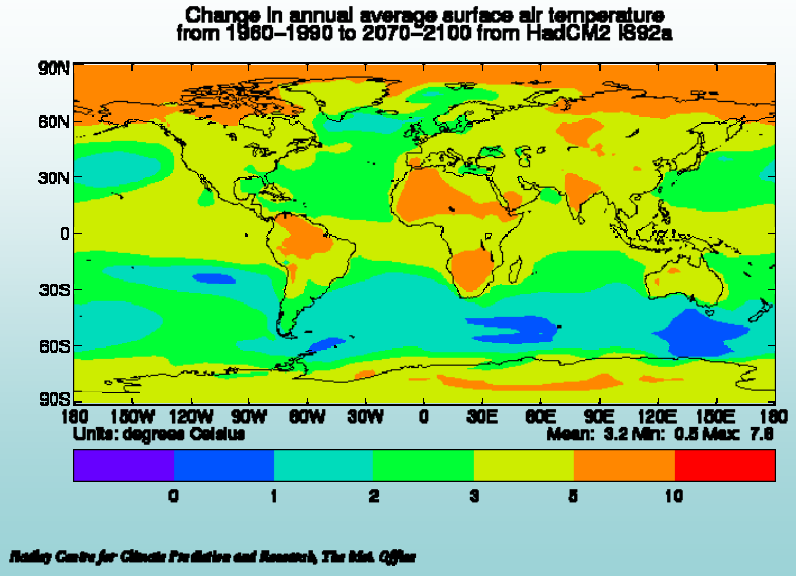
The “Big 3”

1975-2025



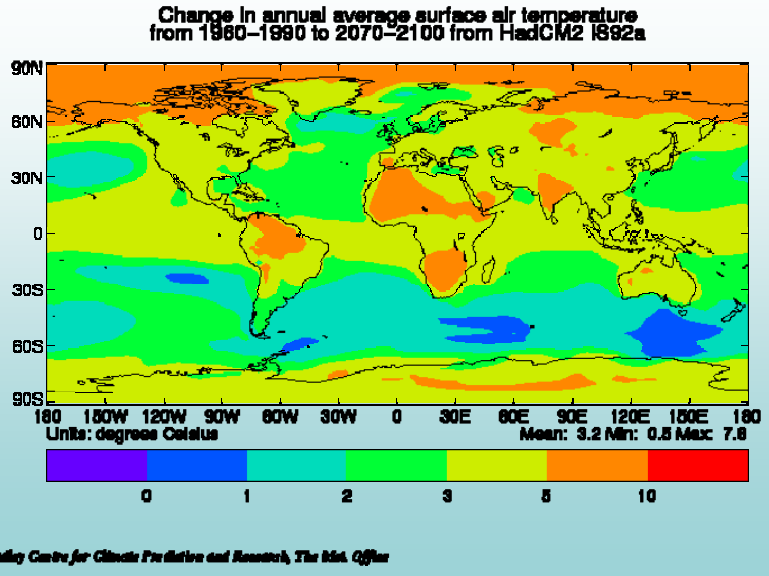
Hadley Centre for Climate Prediction and Research, The Met. Office

The “Big 3”

1975-2025

Mercury

Acid Rain



Climate Change

I will give:

- **a brief update on Mercury**
- **a brief update on Acid Rain**
- **explain how these 2 are linked and why Climate Change affects both,**

or

Why we can't solve environmental problems one at a time

What is mercury?

- **Hg is an element (number 80 in the periodic table)**
- **Because it is an element, it never breaks down**
- **The best we can do is control its distribution and limit its effects – we can never get rid of it!**

Natural Sources

- Volcanoes
- Weathering of rock
- Mined from cinnabar
- Forest fires

Human Sources

Fossil fuel power plants

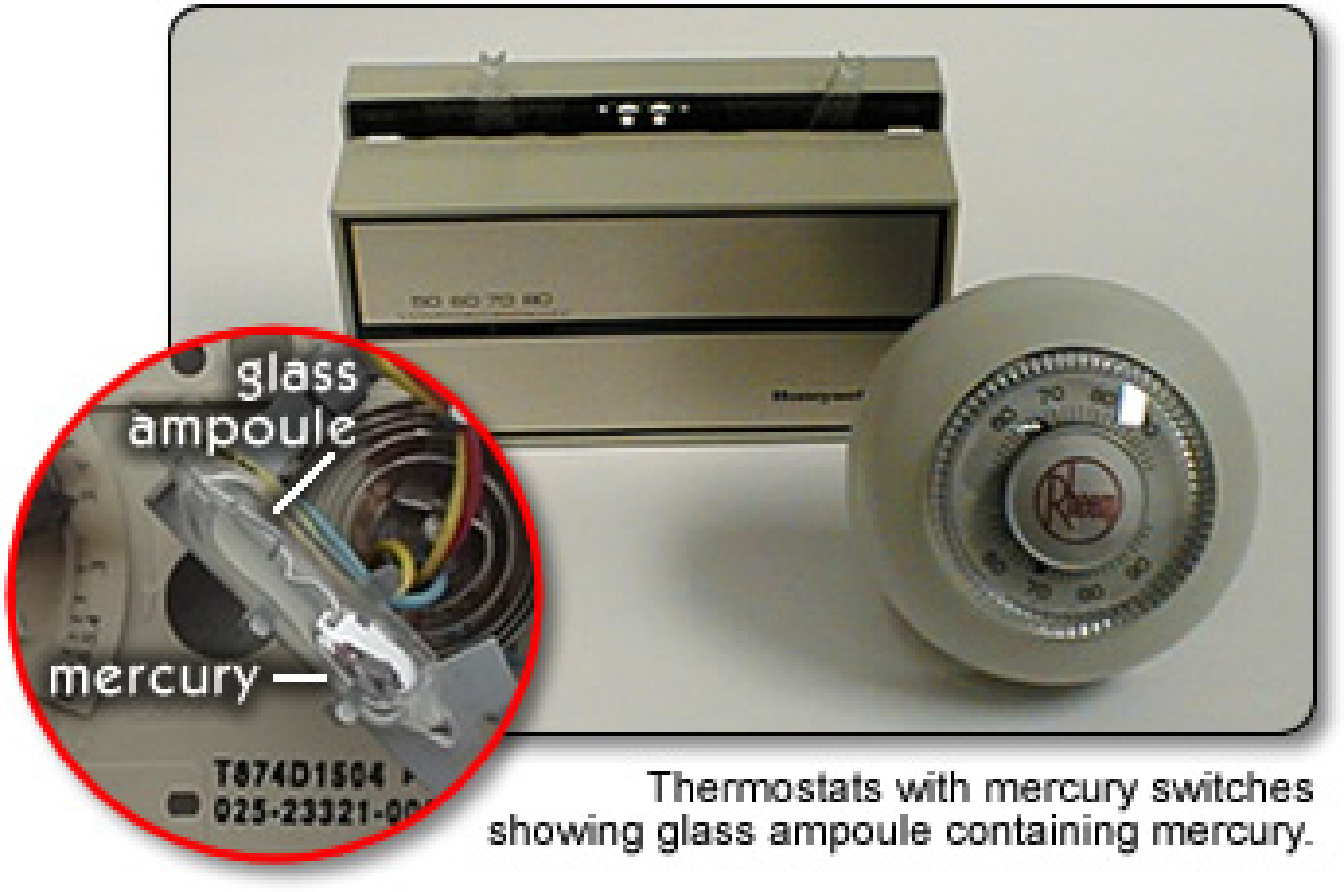
Waste water treatment plants

Human Sources

Incinerators

- **Medical and municipal solid waste incinerators account for about 30% of the total mercury emissions to air in Ontario**

Thermostats contain lots of Hg!!

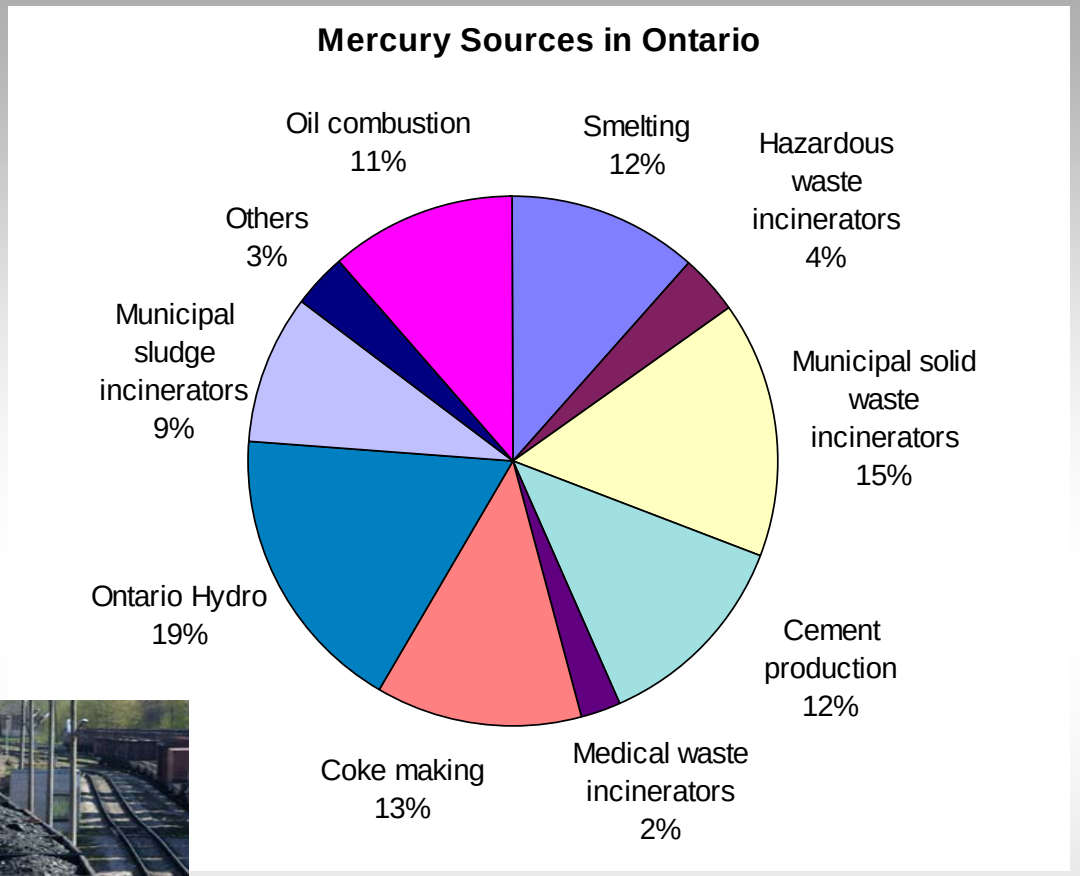


Thermostats with mercury switches showing glass ampoule containing mercury.

