Today

- Quiz
- Earth Day
- Nutrients as Pollutants
- More Atmospheric Pollutants
- Begin Water Pollution
- In-class Debate Prep

Today is Earth Day, April 22nd 2003

http://www.earthday.gov/

Our Society needs a better understanding of how we get clean water for all human needs

- It isn't the pollution that's harming the environment. It's the impurities in our air and water that are doing it.
  - Dan Quayle

What can you do?

ENERGY STAR - Energy-efficient choices can save families about a third on their energy bill with similar savings of greenhouse gas emissions, without sacrificing features, style or comfort. ENERGY STAR is a government-backed program helping businesses and individuals protect the environment and make the energy-efficient choice.

Global Warming Actions In the Home - This page contains information about how individuals can cut their utility bills by purchasing energy-efficient appliances, fixtures, and other home equipment and products while reducing the risk of global warming.

Manage Your Household's Water Pollution - Although individual homes may contribute only minor amounts of water pollution, the combined effect of an entire neighborhood can be serious.

What can you do?

Learn to Conserve Water in Your Home - You can also take a virtual tour that will show you how to save water in nearly every room in your house at the California Urban Water Conservation Council's Web site **H2OUSE**

Maintain Your Septic System - One in four American homes is served by septic systems. The U.S. Bureau of the Census reported that at least 10% of septic systems failed in the previous year.

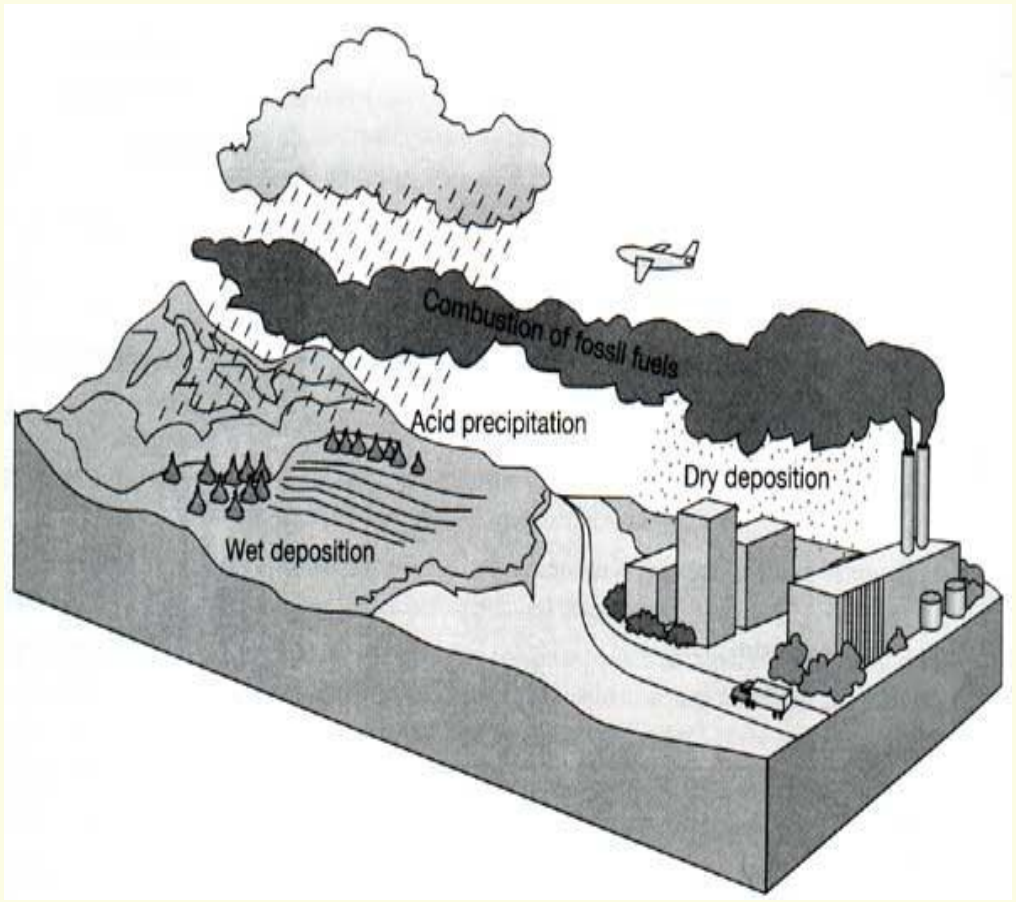
Help Prevent Stormwater Runoff - Pollution from stormwater runoff is the most common cause of water pollution today.

Help Prevent Pollution in Your Community - Learn about a variety of steps you can take.

Ecosystems

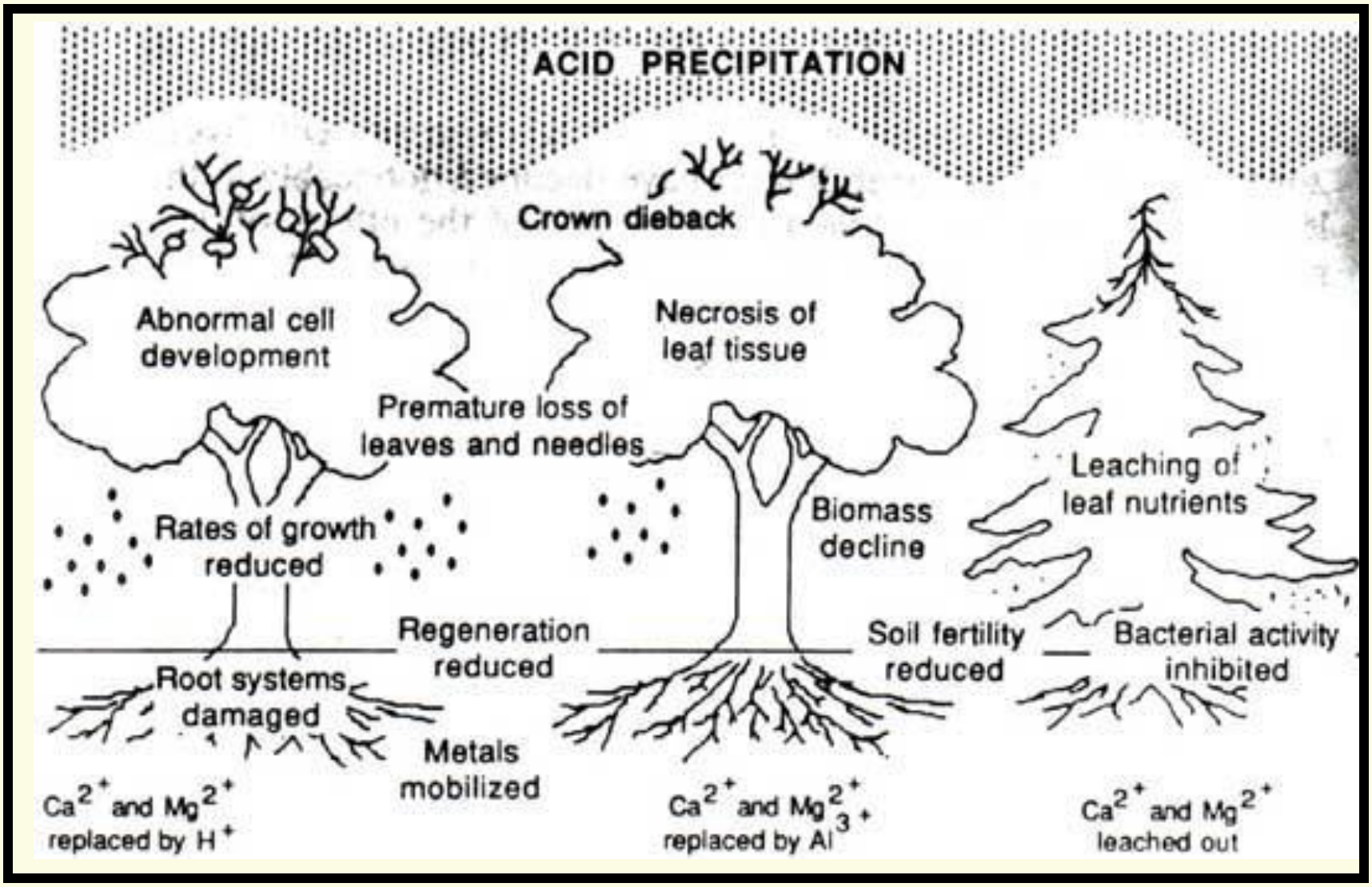
- an assemblage of different *species and their physical environment*, all organized in a way that each population of organisms obtains *energy* and *nutrients* through specific pathways within the ecosystem.

Acid Rain



- Reactions to convert to acid take place in ~2 days - travel 1000 miles
- Down wind - Acid rain
- Dry Dep. vs Wet Dep.
- Dry Deposition
  - 50 % of total
  - Can react with plants - strip nutrients
  - Tree dieback

Acid Rain and Trees



Forests affected by Acid Rain

Northeast US

Canada

Northern Europe

Asia

Acid Rain and Buildings

Many buildings are made of concrete and or stone

These compounds act as bases and react with acid

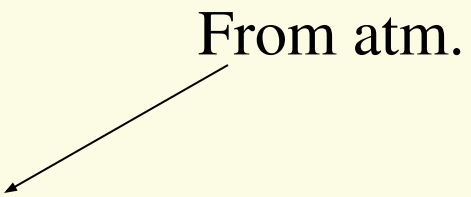
The building technically “weathers” very fast, or
Non technically “crumbles”

Europe

How acid rain affects stonework.
The picture on the left was taken in 1908.
The picture on the right was taken in 1968

The US Capitol

Human Emissions - Combustion



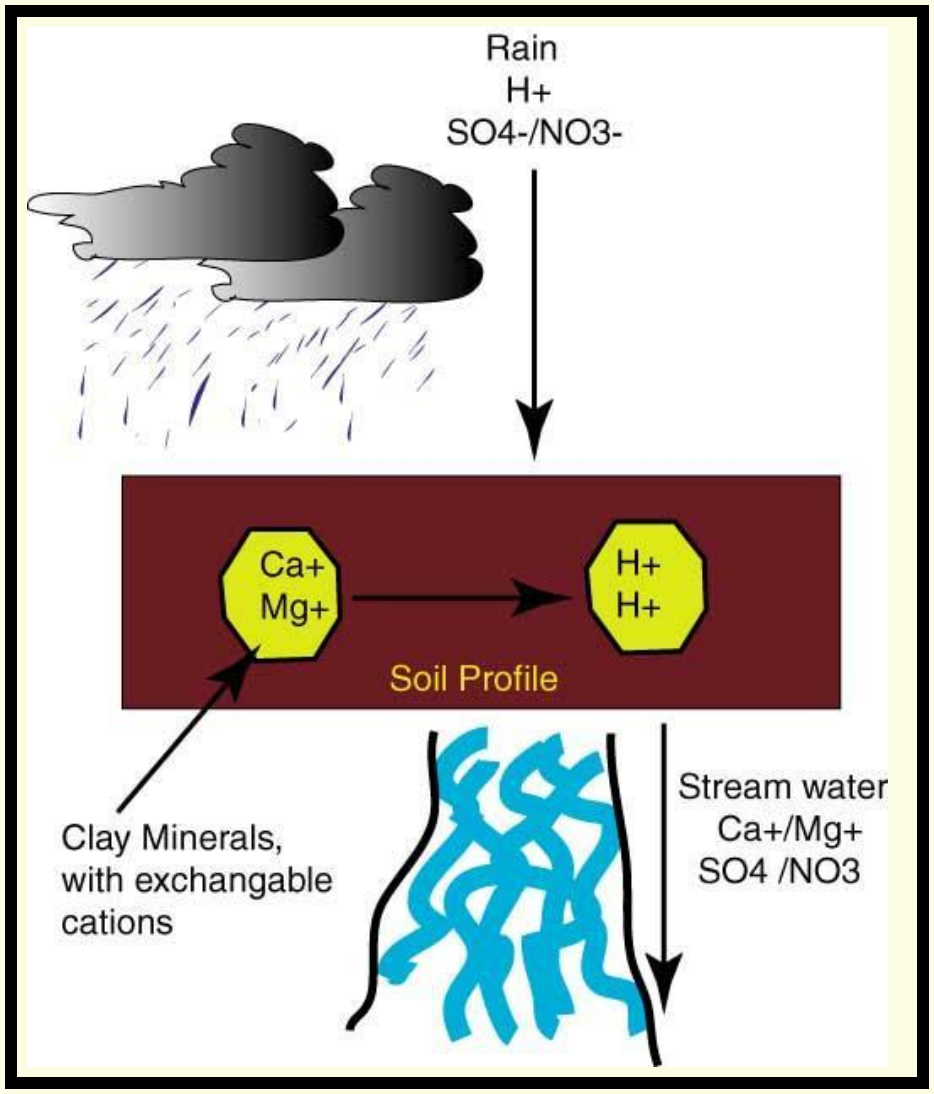
- NO_x
- $N_2 + O_2$ --> 2NO
- Forms in high temperatures of combustion engine
- Converted in the atmosphere to HNO_3 - nitric acid

Human Emissions - Fertilizer

- N_2 +Energy H^+--> NH_3

- Formed by the Haber process
- Added to fields all over the world, but often lost after harvest

Acid Neutralization



- How does this work?
- Cation Exchange on clay minerals
- Role of chemical weathering...

