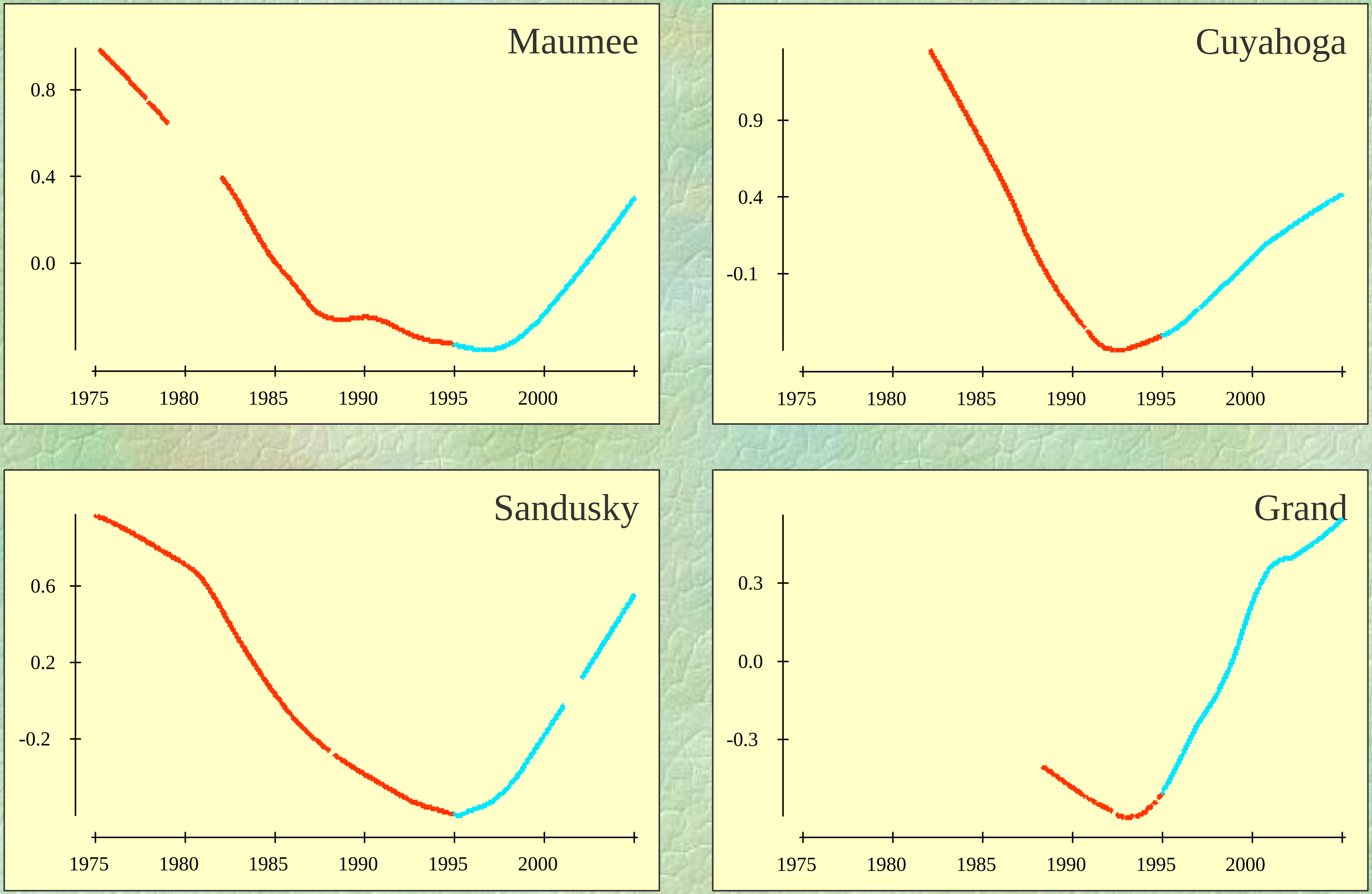
Suspended Sediment



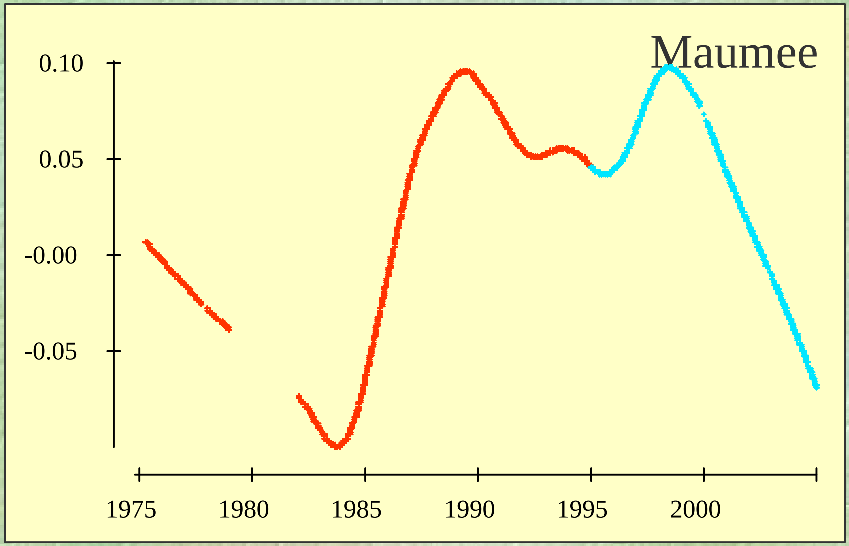
Total Phosphorus

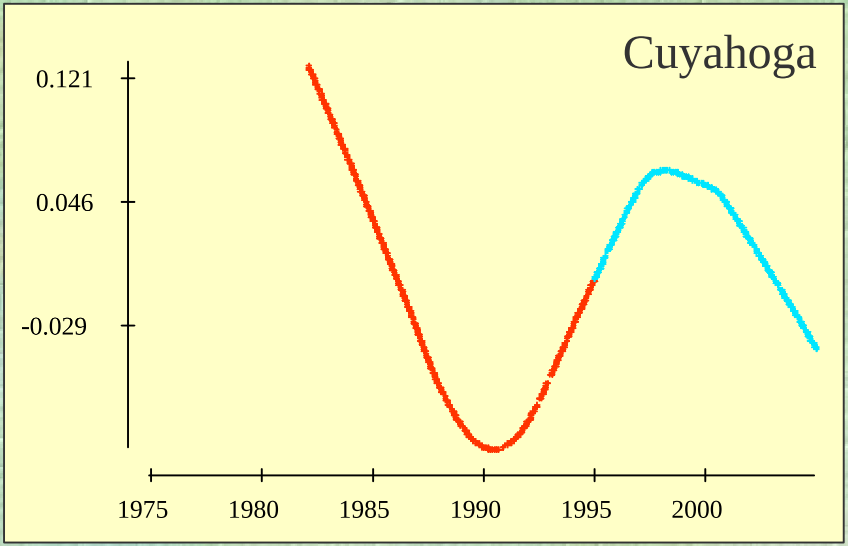


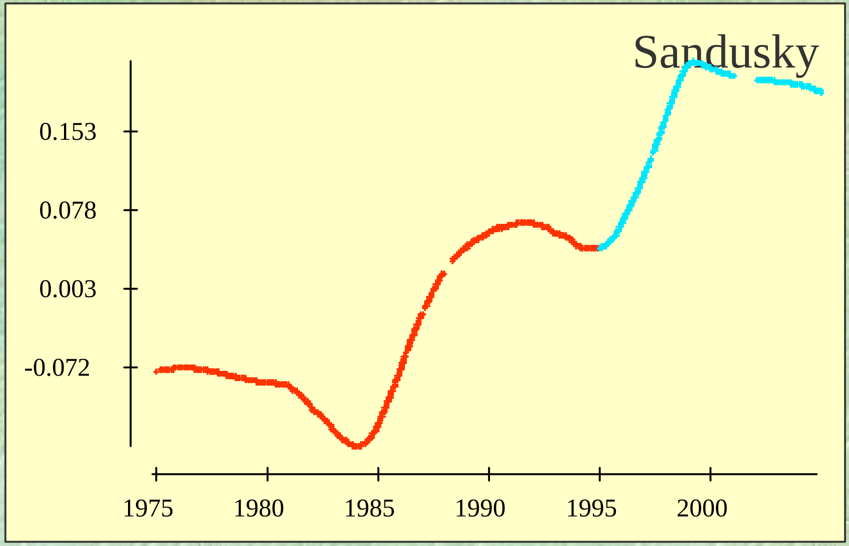
Dissolved Reactive Phosphorus

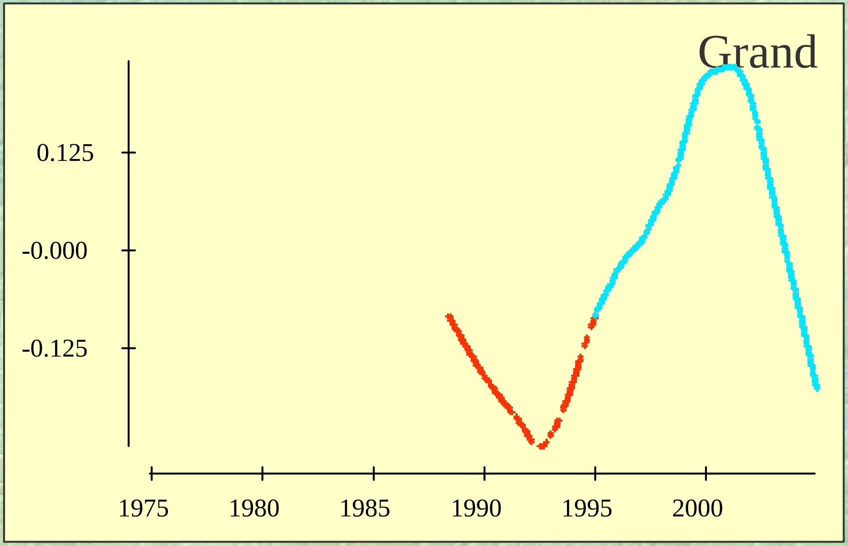


Nitrate Nitrogen

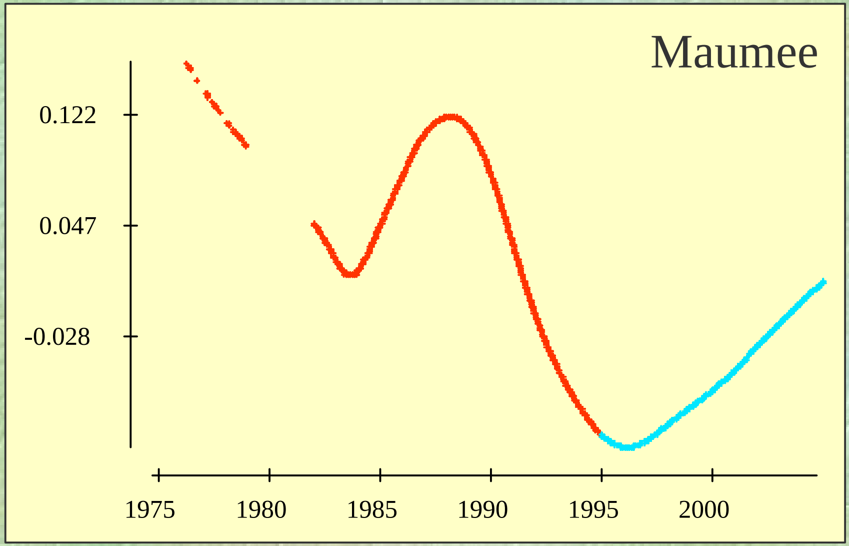


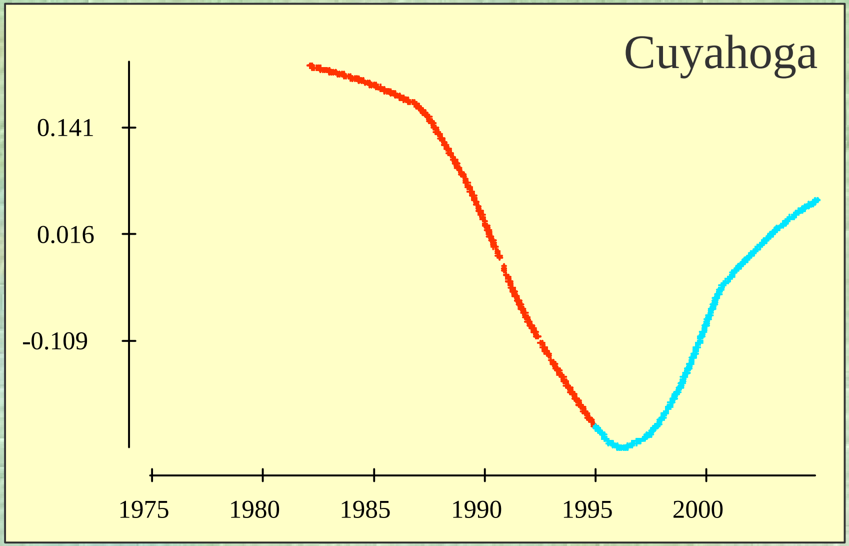