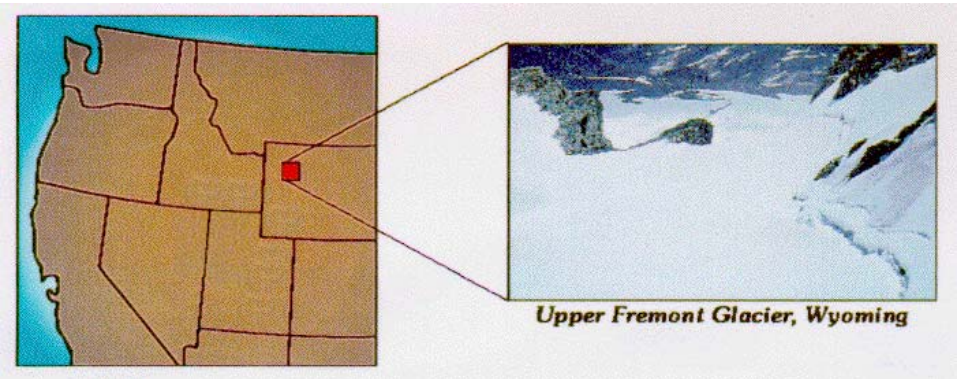
Fluorescent bulbs

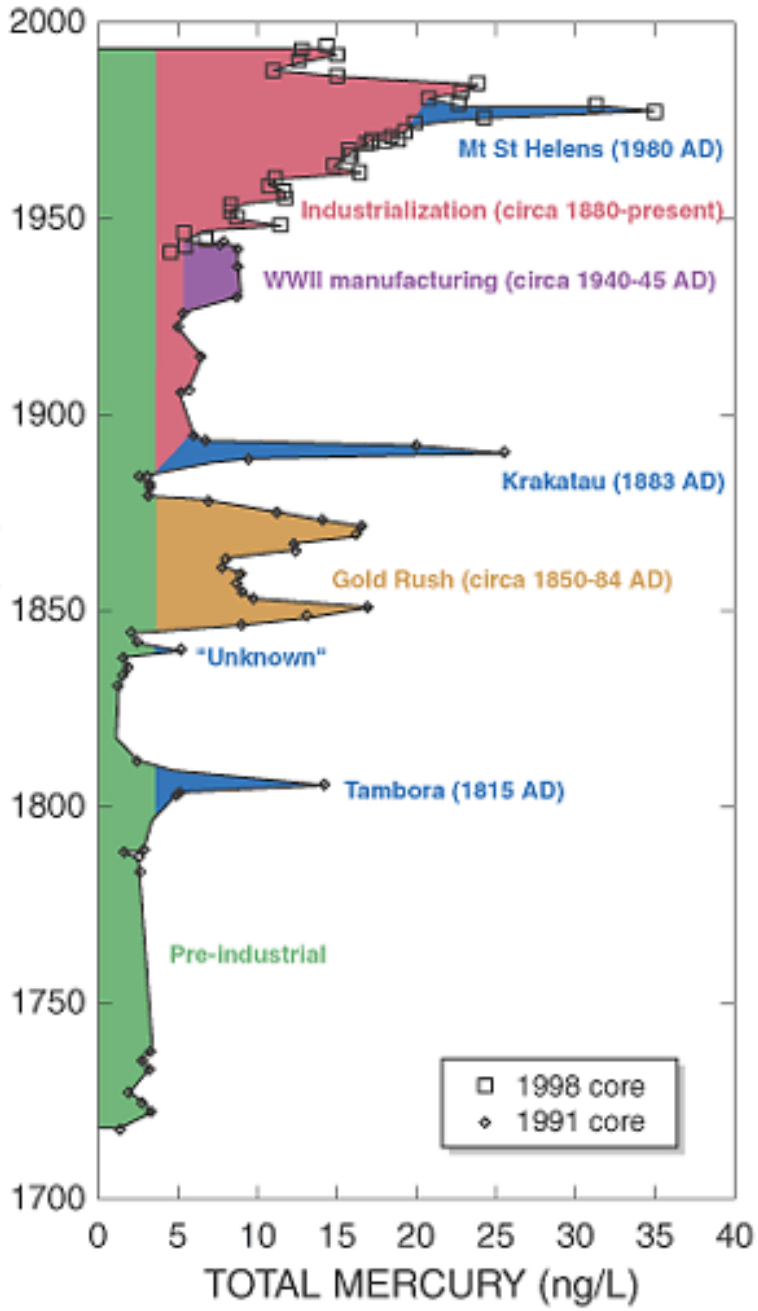
- Use less energy
- Good for the environment!!

Dental amalgam – about 50% Hg

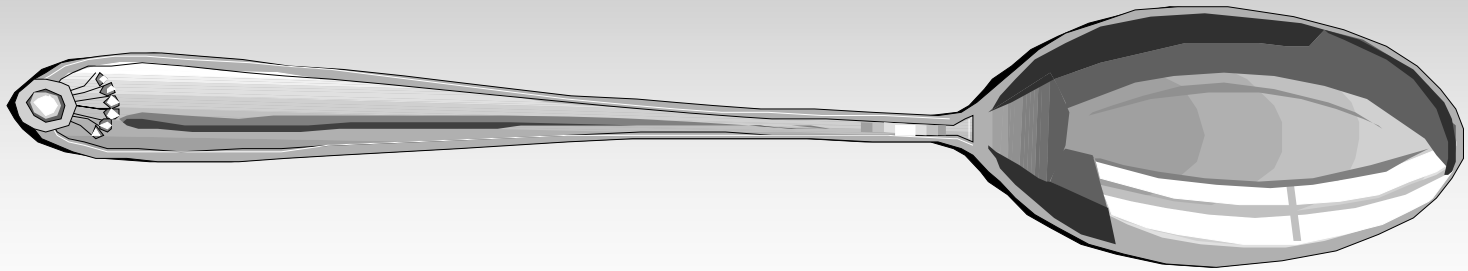

Mercury Sources in Ontario
Oil combustion 11%
Smelting 12%
Hazardous waste incinerators 4%
Others 3%
Municipal sludge incinerators 9%
Municipal solid waste incinerators 15%
Ontario Hydro 19%
Cement production 12%
Coke making 13%
Medical waste incinerators 2%

Hg in Fremont glacier ice core





It only takes a little bit…



- **One gram of mercury per year can contaminate a small lake lake**
- **1 teaspoon of mercury weighs 70 grams**

Effects

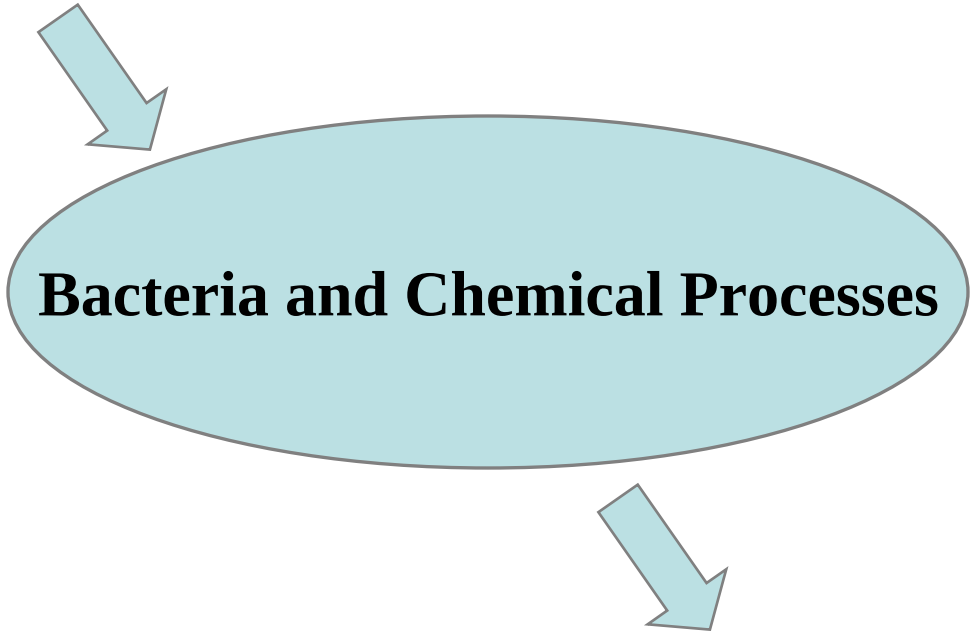
1 broken fluorescent bulb – used to contain 50 mg Hg, enough to contaminate 100 kg of lakes trout, pike, bass; now contain 2-5 mg Hg

1 broken thermometer – 3 g Hg, enough to contaminate 6000 kg of sports fish, the average annual fish production of a moderate-sized lake, e.g. one of the Kawarthas

In Lakes and Streams Mercury is Transformed to a Toxic Form

Mercury (Hg^0)

-not very bioavailable



MethylMercury (CH_3Hg+)

- Organic, bioavailable, TOXIC!