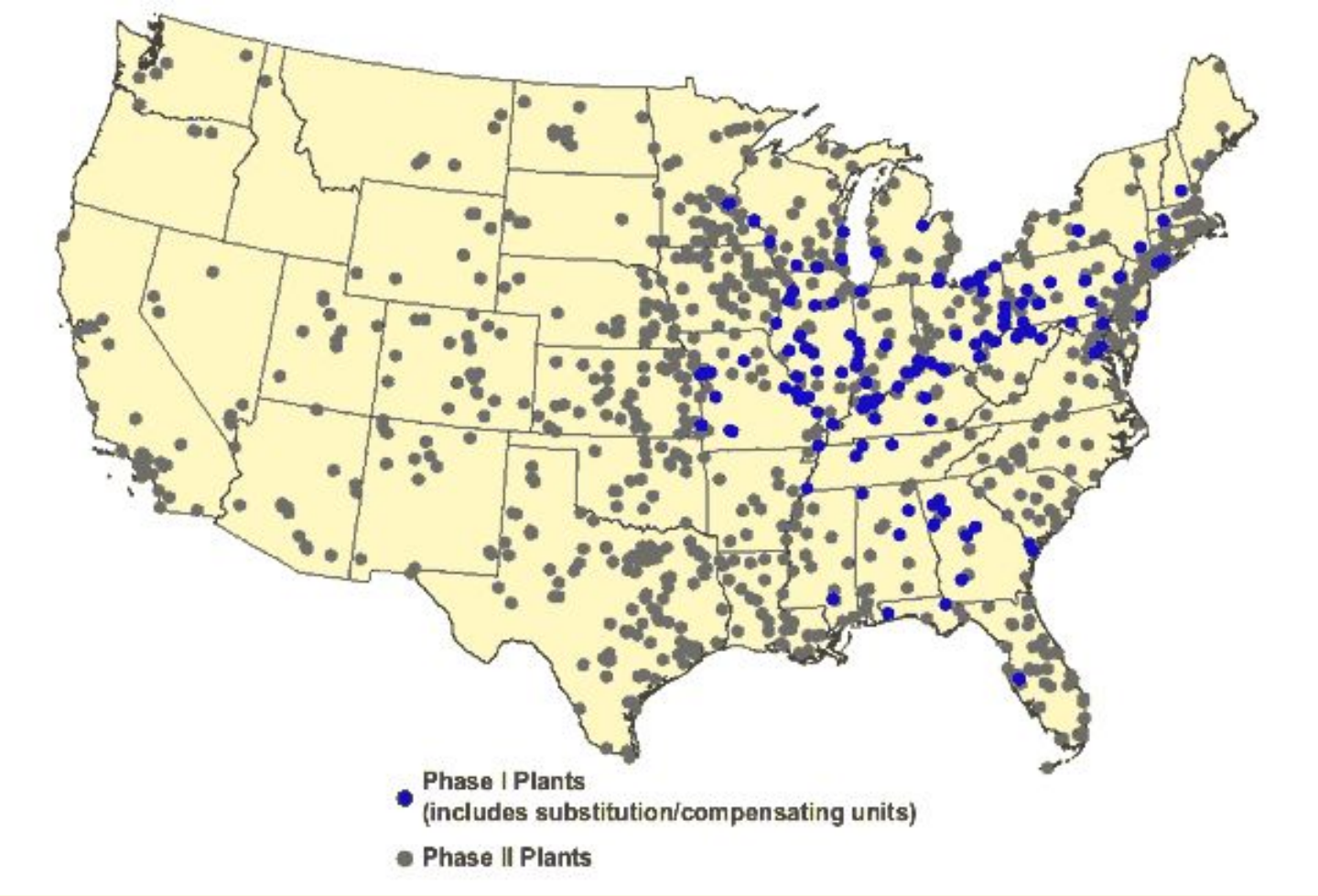
Where do N emissions originate?