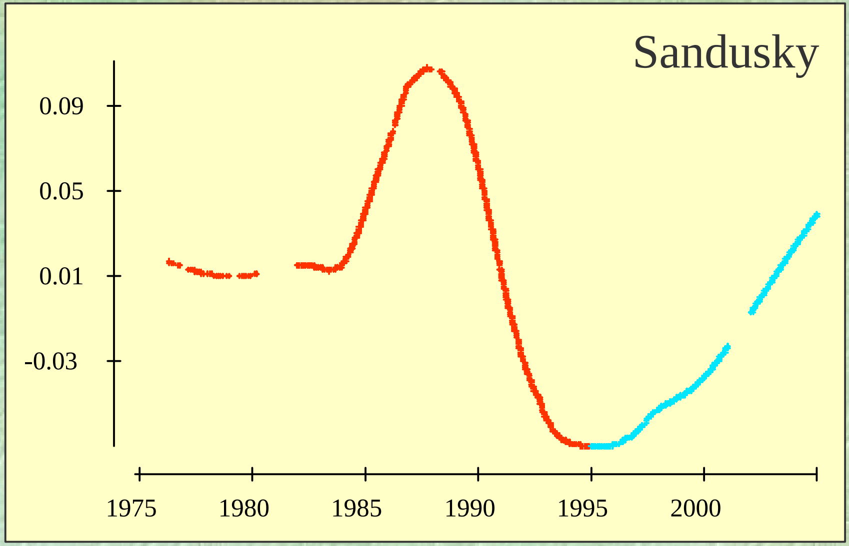


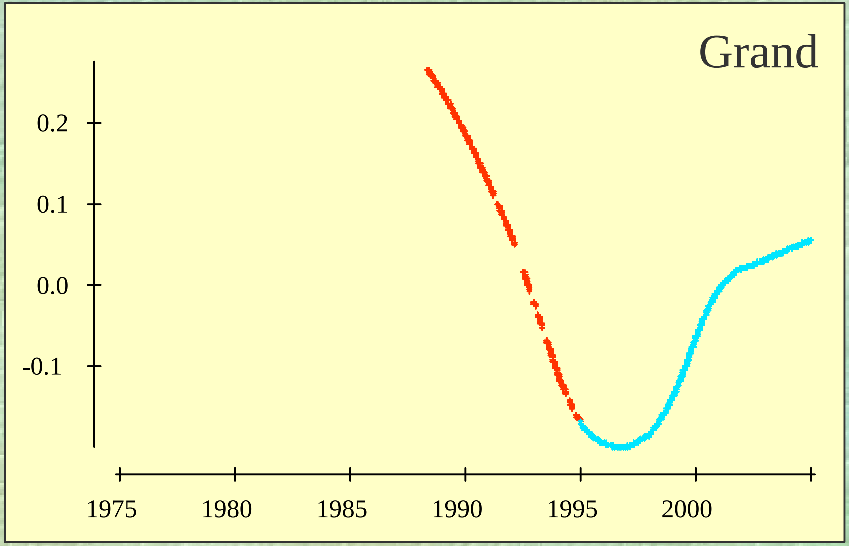


Total Kjeldahl Nitrogen









Summary

- General improvements (except nitrate) during 1975-1995
- Backsliding for DRP, TKN since then
- Continued improvement in Maumee and Sandusky SS (CREP watersheds!) but not in Cuyahoga and Grand
- Mixed results for TP and NO3

Causes?

- Weather? (but we adjusted for flow…)
- No-till concentrates nutrients at surface?
- Concentrated animal agriculture?
- Winter spreading of manures?
- Global climate change?

Impacts?

- Renewed problems in Lake Erie
  - Increased in-lake phosphorus concentrations
  - Hypoxia in summer
  - Microcystis and other cyanobacteria
- Tributary inputs are probably contributing to these problems
- Whatever the cause(s) of increased tributary nutrients, expect demands for renewed diligence!

A Lesson Learned

- We were quite happy to attribute improvements in water quality to changes in ag practices, even if the case was a bit tenuous.
- Now that some things are getting worse, can we do other than blame ag practices?!
- Inferring cause-and-effect from empirical trends is a tricky, and perhaps hazardous, exercise.


The
End