Ingestion Incidents

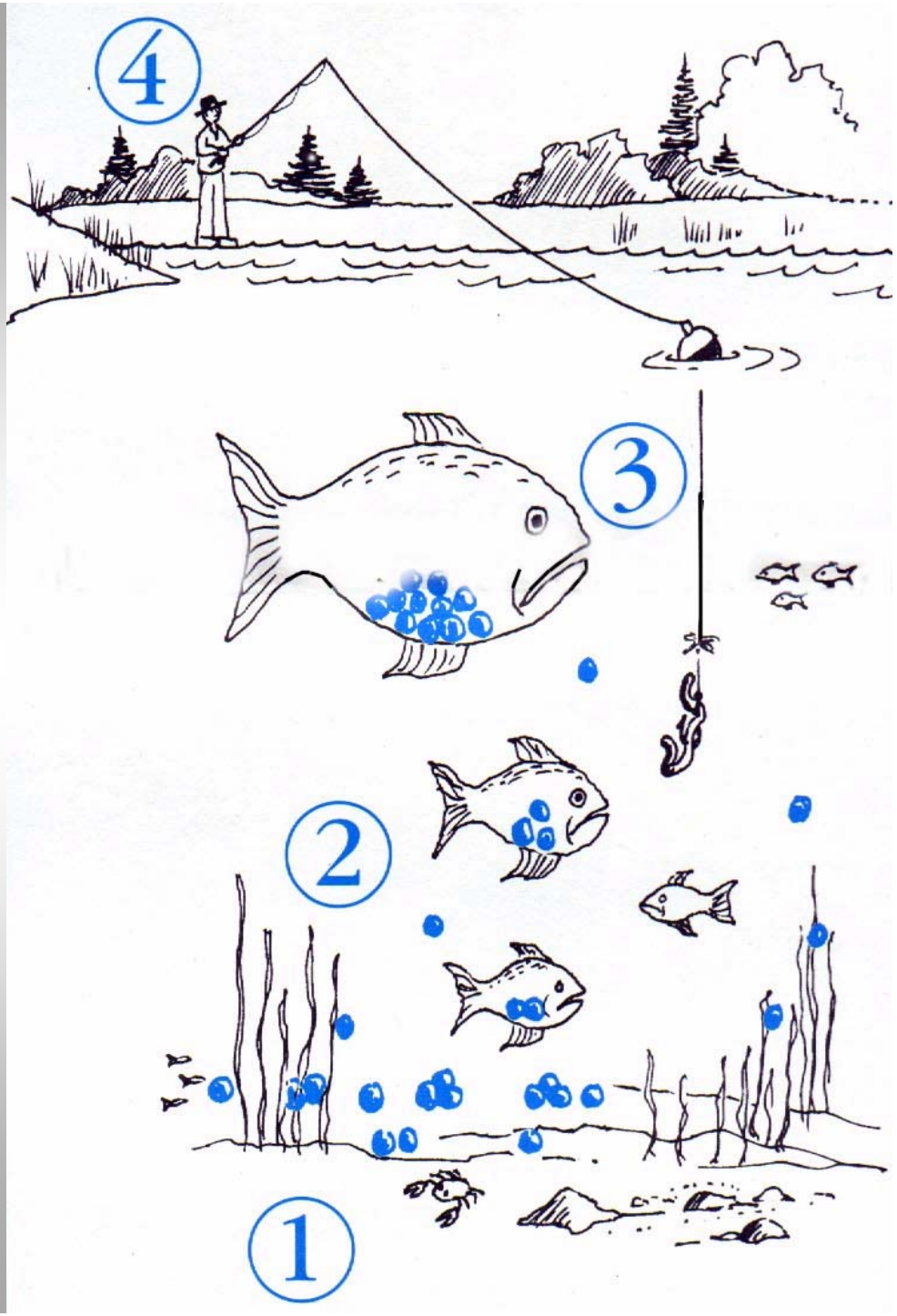
Minimata, Japan, 1932-1968

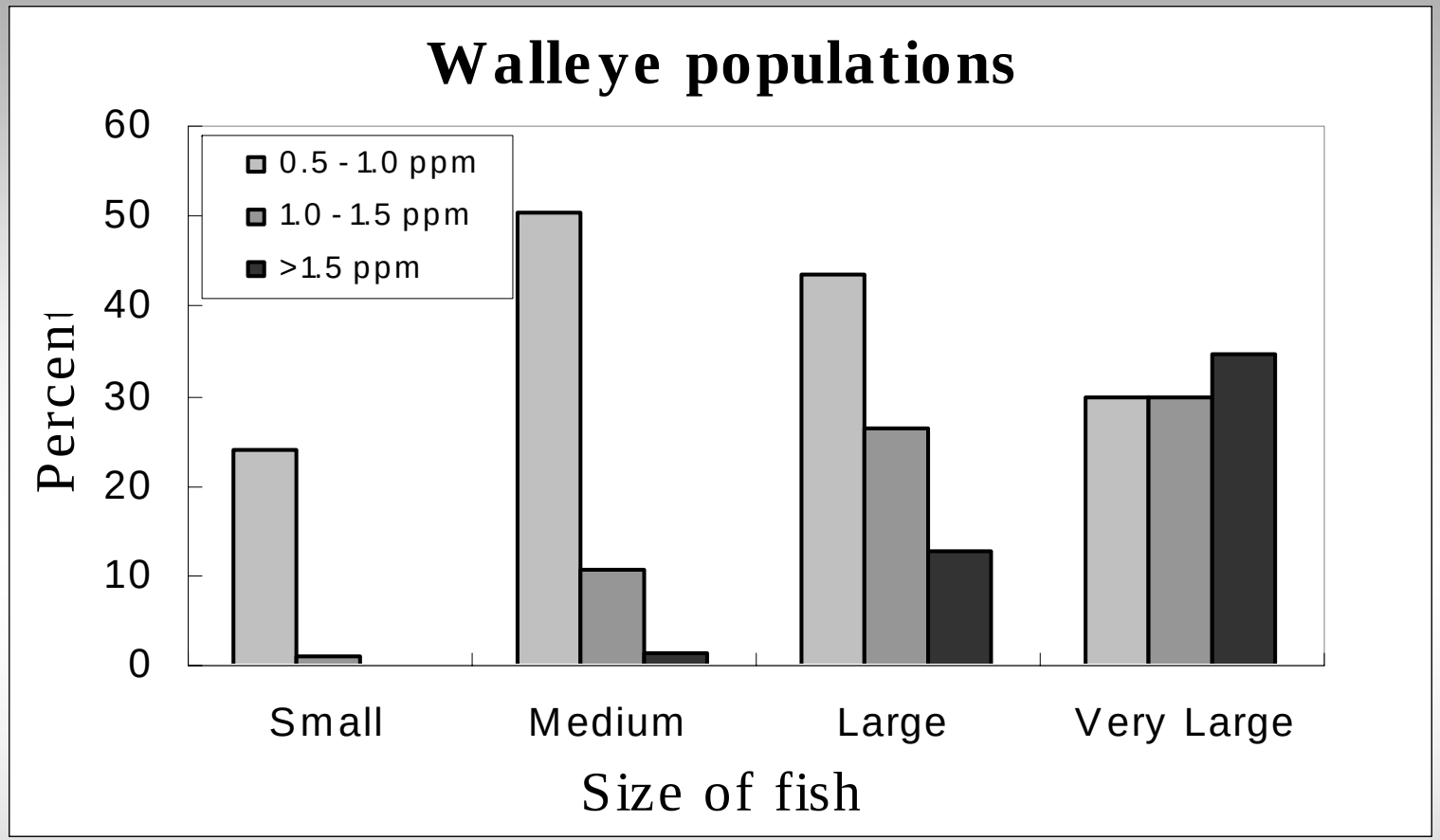
- 27 tons of mercury compounds released into Minimata Bay
- Chisso Corporation, used mercury as a catalyst
- the illness became known as the "Minimata Disease"
- first diagnosed: 3 little girls couldn't walk or speak, delirious, numbness, paralysis, deformity, convulsions, death
- 700 died, 9000 with brain damage

BIOMAGNIFICATION

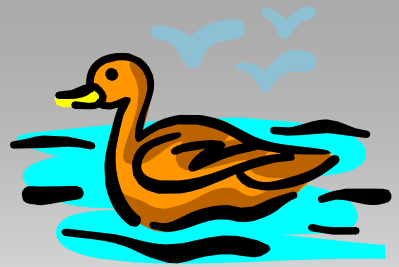
1. **Methylmercury accumulates in zooplankton**
2. **Zooplankton are eaten by small fish**
3. **Small fish are eaten by bigger fish**
4. **Biggest fish are eaten by humans or other animals**

Larger fish can have methylmercury concentrations 250,000 times higher than the water they are in!



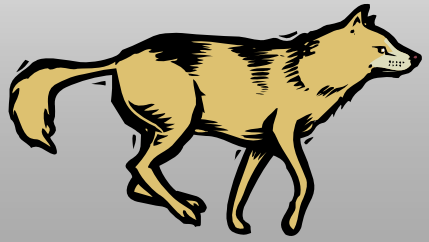


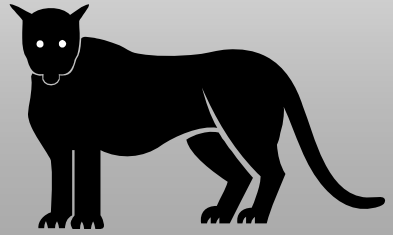
Frequencies of fish populations with Hg concentrations exceeding consumption guidelines in Ontario

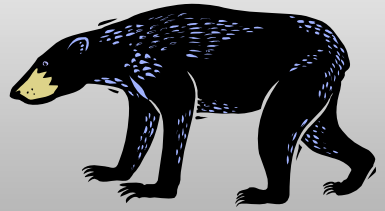


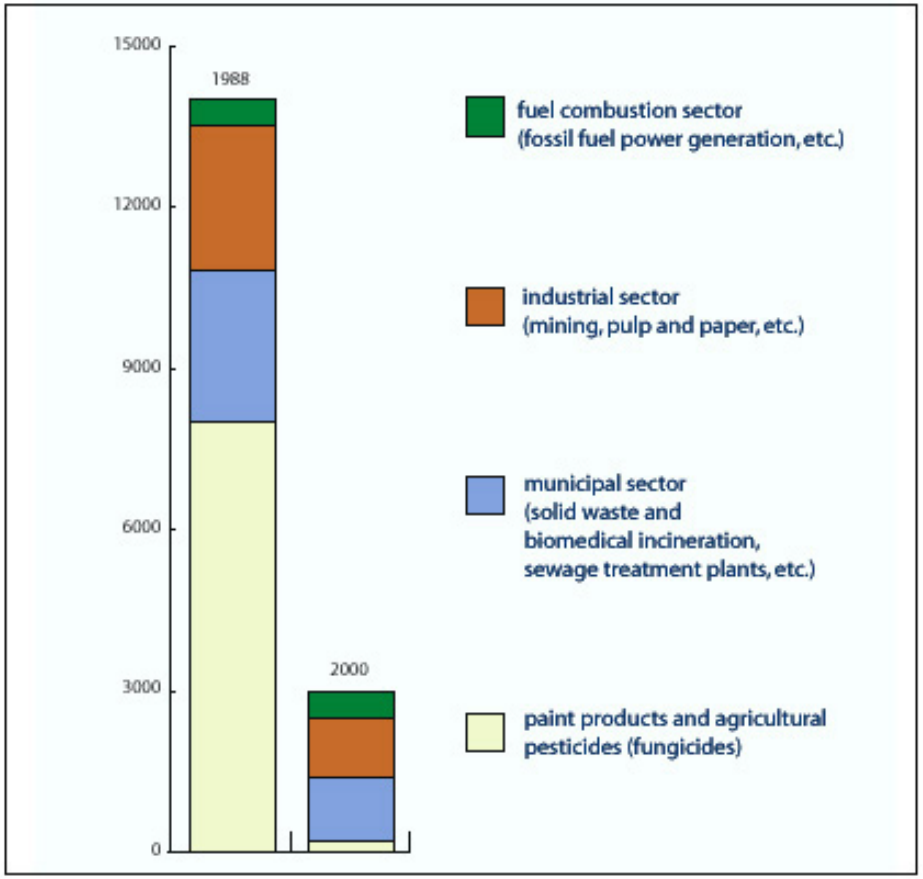
Wildlife

- **Elevated mercury levels cause:**
  - **weight-loss**
  - **reproductive problems**
  - **early death**
- **Fish-eating creatures: loons, mink, otter, eagles and hawks, bears, bobcats, wolves**





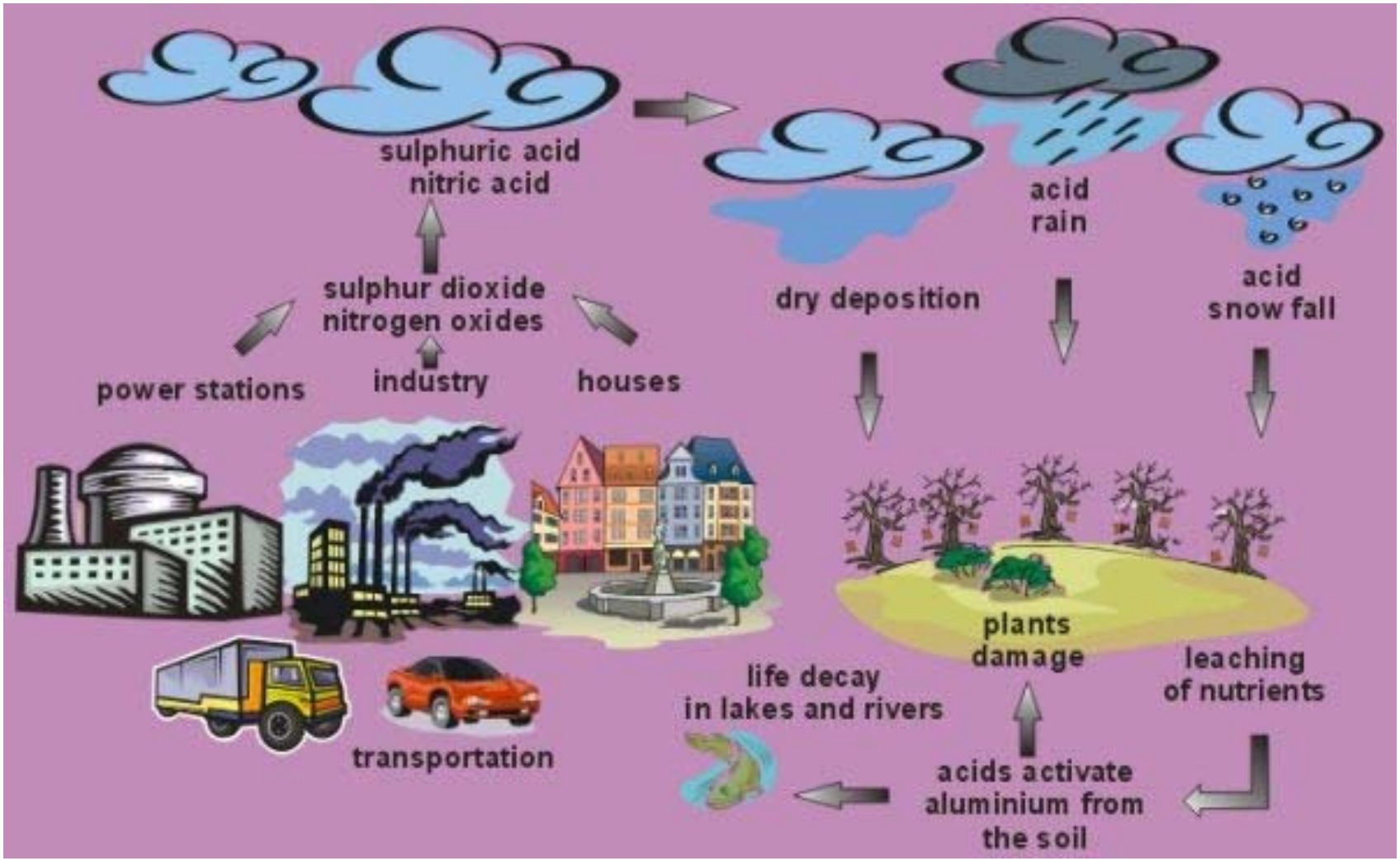




Mercury releases in the Great Lakes basin have been cut by more than 11,000 kg since 1988.

Our Hg use has declined and will continue to decline but the extra that we have introduced into the environment will circulate for decades or even centuries

What is acid rain?