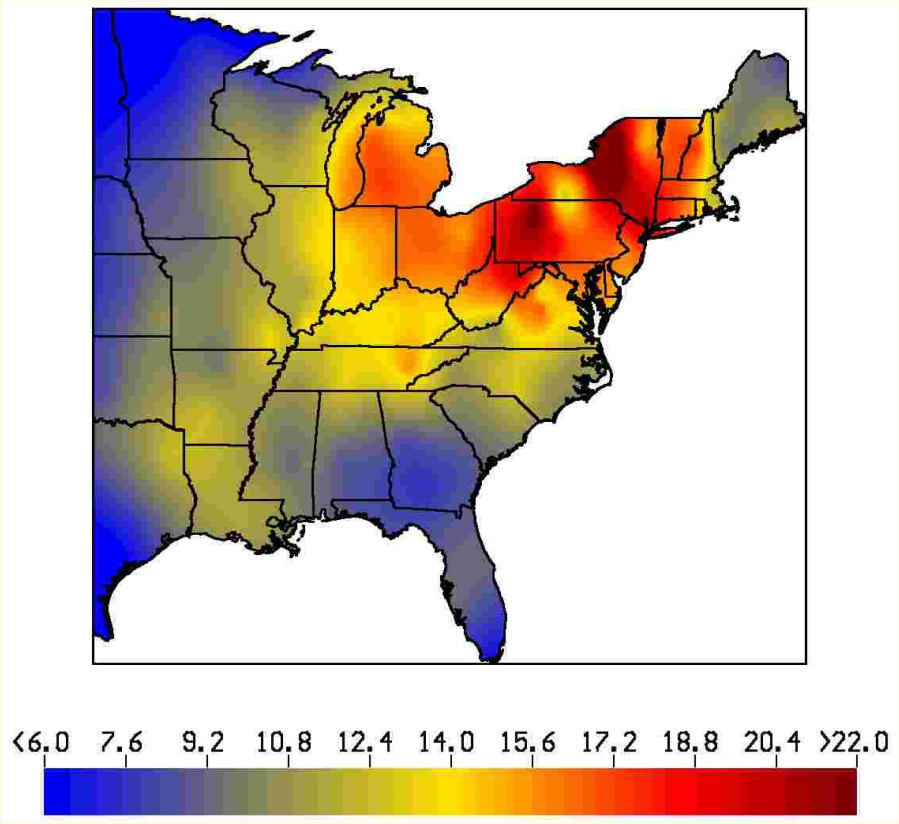
~ 55% come from agriculture

~ 25% come from industry – e.g. coal fired power plants

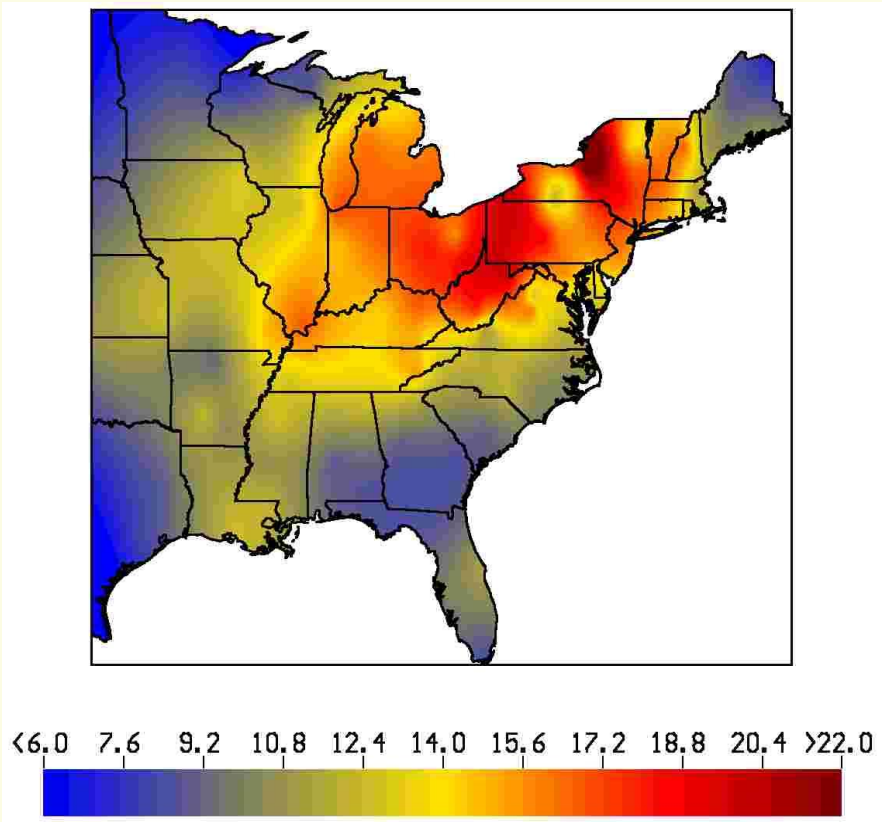
~ 20% come from automobiles

Major powerplants – sources of N emissions – Acid rain



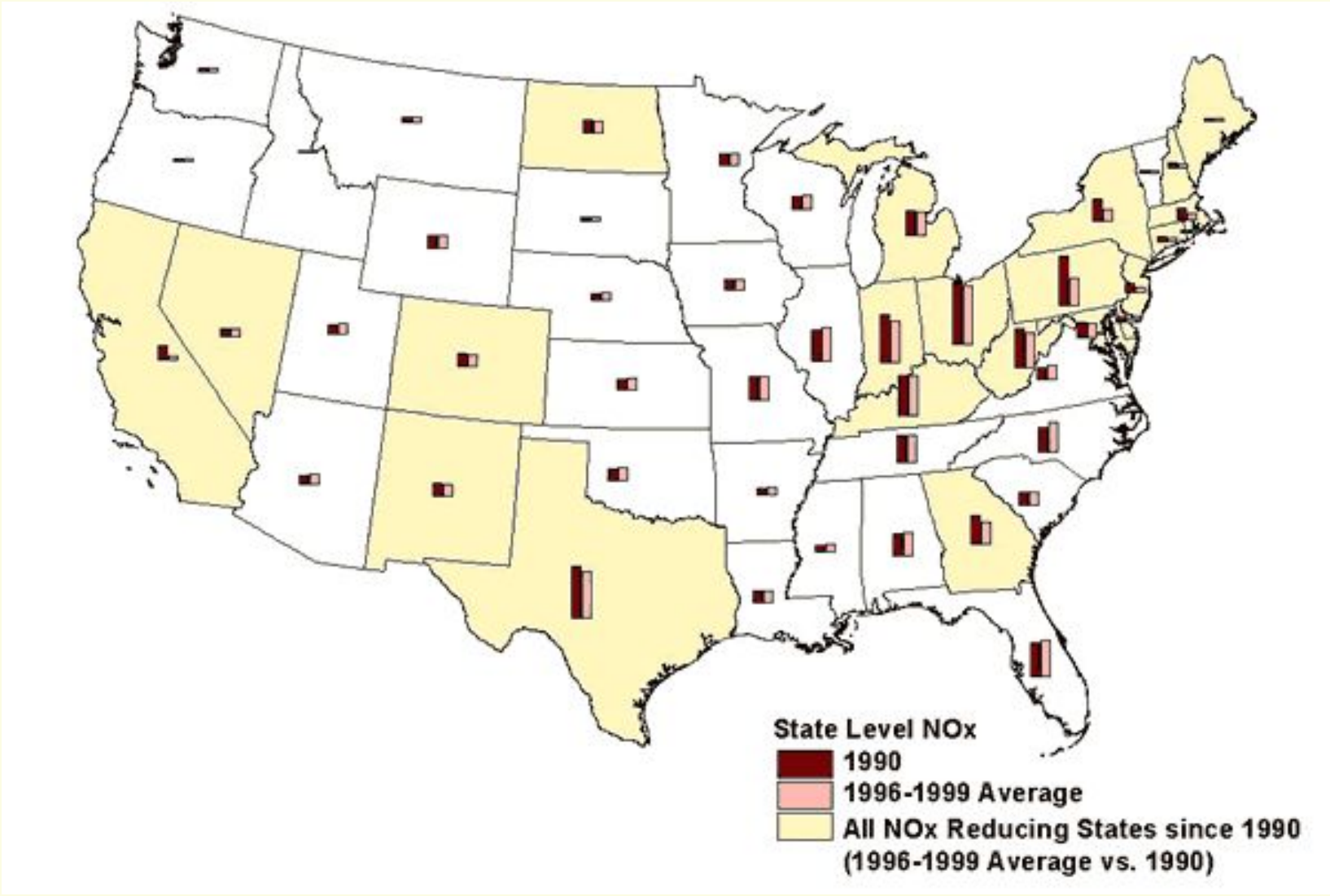


Nitrogen deposition 1989 - 1991

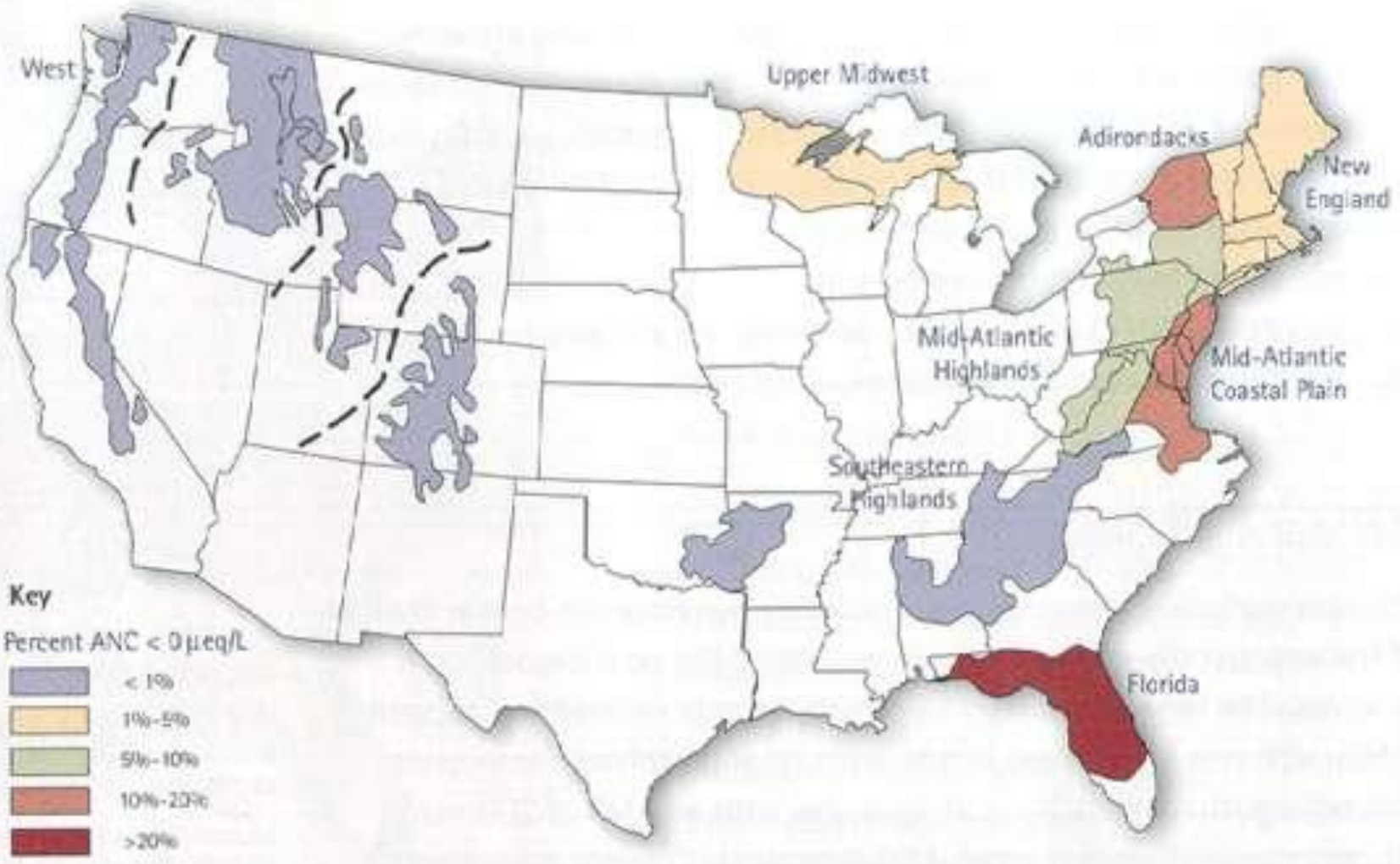


Nitrogen deposition 1995 - 1998

Change in NOx emissions 1990 - 1999



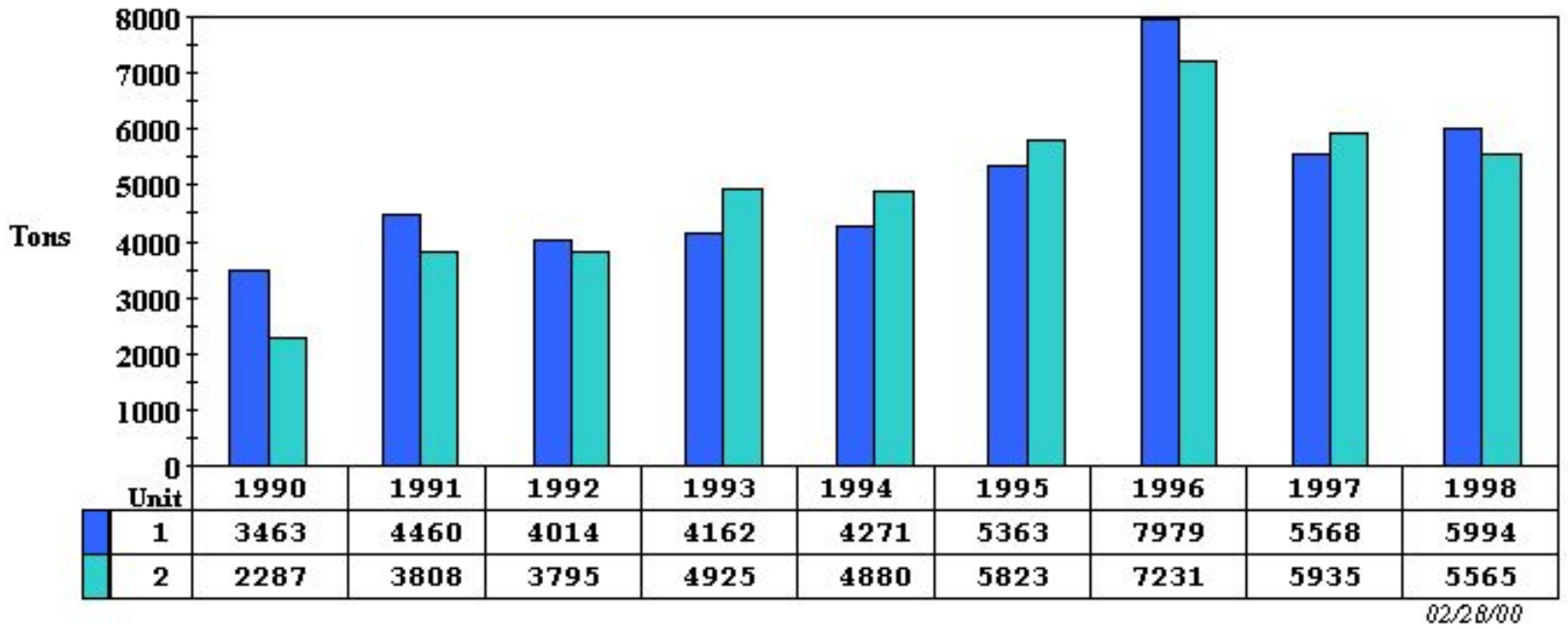
Surface water sensitivity to Acid Deposition - known in 1990



Source: NAPAP. 1991. 1990 Integrated Assessment Report.

Surface water sensitivity to Acid Deposition - known in 1998

Emissions increasing in the western US

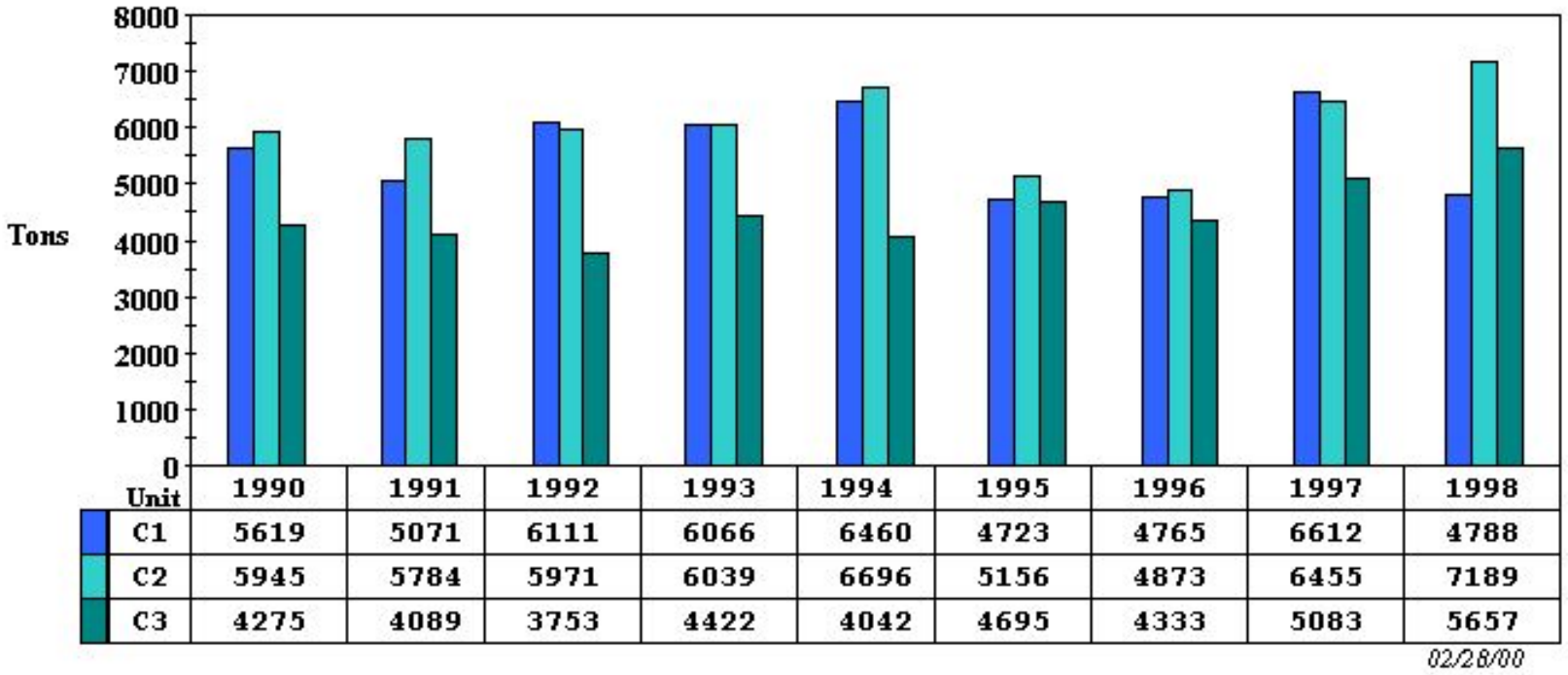


Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	3463	4460	4014	4162	4271	5363	7979	5568	5994
2	2287	3808	3795	4925	4880	5823	7231	5935	5565