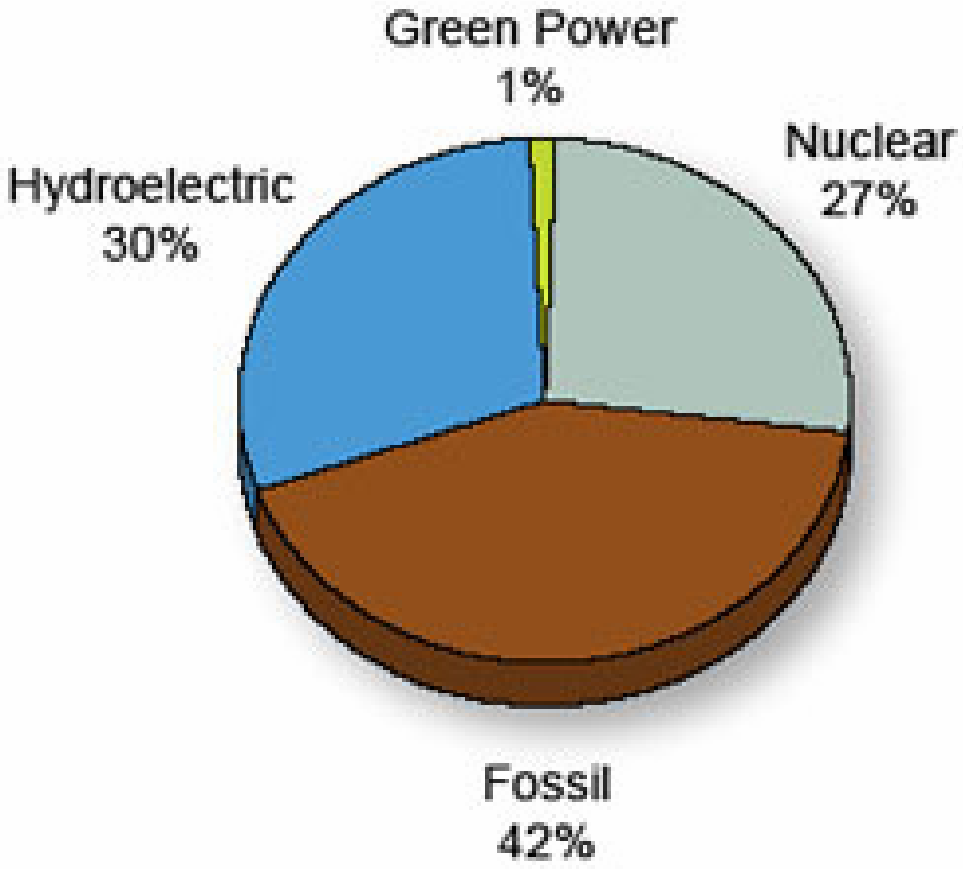
Acid Rain as a Problem

- considered a localized problem in North America in the ’50’s and ‘60’s, e.g. Sudbury, Noranda

- recognized globally at Stockholm Conference on the Human Environment in 1972

- Scandinavia, then US and Canada became aware of acid rain in ’70’s, then rest of Europe

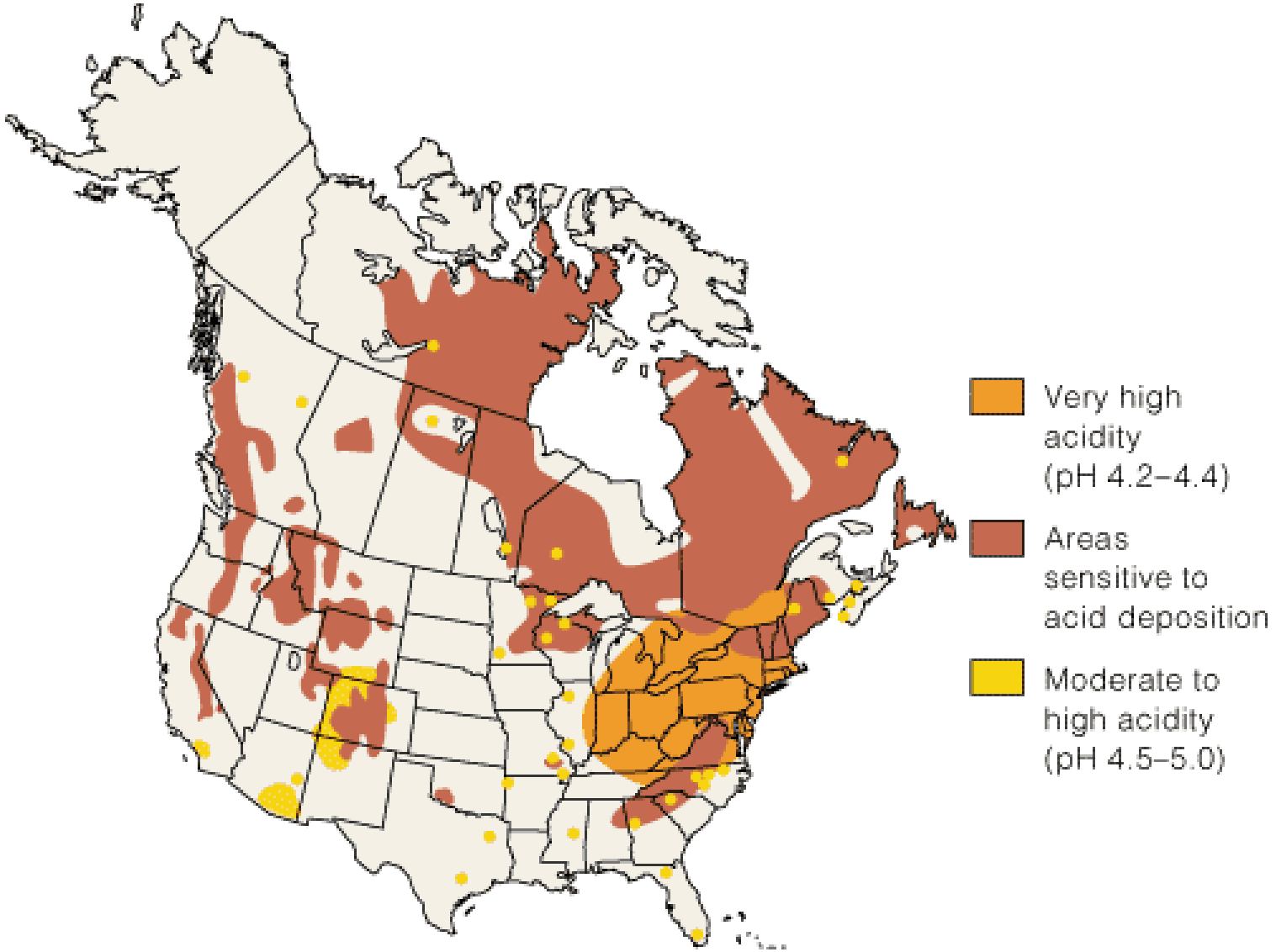
- in ’90’s recognized in China, Japan as major problem, with China considered



OPG's 22,790 MW (as of Dec.31/04) respresents about 75% of Ontario's installed generation.

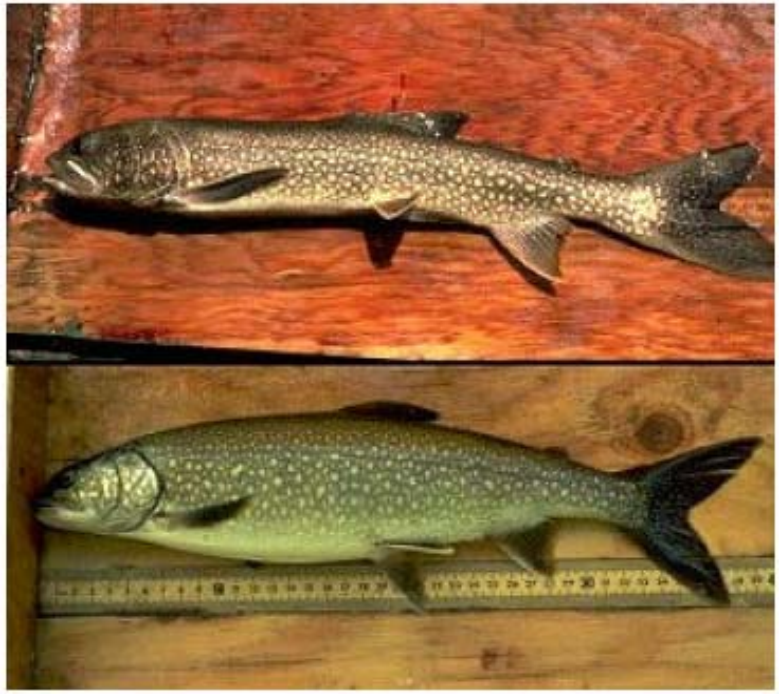
Nanticoke Power Station

Acid Deposition:
Soil & Surface Water Sensitivity



Acid kills fish directly: low pH poisons fish

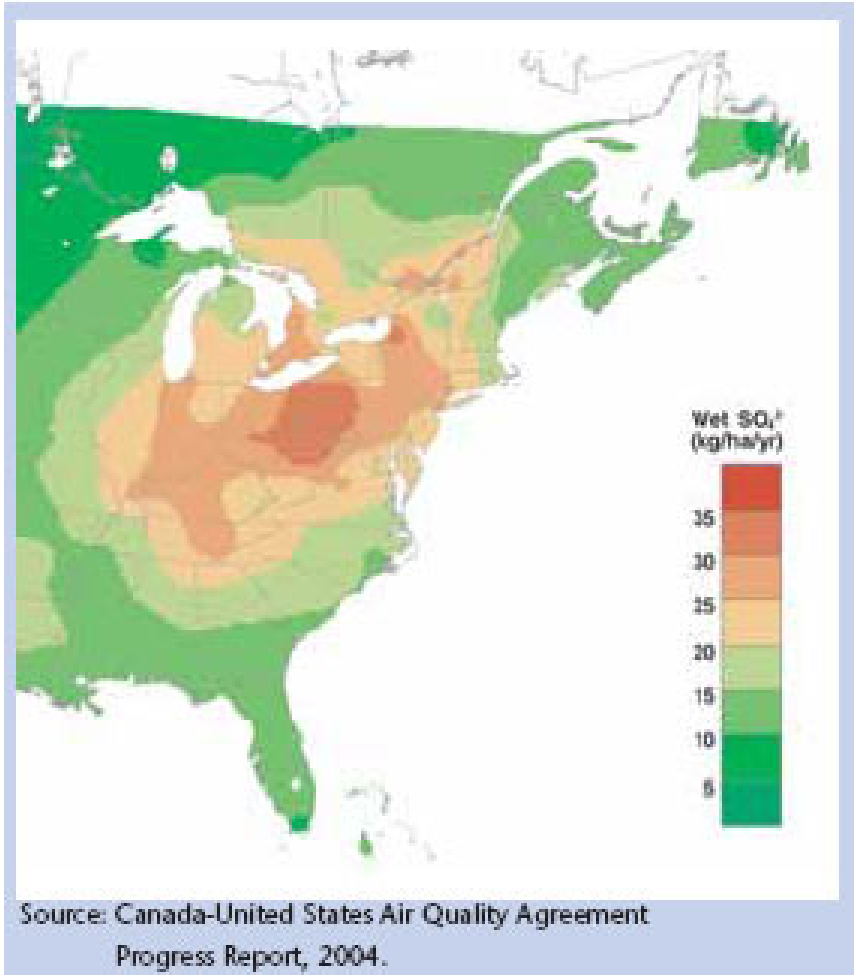

Acid kills fish indirectly: low pH releases Aluminum from soils to streams – Al poisons fish



The skinny lake trout in the upper photo was captured in an acidified ELA lake at pH 5.1. It was slowly starving because most of its food had disappeared from the lake. When the lake was permitted to recover from acidification, the trout were able to obtain food and their condition improved dramatically (lower photo).

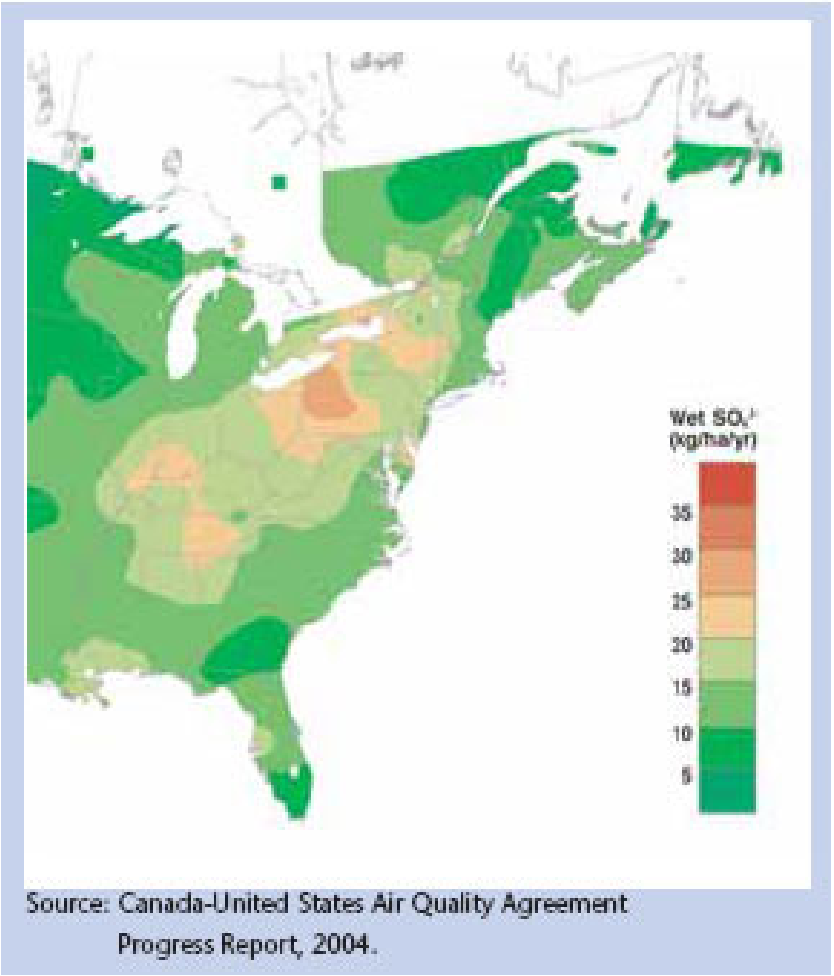
What has been done about acid rain?