1990
5,700

1998
11,600

Emissions increasing in the western US

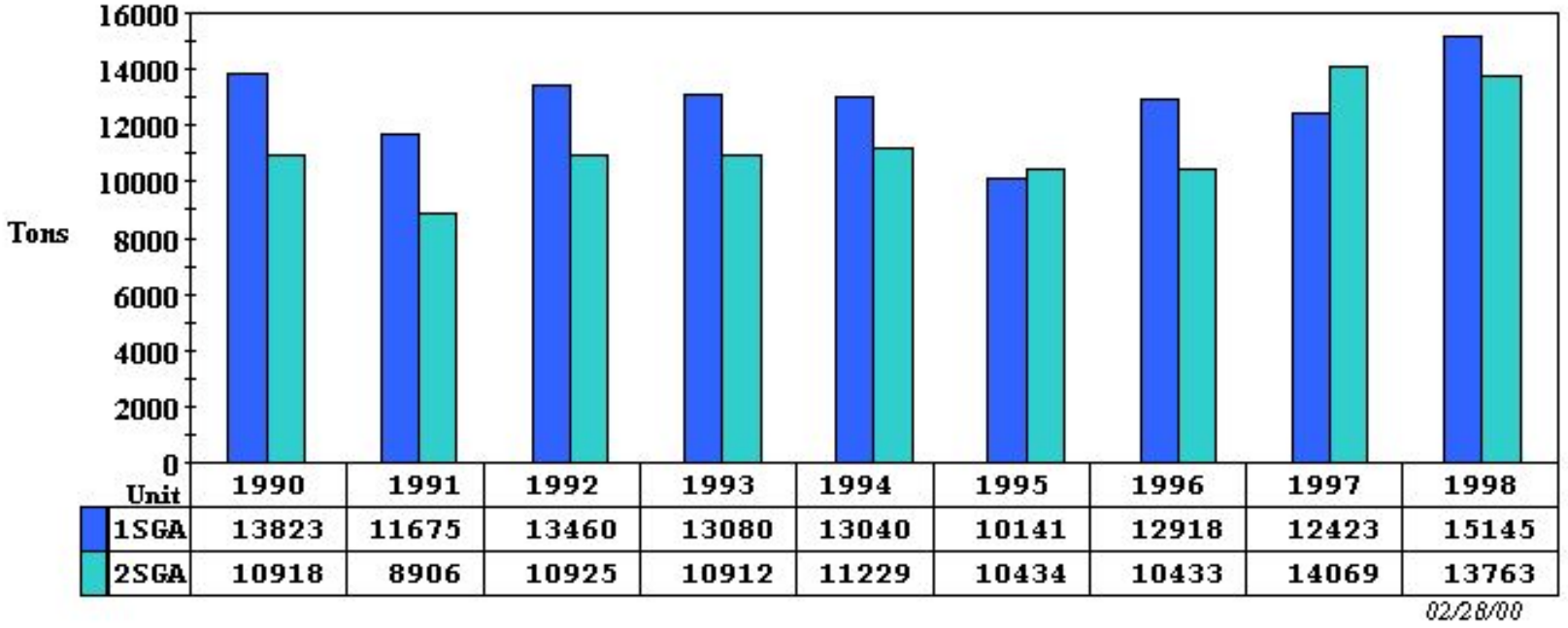


Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998
C1	5619	5071	6111	6066	6460	4723	4765	6612	4788
C2	5945	5784	5971	6039	6696	5156	4873	6455	7189
C3	4275	4089	3753	4422	4042	4695	4333	5083	5657

1998
17,600

1990
15,800

Emissions increasing in the western US



Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998
1SGA	13823	11675	13460	13080	13040	10141	12918	12423	15145
2SGA	10918	8906	10925	10912	11229	10434	10433	14069	13763

1998
28,800

1990
24,700

Acid Rain Summary

Recent and current policies to reduce acid precipitation and Nitrogen emissions are shifting the problem from one area to another

While emissions are remaining stable or decreasing in already Heavily impacted areas, they are increasing in formerly "clean" or relatively unimpacted areas (including other countries!)

-Nitrogen is only one compound important in acid rain and pollutant emissions to the atmosphere

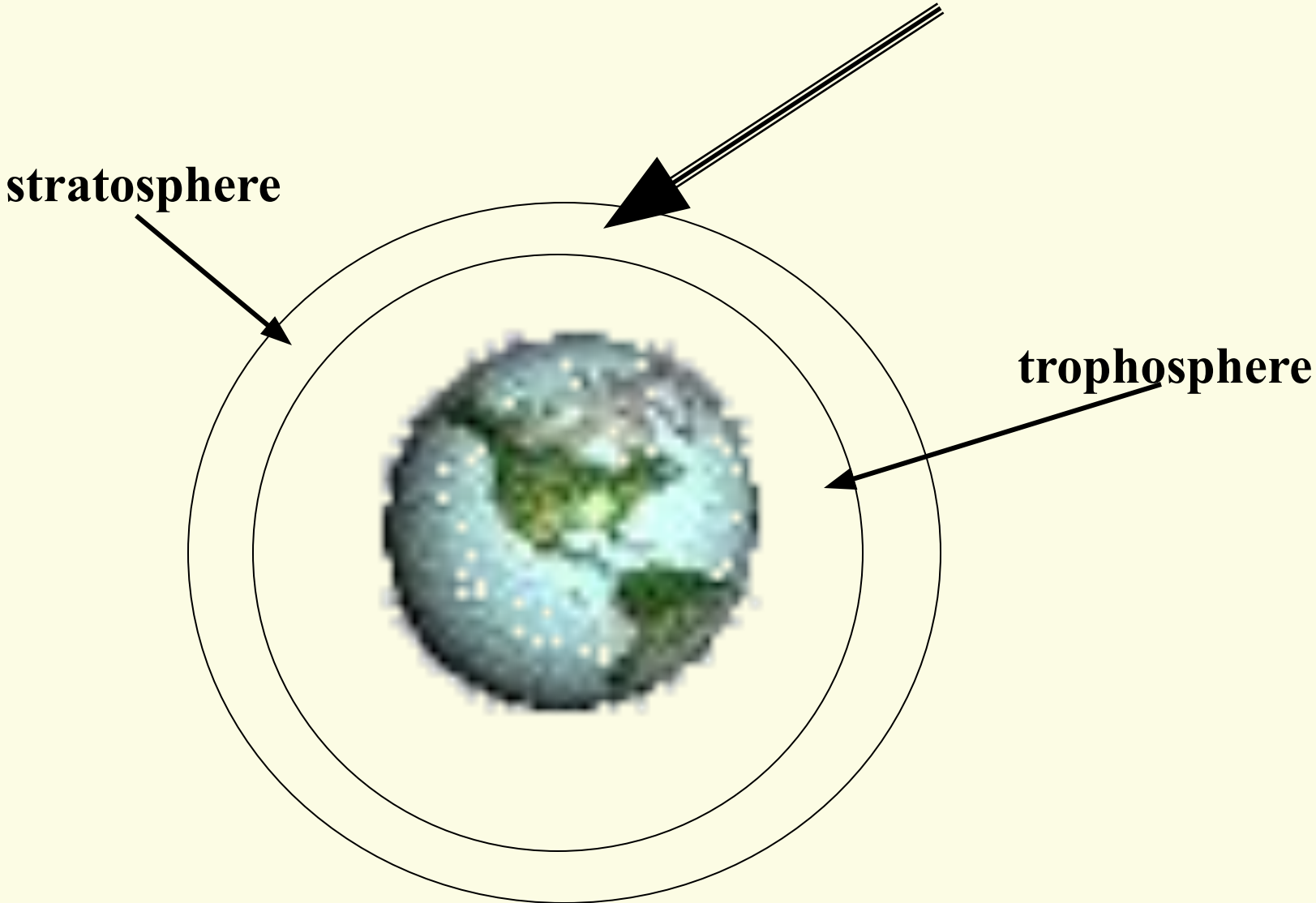
sulfur – SOx – has been a relative success story

mercury is not an acid forming element, but is extremely toxic and is still increasing

Other types of air pollution

- The difference between stratospheric and tropospheric ozone
- Photochemical smog
  - Inversion layers

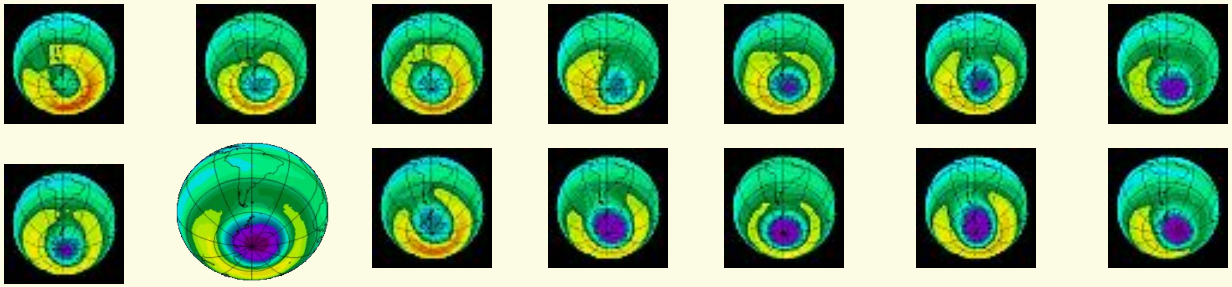
Where is ozone the “good guy”?



In the stratosphere….

- Ozone blocks incoming Ultra-violet radiation
- Ultraviolet radiation
  - Skin cancer
  - Cataracts
  - Plant Damage

But, what's happening to ozone in the Stratosphere?