1990-1994



Source: Canada-United States Air Quality Agreement Progress Report, 2004.

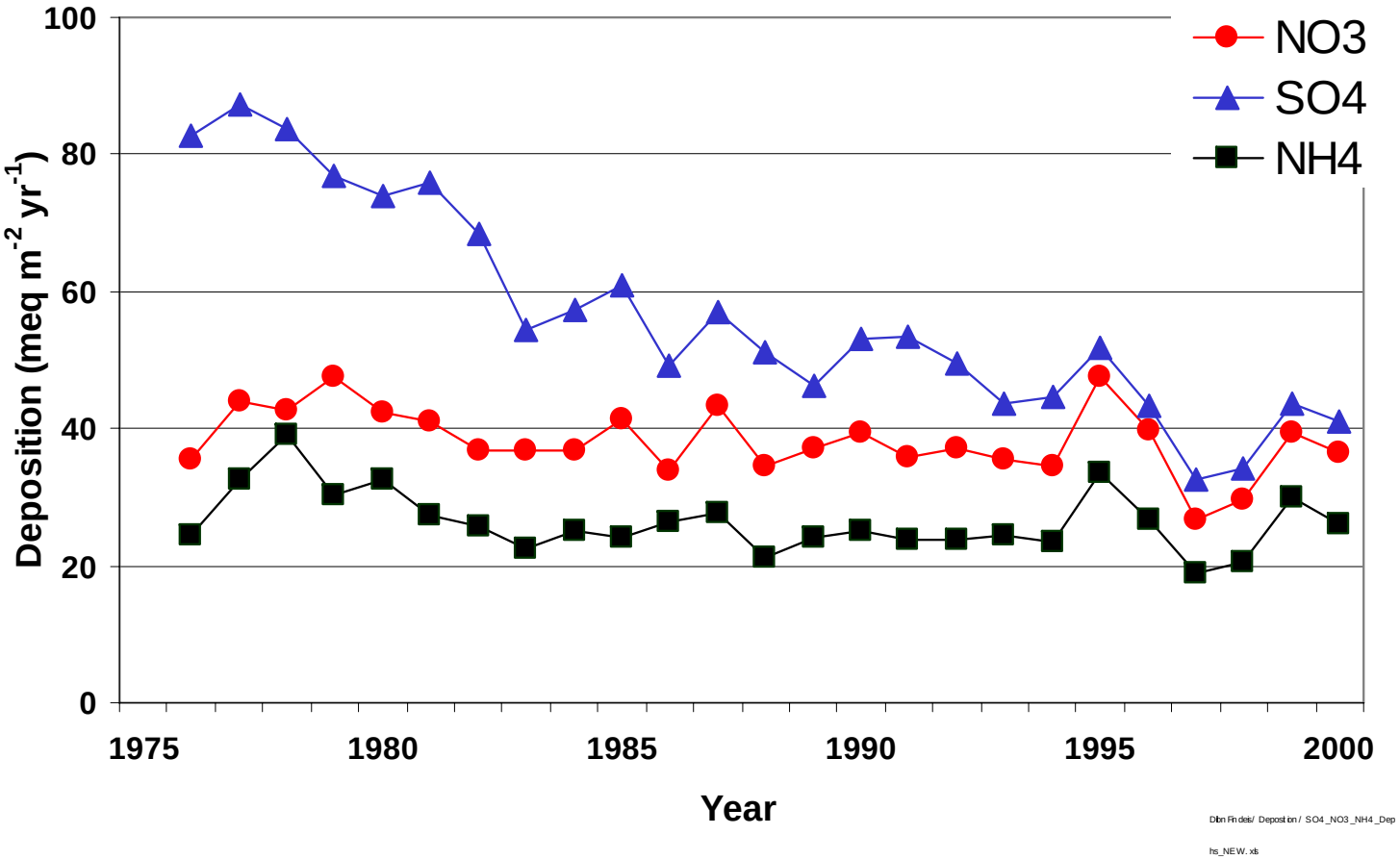
1995-2000

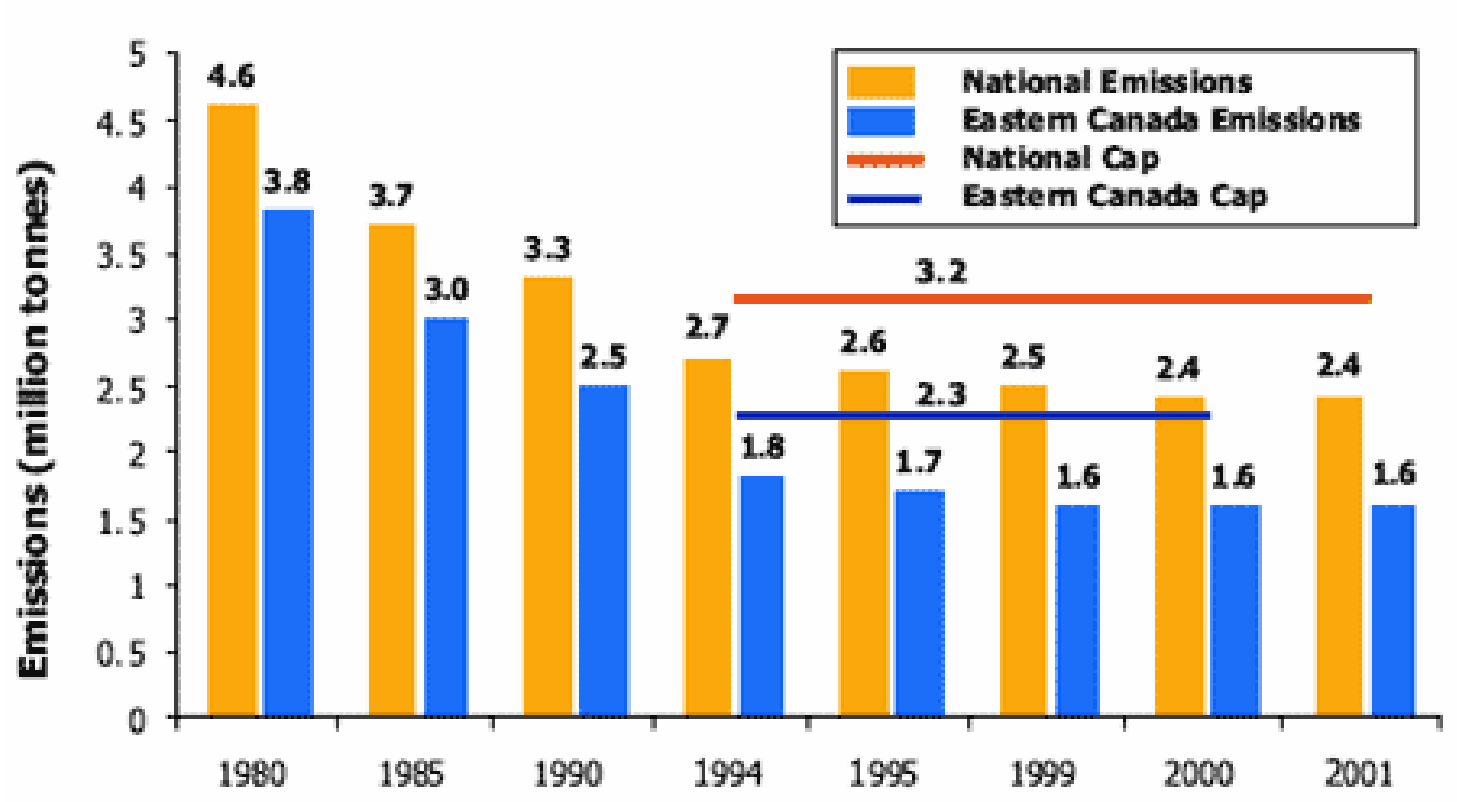


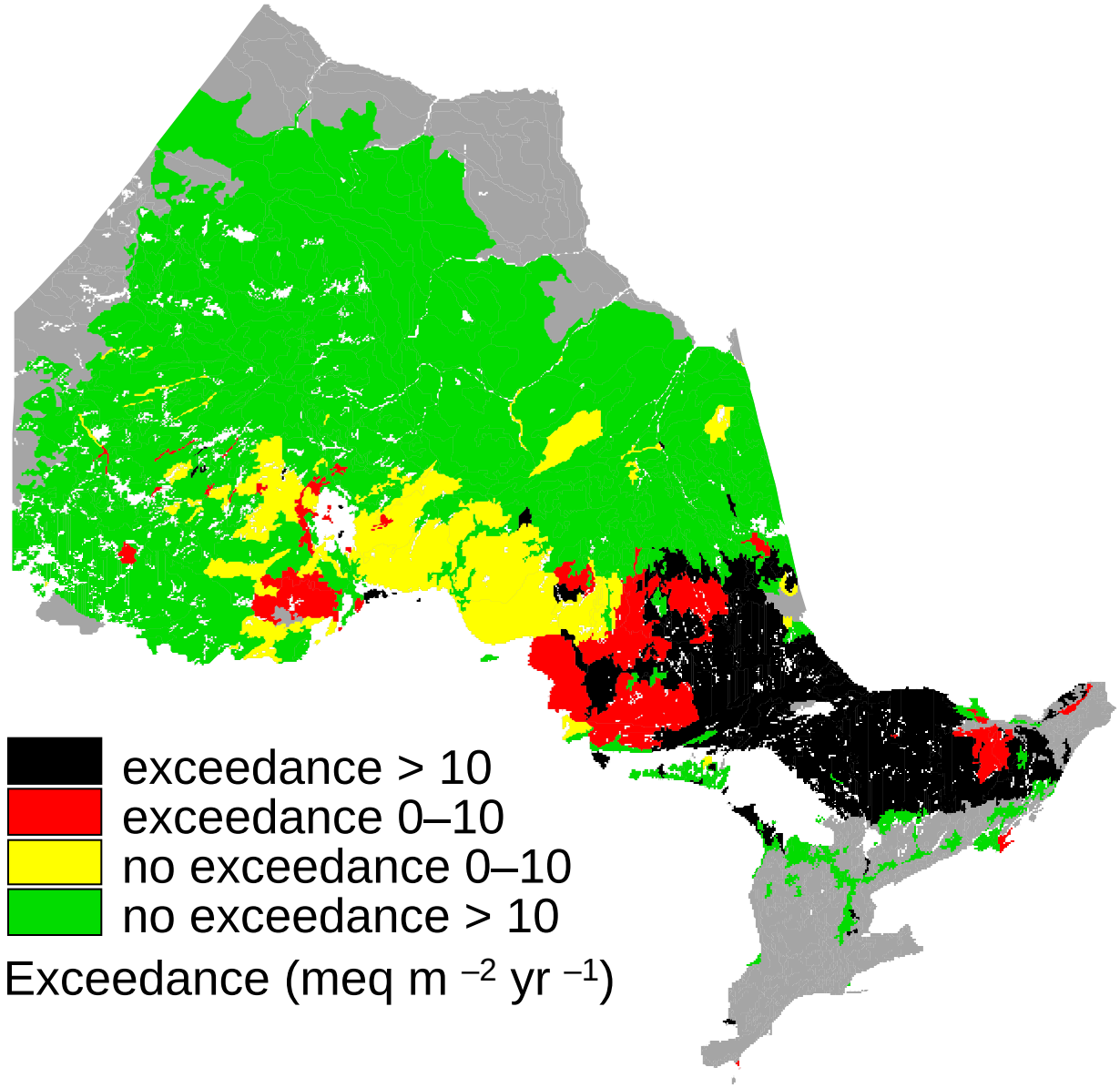
Source: Canada-United States Air Quality Agreement Progress Report, 2004.