1979-1985

1986-1992

Nimbus – 7
Total Ozone Mapping
Spectrometer (TOMS)
Images

Deeper purple color means Less ozone above Antartica

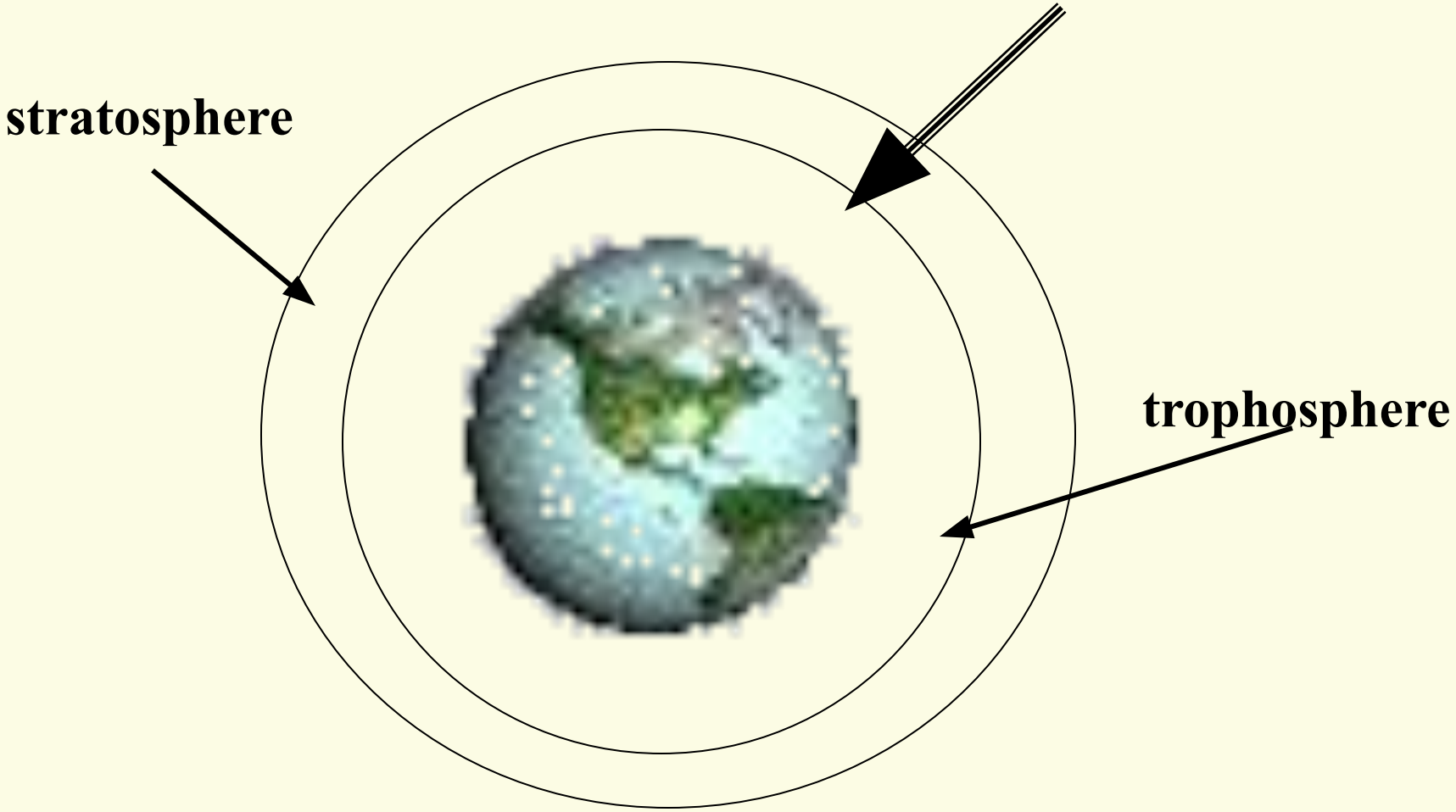
Why?

- Chlorofluorocarbons (CFC) are *very* stable compounds that we produce at earth's surface
- They migrate to the stratosphere
- Their chlorine gets excited by ultraviolet light
- After excitation, chlorine attacks ozone layer, depleting it.

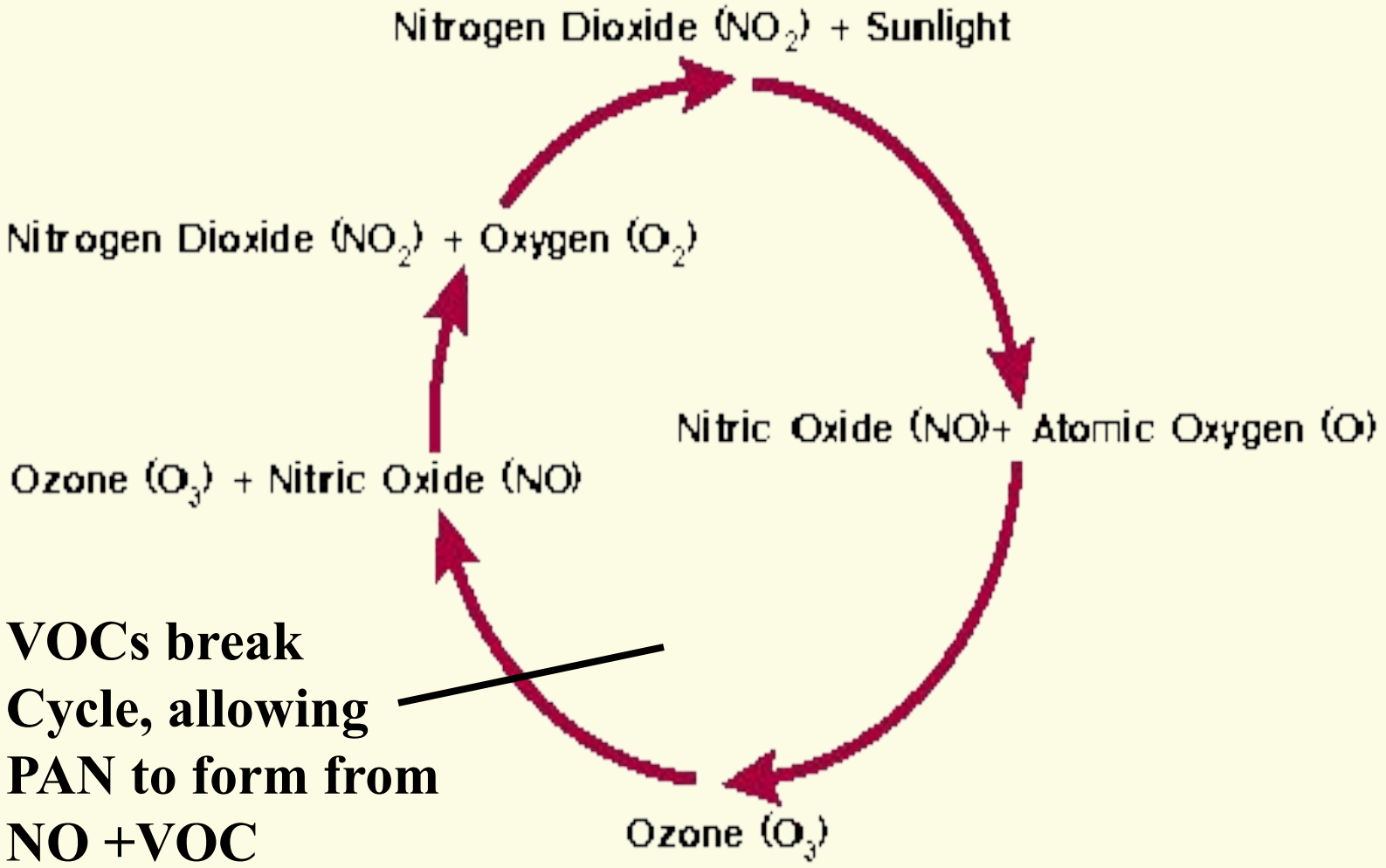
The Montreal Protocol has reduced use of CFC's, but…

- Their long life span means that they will be in the stratosphere for a long time, still destroying ozone.
- However, the rate of increase of ozone depletion has slow, showing we are on the right track
- By the way, ozone "holes" are opening up in places other than Antarctica

Where is ozone the “bad guy”?



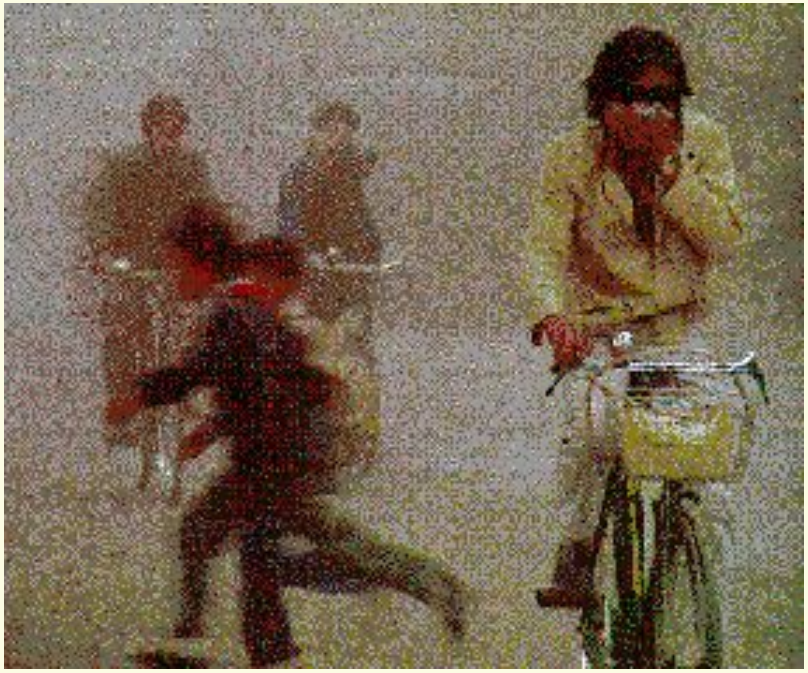
Photochemical Smog



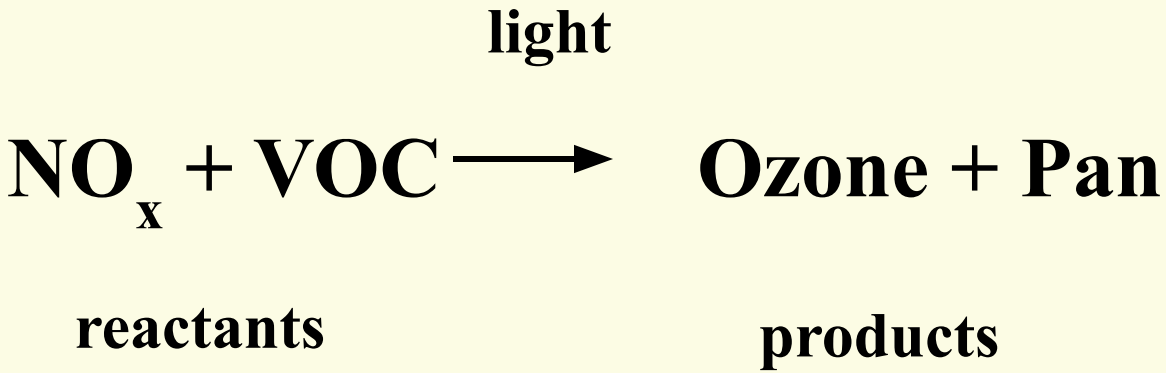
VOCs break Cycle, allowing PAN to form from NO +VOC

PAN = Peroxyacetyl nitrate

Examples of Smog



Chemical Equation for Photochemical Smog

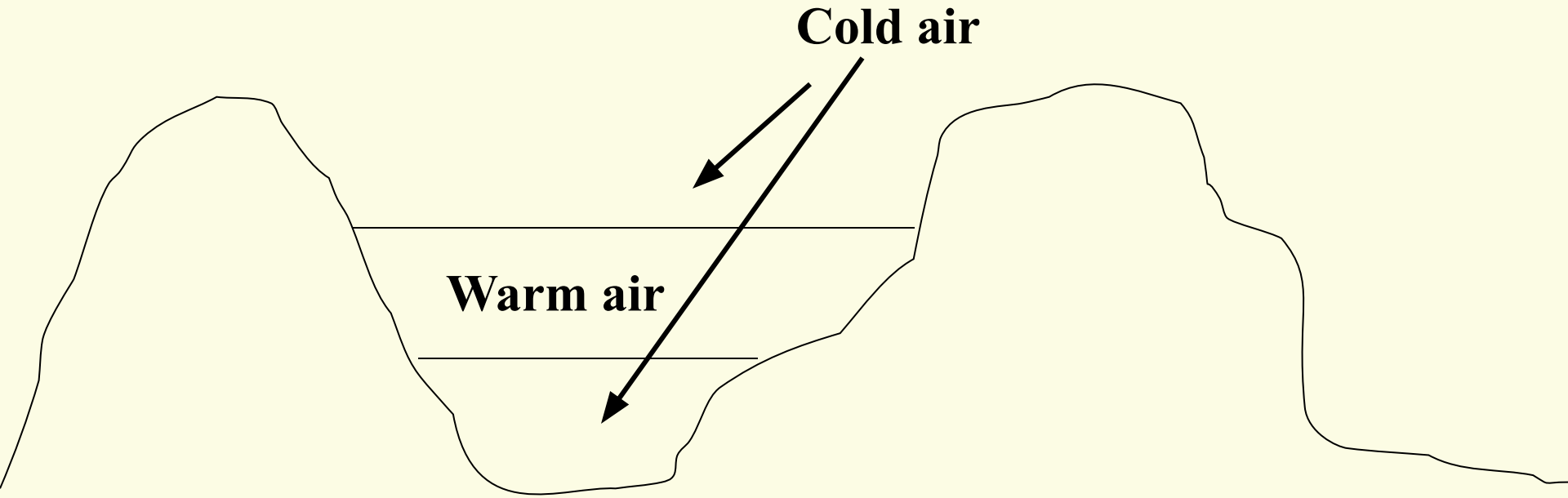


PAN = Peroxyacetyl nitrate

Where reactants come from

- NO_x primarily from transportation
- VOC from a variety of sources, including refining, other industries, etc.