Annual Deposition

Dorset, Ontario




Emissions (million tonnes)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
National Emissions
Eastern Canada Emissions
National Cap
Eastern Canada Cap
4.6
3.8
3.7
3.0
3.3
2.5
2.7
1.8
3.2
2.6
1.7
2.3
2.5
1.6
2.4
1.6
2.4
1.6
1980
1985
1990
1994
1995
1999
2000
2001

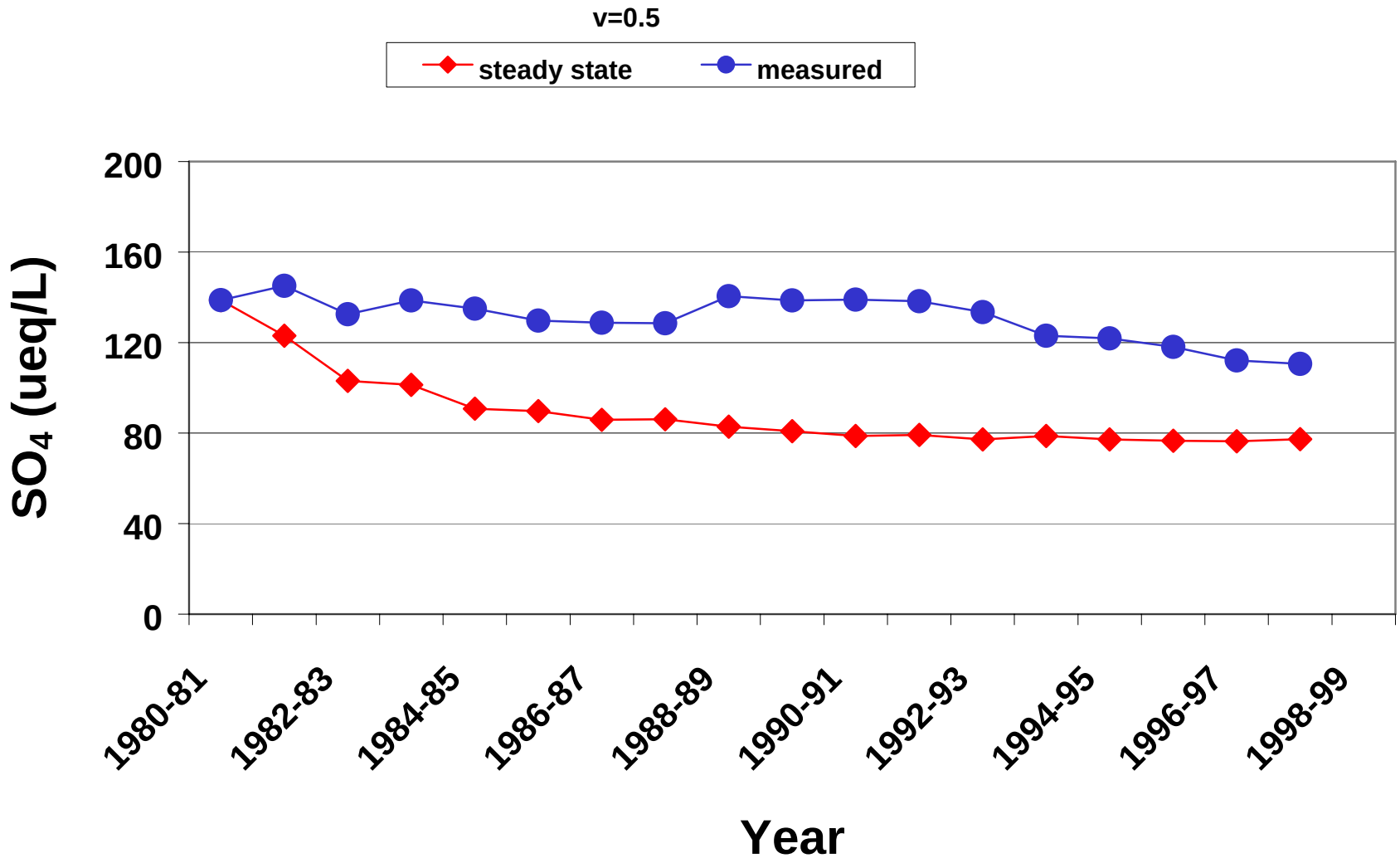

exceedance > 10
exceedance 0–10
no exceedance 0–10
no exceedance > 10
Exceedance (meq m −2 yr −1)

So, we haven't done enough,

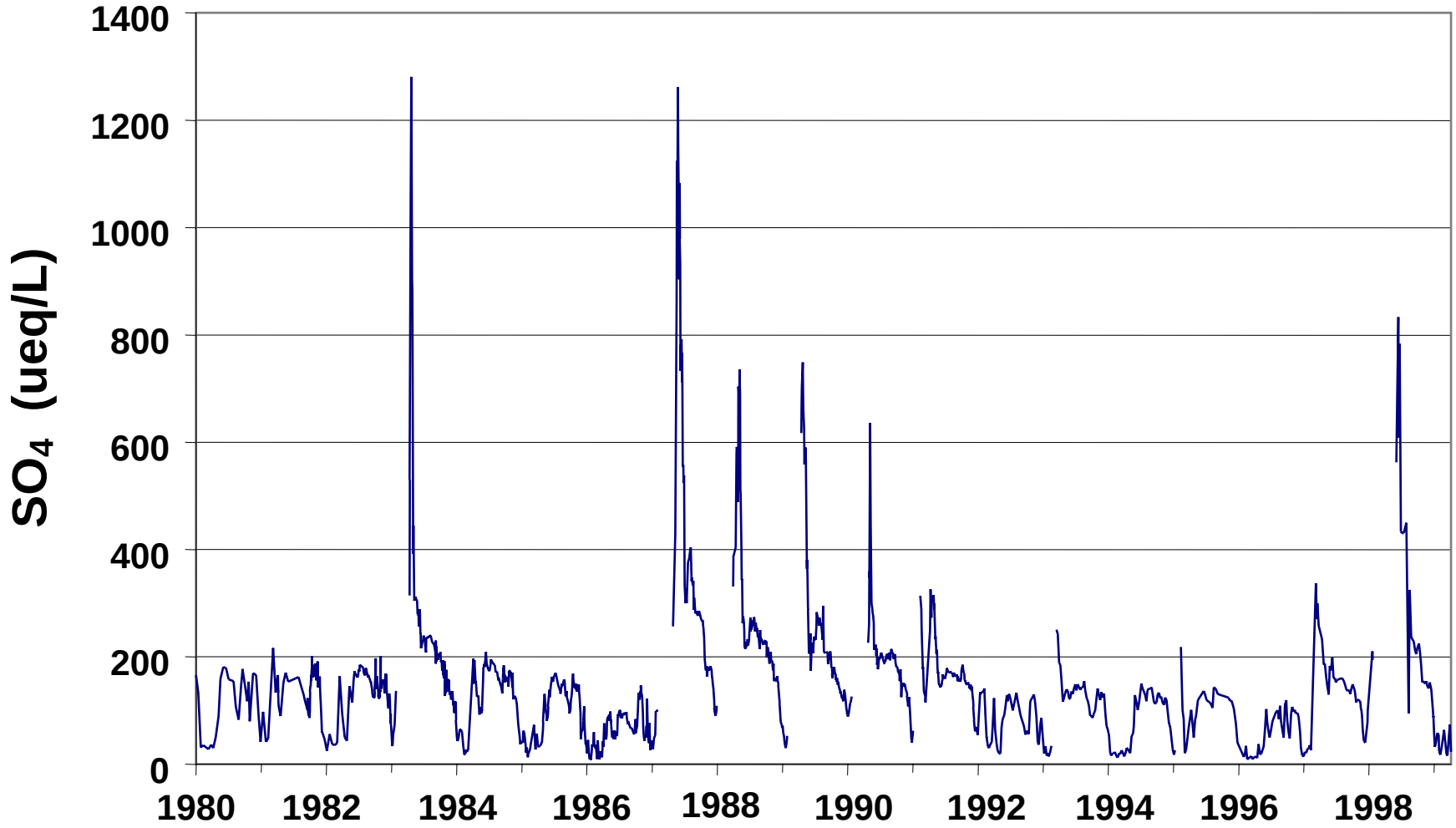
BUT….