Inversion layers trap cold air, allowing pollutants to build up in concentrations, including the compounds needed for photochemical smog



Ozone's bad features

- Extremely reactive will burn leaves, lungs, synthetic compounds (e.g. rubbers, plastics)
- Because of reactivity, is toxic in very low concentrations (parts per billion)

Water Pollution

Humans depend on very small reservoirs of water for all our needs

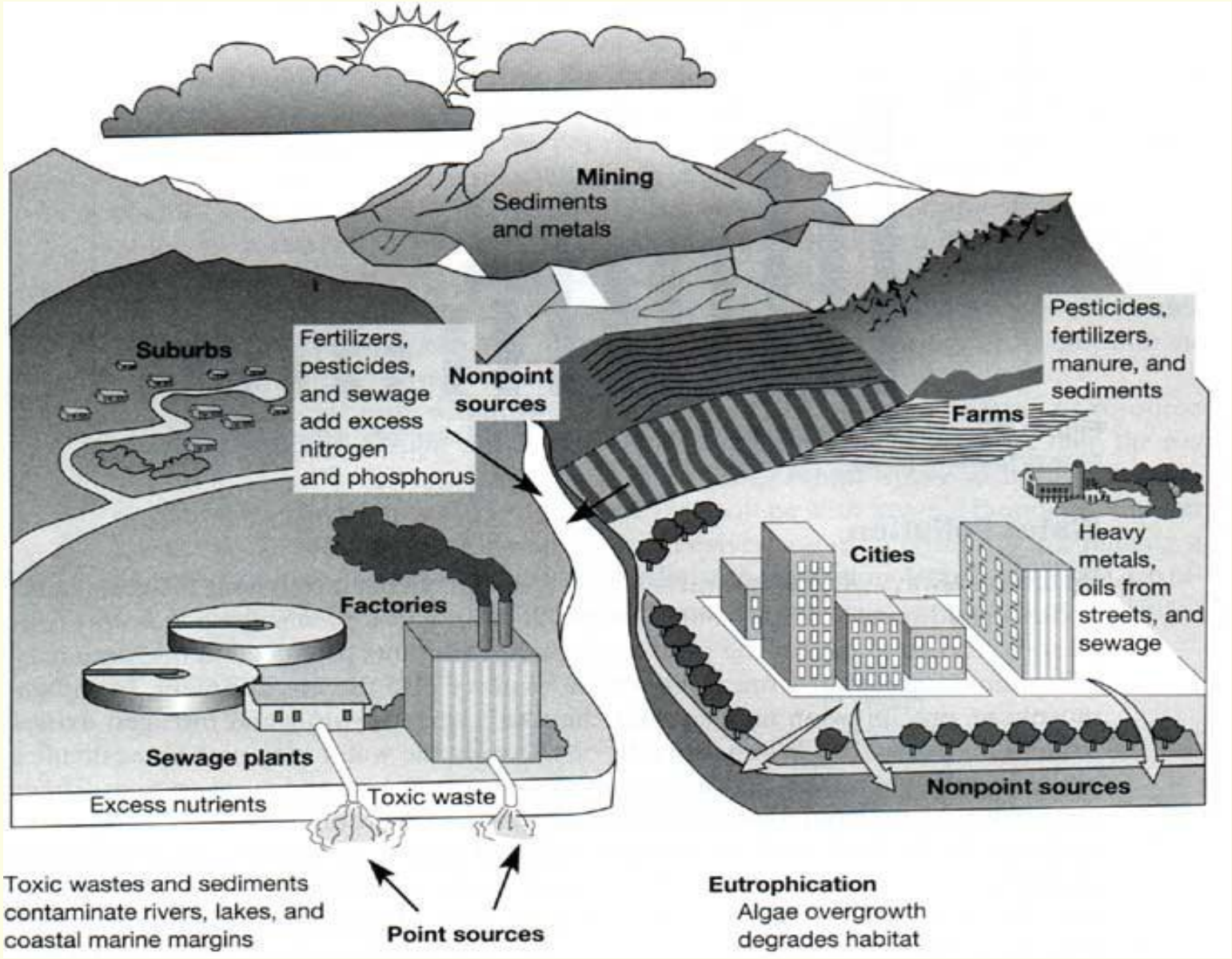
These reservoirs cycle/ turnover very quickly

As they cycle they can either

collect pollution from other sources, or

be cleaned by passing through functioning ecosystems

Water Pollution



Water Pollution

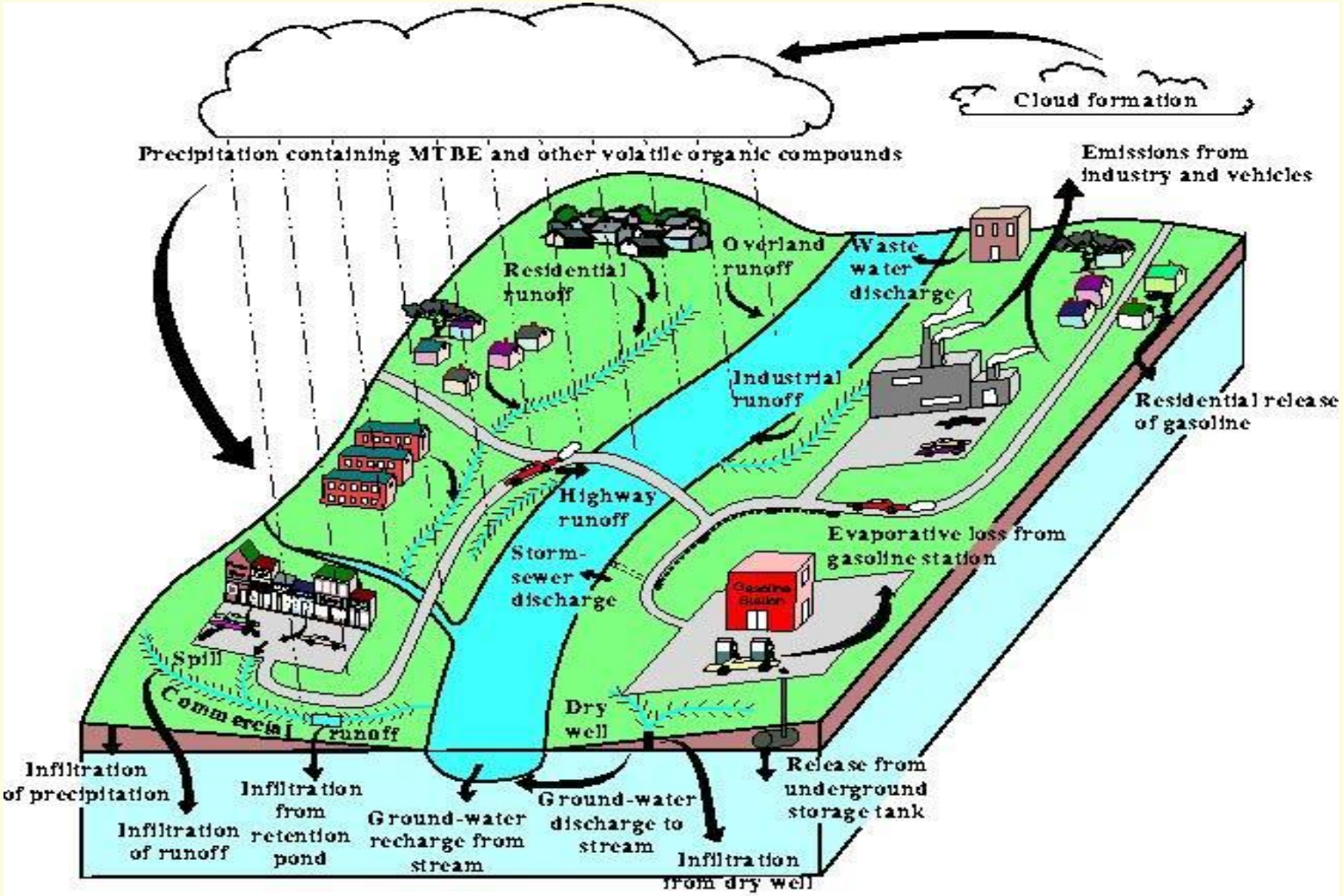


Figure 1. Movement of MTBE and other volatile organic compounds in the hydrologic cycle.

Water Pollution

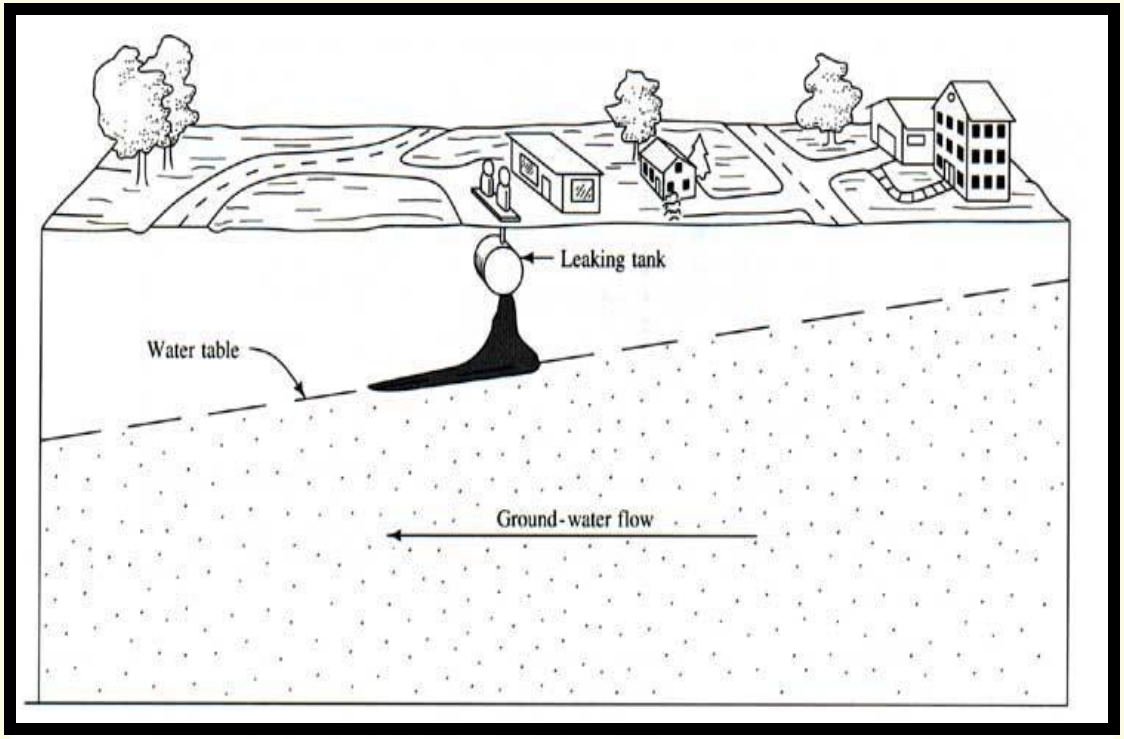
Two major classifications

- Point Source
- Non-point Source

Point Sources

- Single large source
- Can localize it to one spot
  - Industrial Plants
  - Sewage pipes

Point Source - Example



- LUST - Leaky Underground Storage Tanks
- 22% of the 1.2 million UST are LUSTy
- Look at water pollution from gasoline...

Point source examples

- Non-point Sources

- Diffuse source or many smaller point sources
- Automobiles
- Fertilizer on fields

Non point source examples

Non-point source pollutants - nutrients

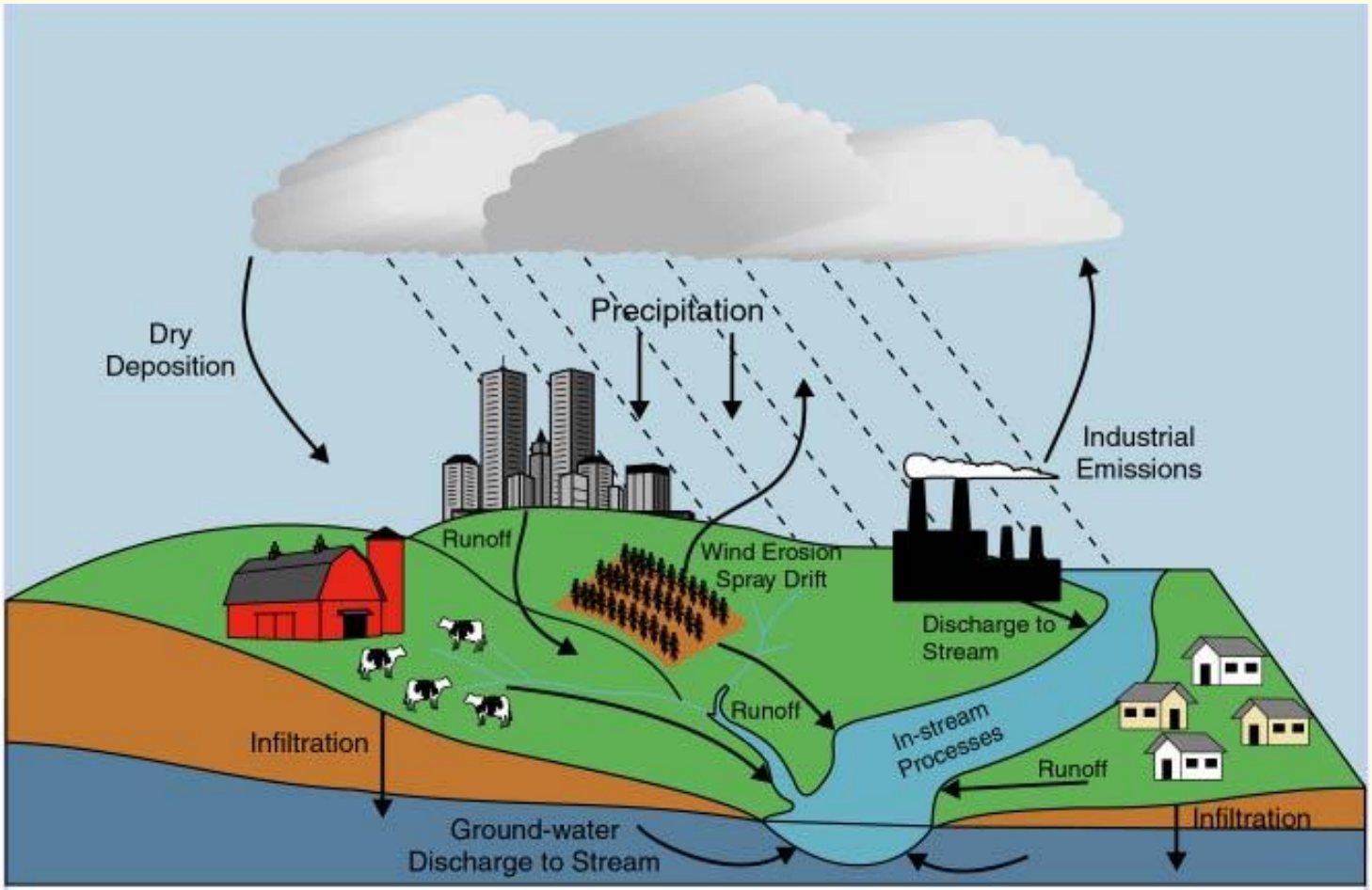
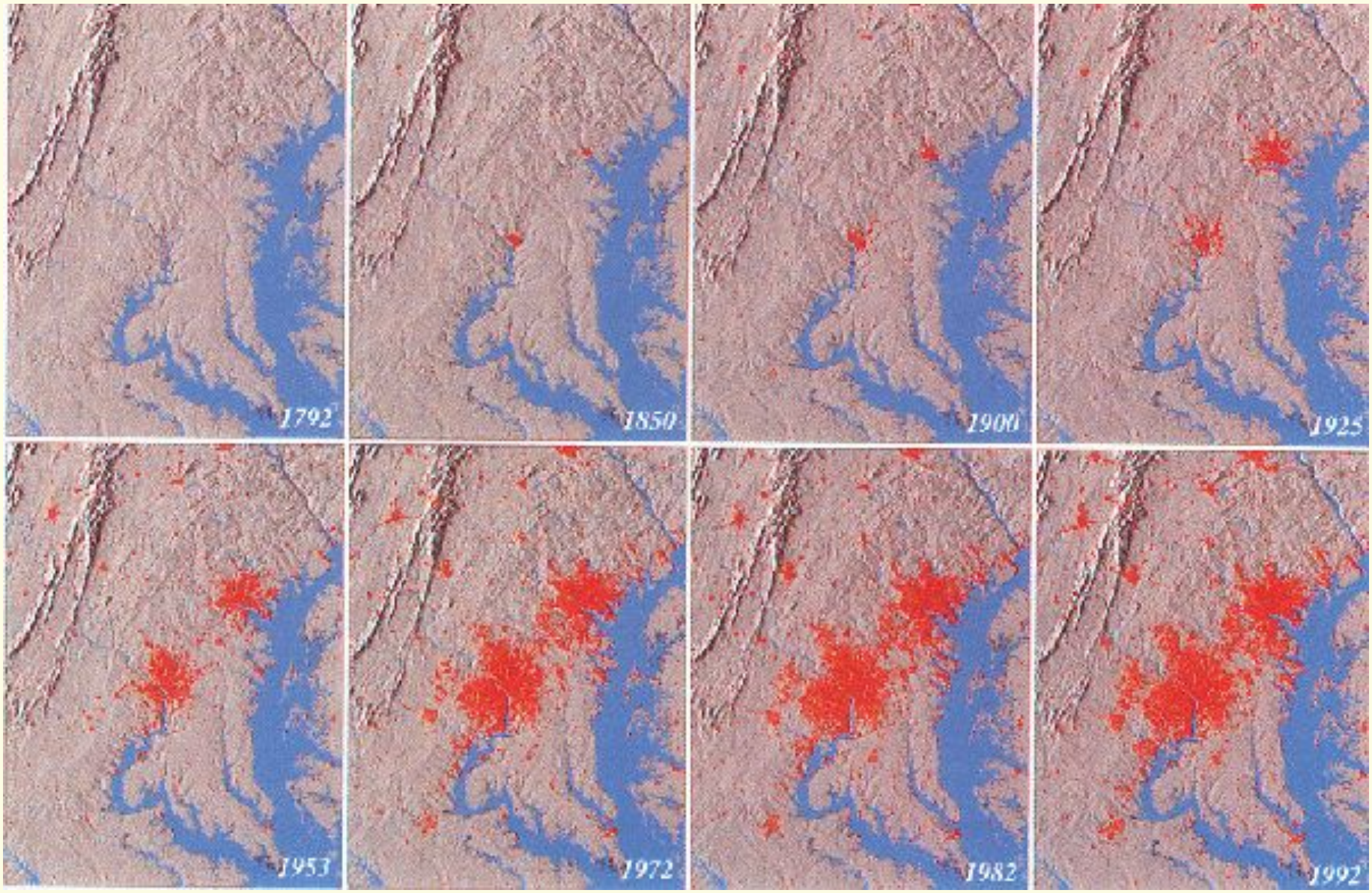


Figure 2. Nutrient movement in the hydrologic cycle.

End Lecture 4/22/03

In class activity – pollutant sources in the Chesapeake Bay



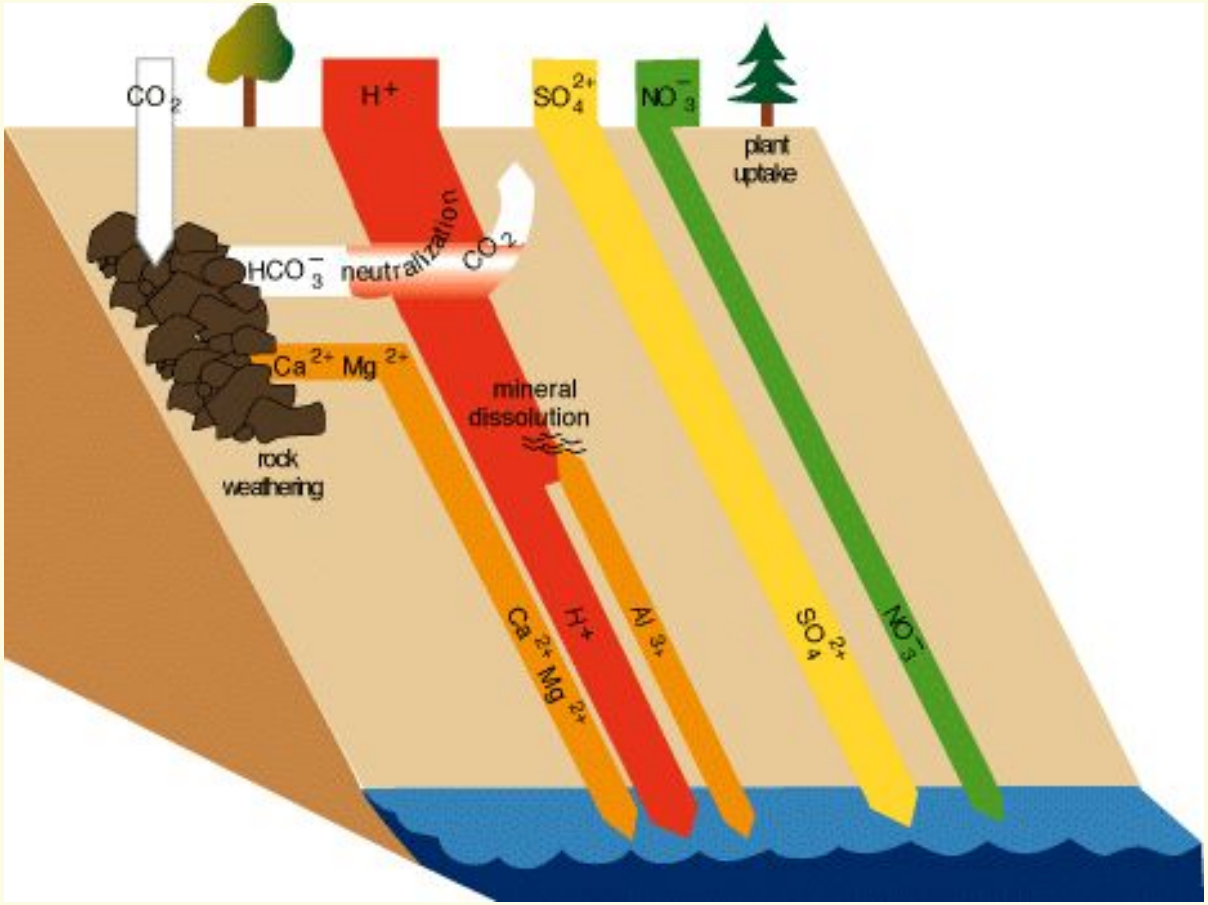
The four main roles for class debate on 5/1/2003

Pacific Lumber Company /Maxxam Corporation
The CEO's
The managing directors of the project

Environmentalists
Sierra Club Members
EarthFirst! Activists

Townspeople
Local loggers
Local sports persons

Government Representatives
Bureau of Land Management
California Representative who introduced the legislation


CO_2
H^+
SO_4^{2-}
NO_3^-
plant uptake
HCO_3^- neutralization CO_2
Ca^{2+} Mg^{2+}
mineral dissolution
rock weathering
Ca^{2+} Mg^{2+}
H^+
Al^{3+}
SO_4^{2-}
NO_3^-