What was supposed to change, i.e. recovery of aquatic systems, hasn't happened

Plastic: steady-state model

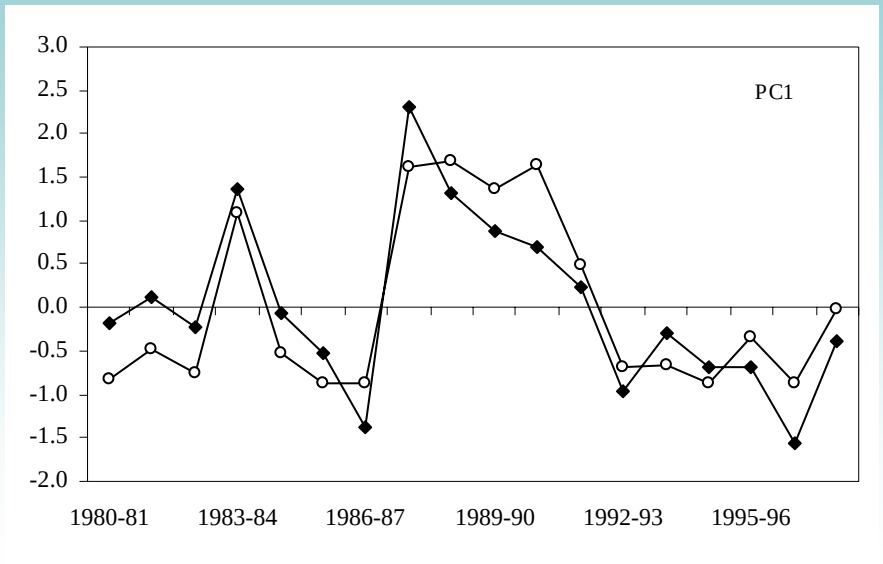


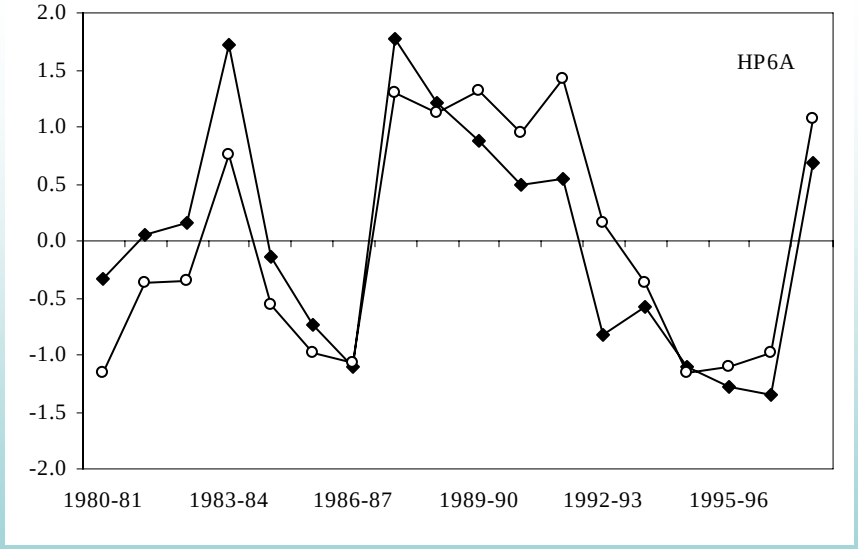
Plastic Lake inflow



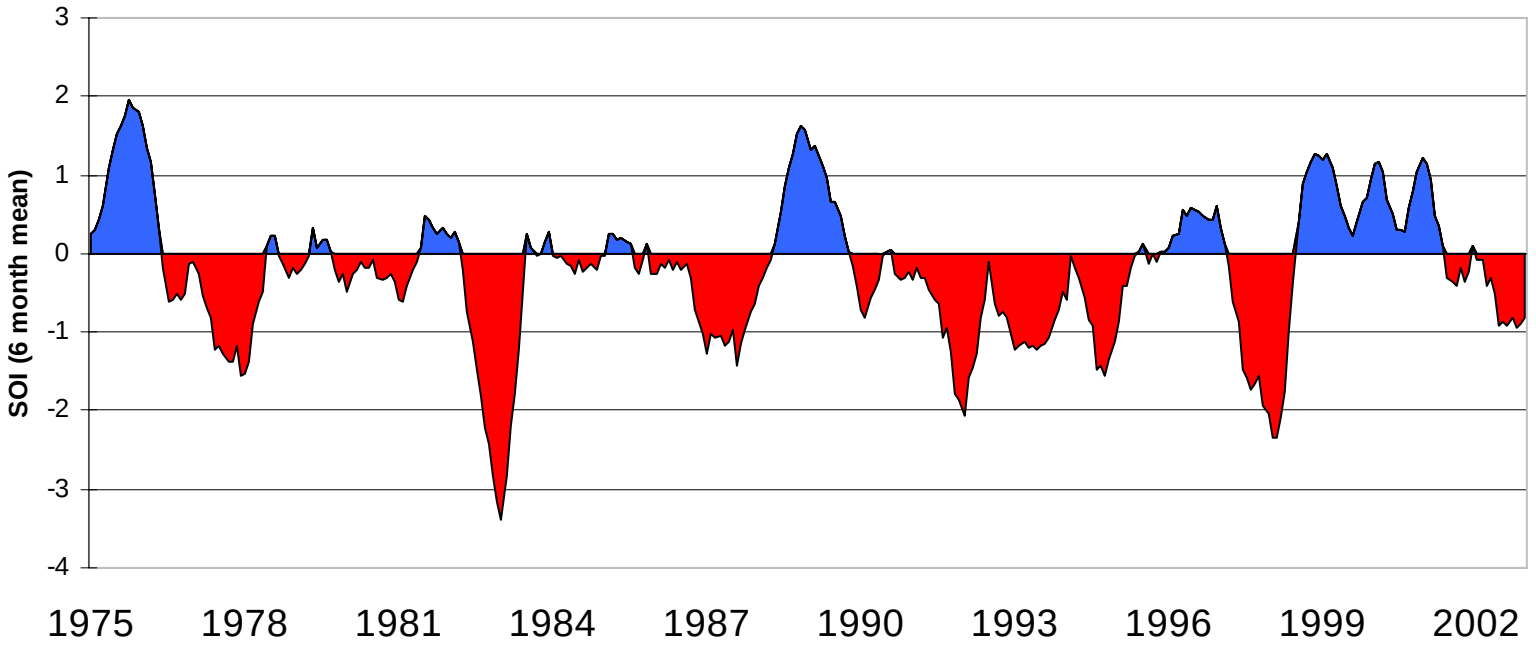
[SO_4] **solid**

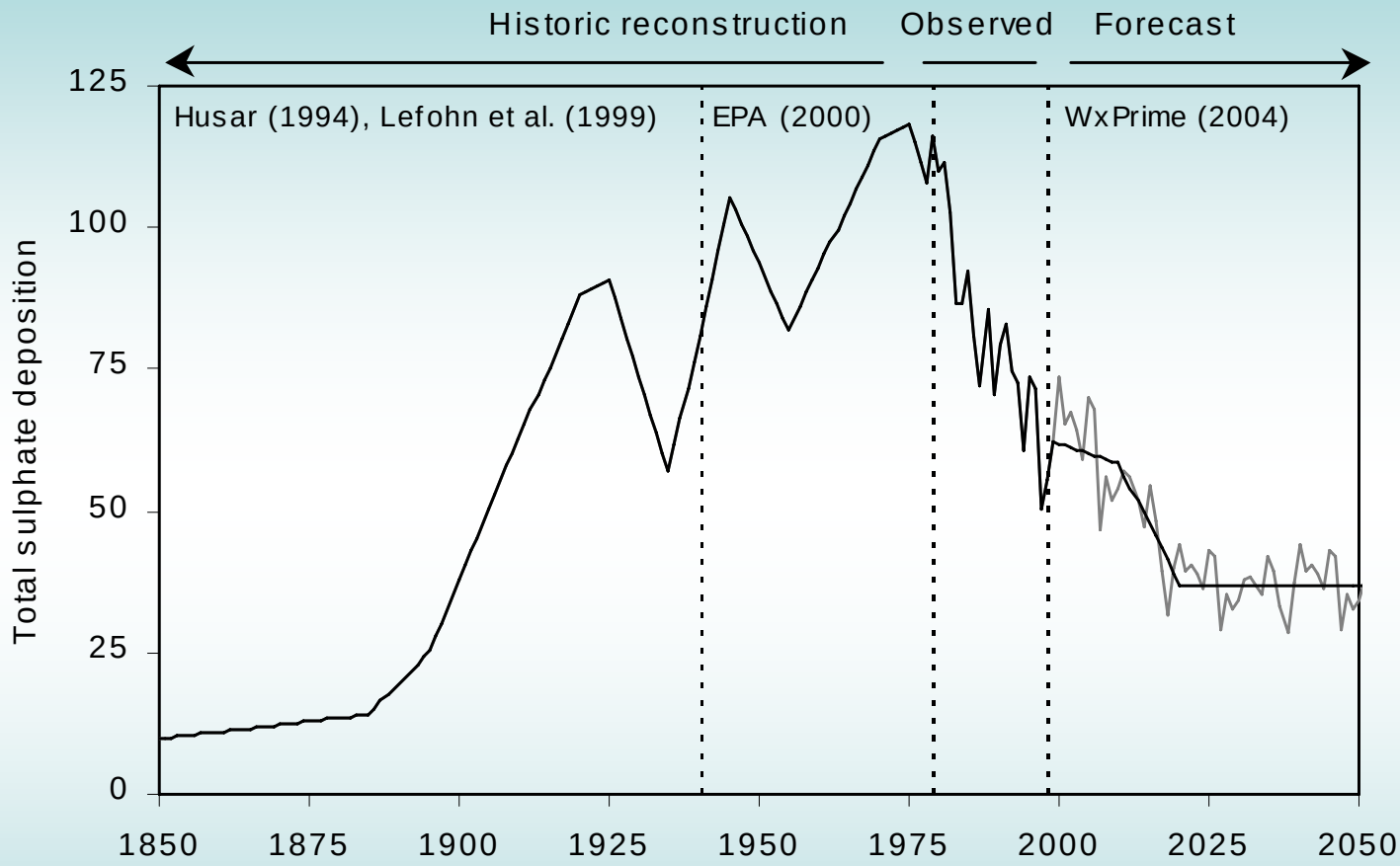
Flow = 0 **open**

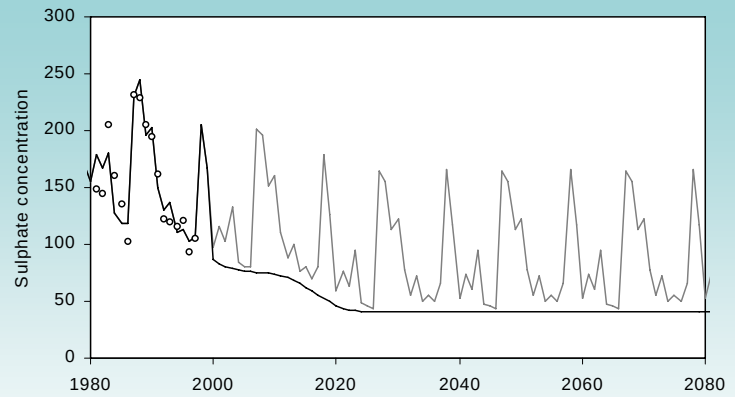


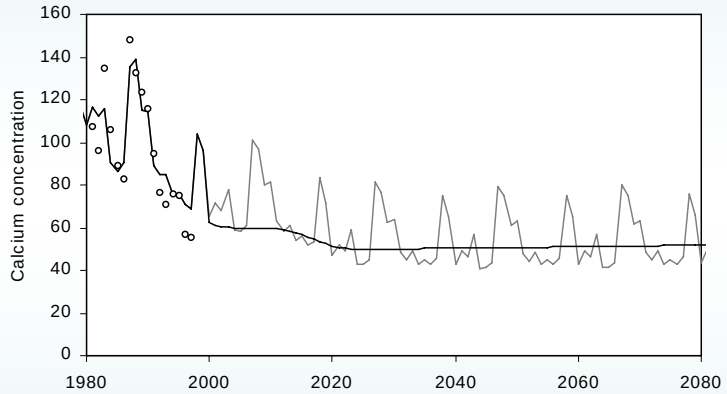


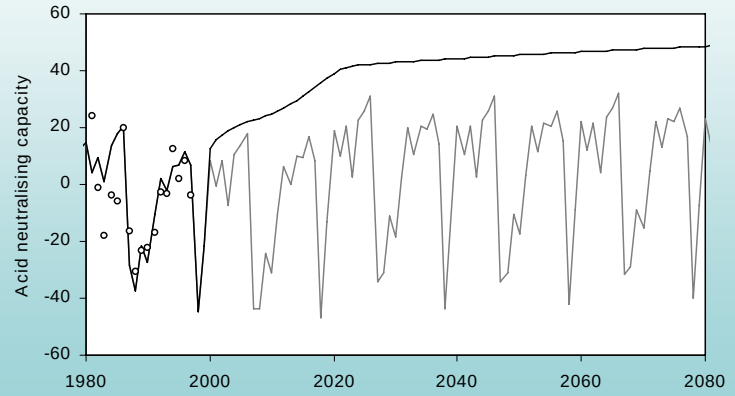
Southern Oscillation Index



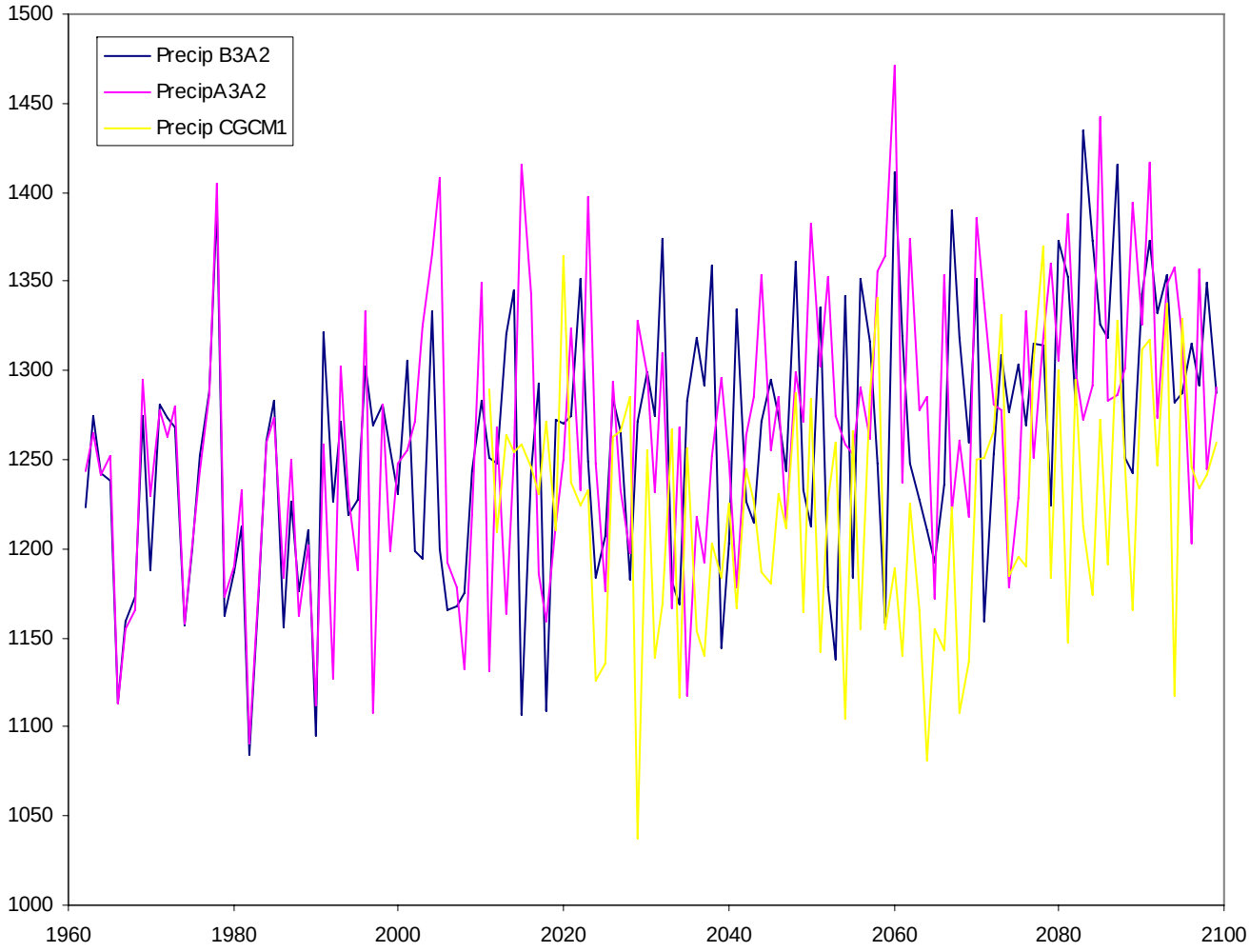

Historic reconstruction
Observed
Forecast
Husar (1994), Lefohn et al. (1999)
EPA (2000)
WxPrime (2004)
Total sulphate deposition
125
100
75
50
25
0
1850
1875
1900
1925
1950
1975
2000
2025
2050