How does acid kill the fish? One way is mobilizing metals

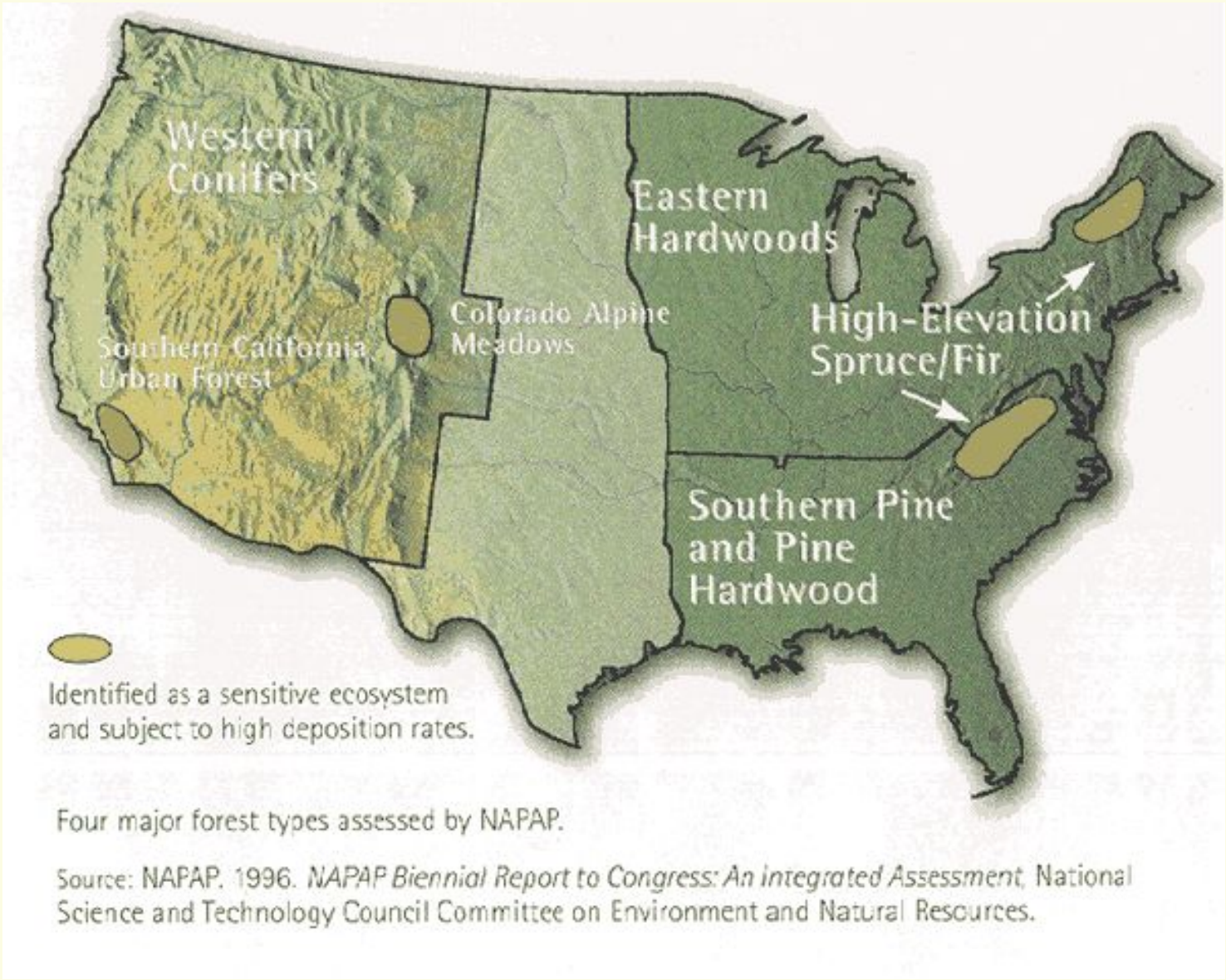
- When all base cations are striped from soils
- Acid now reacts with metals e.g. aluminum
  - Normally aluminum is immobile
  - below pH 5 - mobile aluminum
- Fish breath in the water
  - Aluminum comes out of solution
  - Clogs gills - suffocate

Acid Rain Effects – Aquatic Systems

When the pH drops below 6.0 species start to die off.
When one species dies, others that depend on it may as well

Watersheds – Large areas thought to be nitrogen saturated

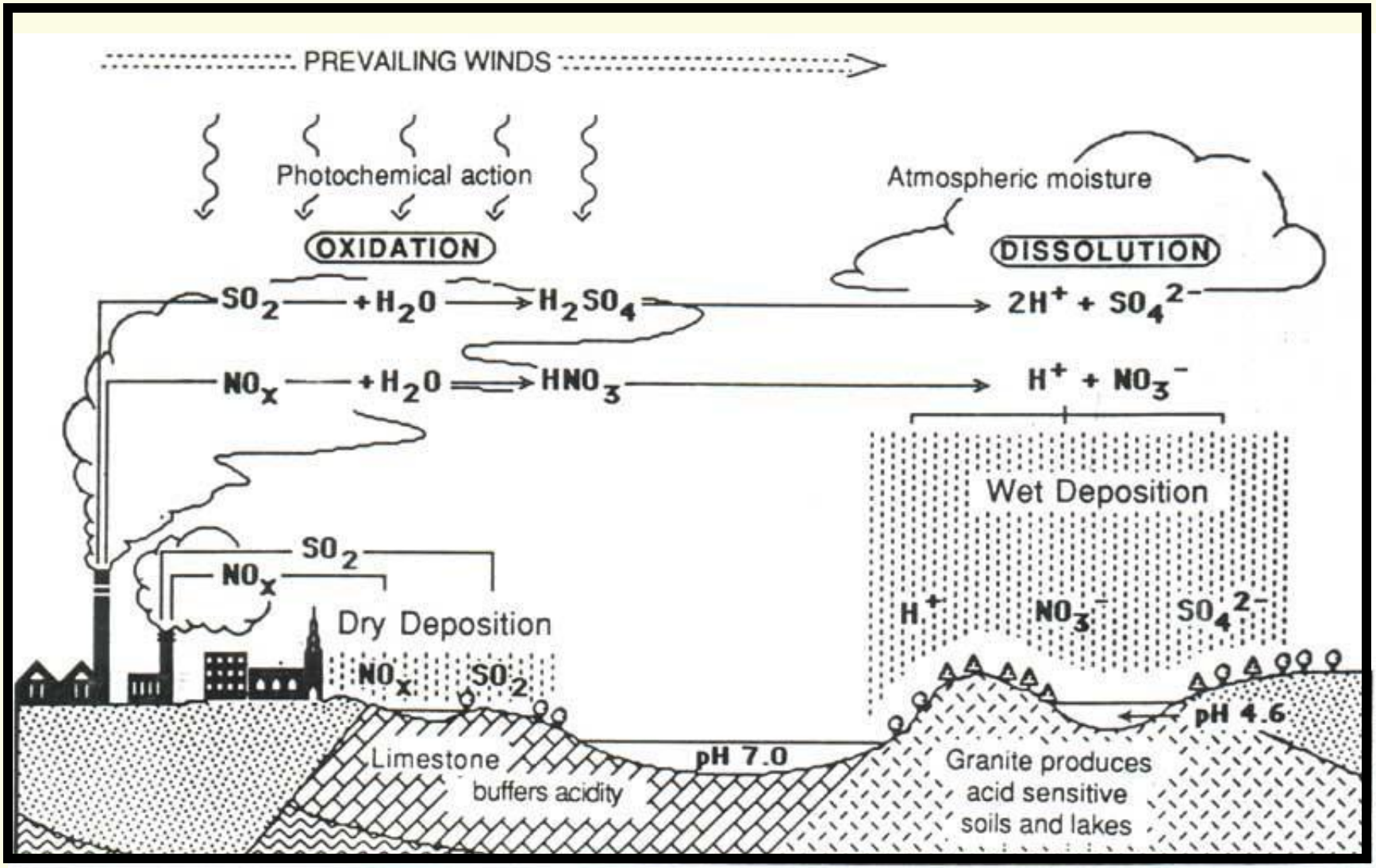
Land - Sensitive Ecosystems to Nitrogen Deposition



Four major forest types assessed by NAPAP.

Source: NAPAP. 1996. *NAPAP Biennial Report to Congress: An integrated Assessment*, National Science and Technology Council Committee on Environment and Natural Resources.

Acid Rain Summary



We're not the only ones concerned about photochemical smog

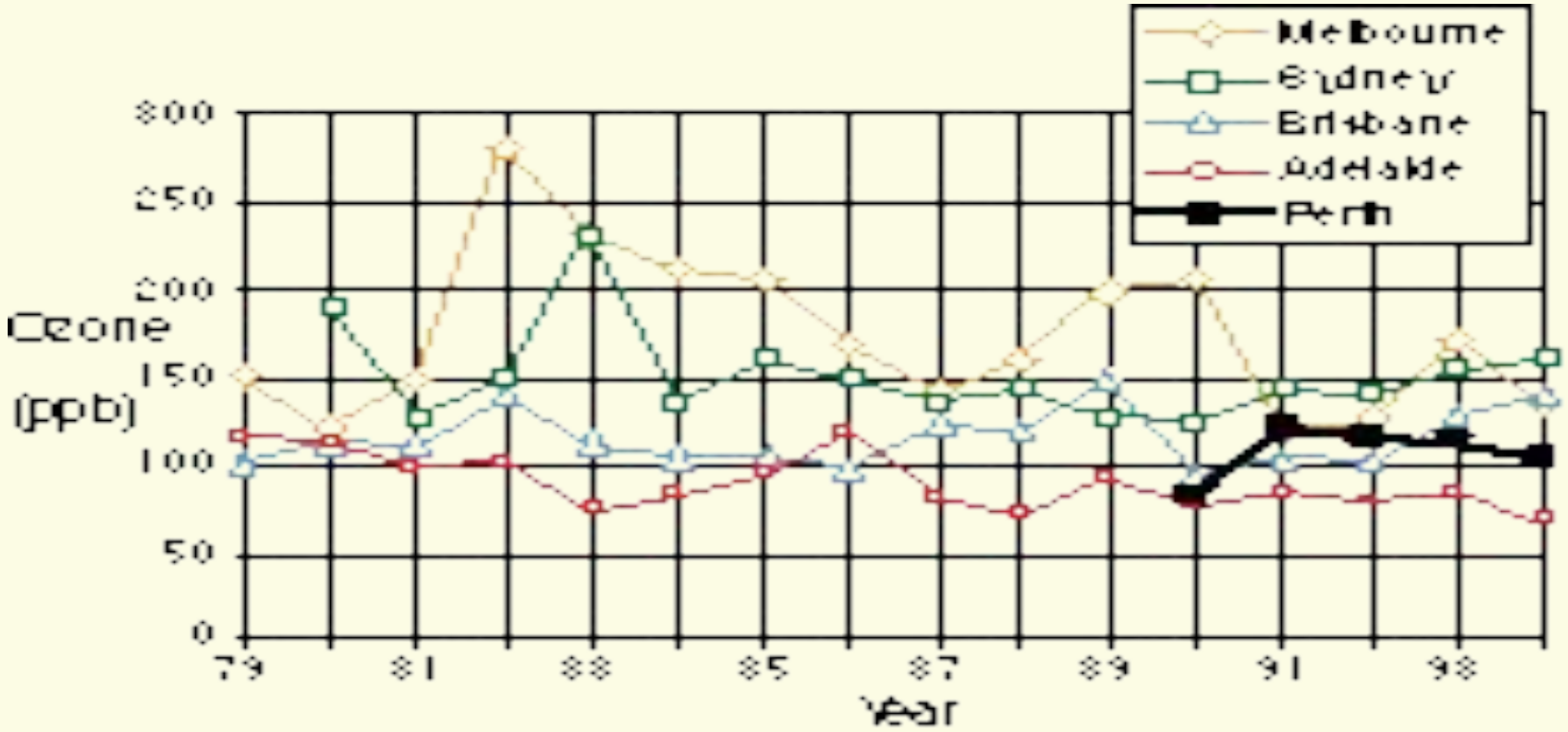


Figure 5. Peak 1-hour ozone concentrations in Australian cities. Average are for clock hours, except for Queensland values, which are based on rolling half-hour averages.