Sulphate concentration
300
250
200
150
100
50
0
1980
2000
2020
2040
2060
2080

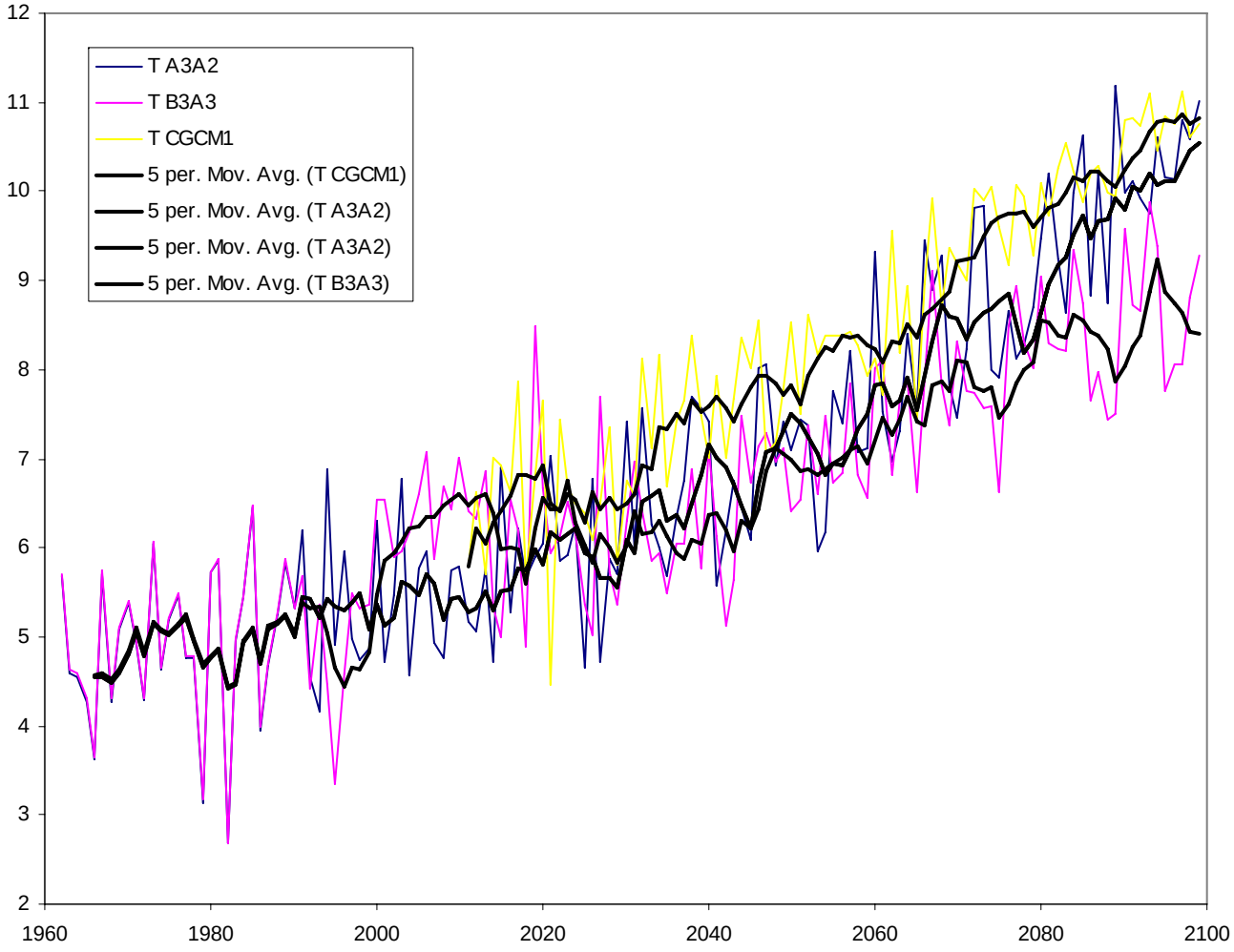

Calcium concentration
160
140
120
100
80
60
40
20
0
1980
2000
2020
2040
2060
2080


Acid neutralising capacity
60
40
20
0
-20
-40
-60
1980
2000
2020
2040
2060
2080

Predicted precipitation change at Muskoka airport



Predicted temperature change at Muskoka airport



Summary – aquatic systems

- lakes have recovered about half as much as expected in terms of SO_4, much less in terms of pH and alkalinity
- droughts following major climate events have resulted in re-oxidation and release of stored reduced S from peat
- the synchronous patterns in lake and stream chemistry relate to both climate and S deposition

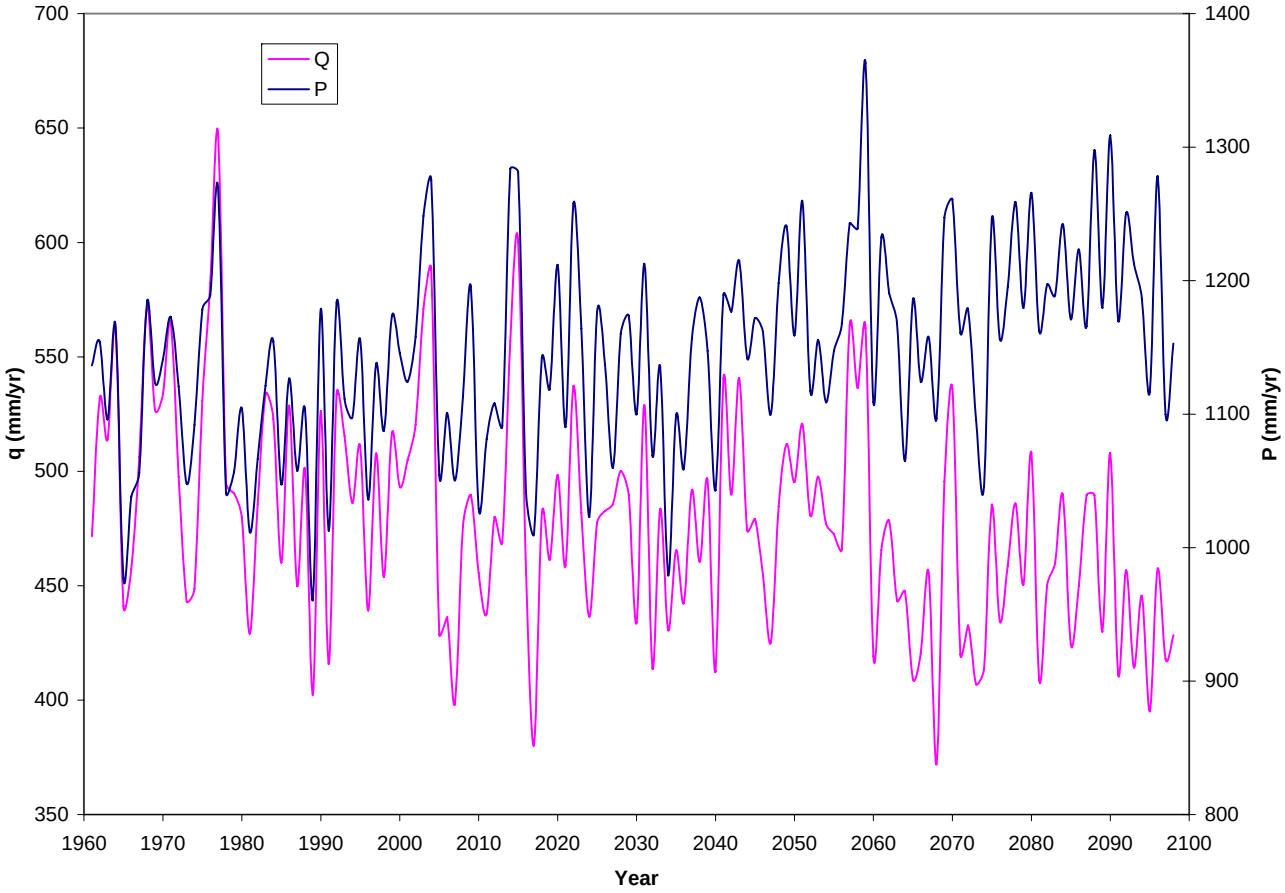
CONCLUSION

Need for new and lower emission targets for S and for N

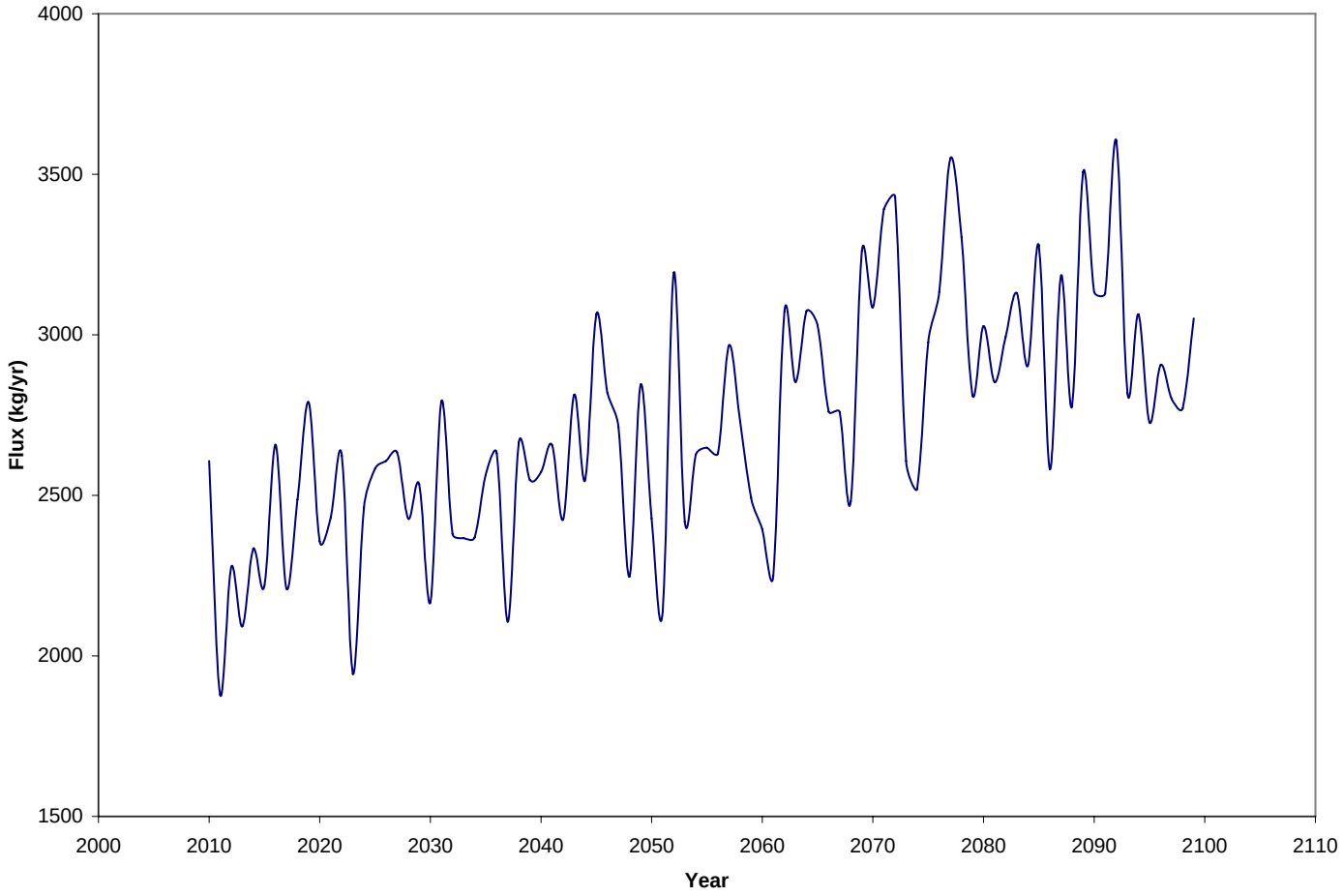
Need to build climate change into our thinking


Thanks for your
attention

Had3a2a /Pc1 Annual Flow and Precipitation



De5 CGCM1 DOC Flux



Conclusions

- Temperature is expected to increase
- Precipitation will remain about the same
- Flows will decrease under all 3 scenarios
- DOC flux will probably increase