

# Today

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



# Today is Earth Day, April 22<sup>nd</sup> 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.

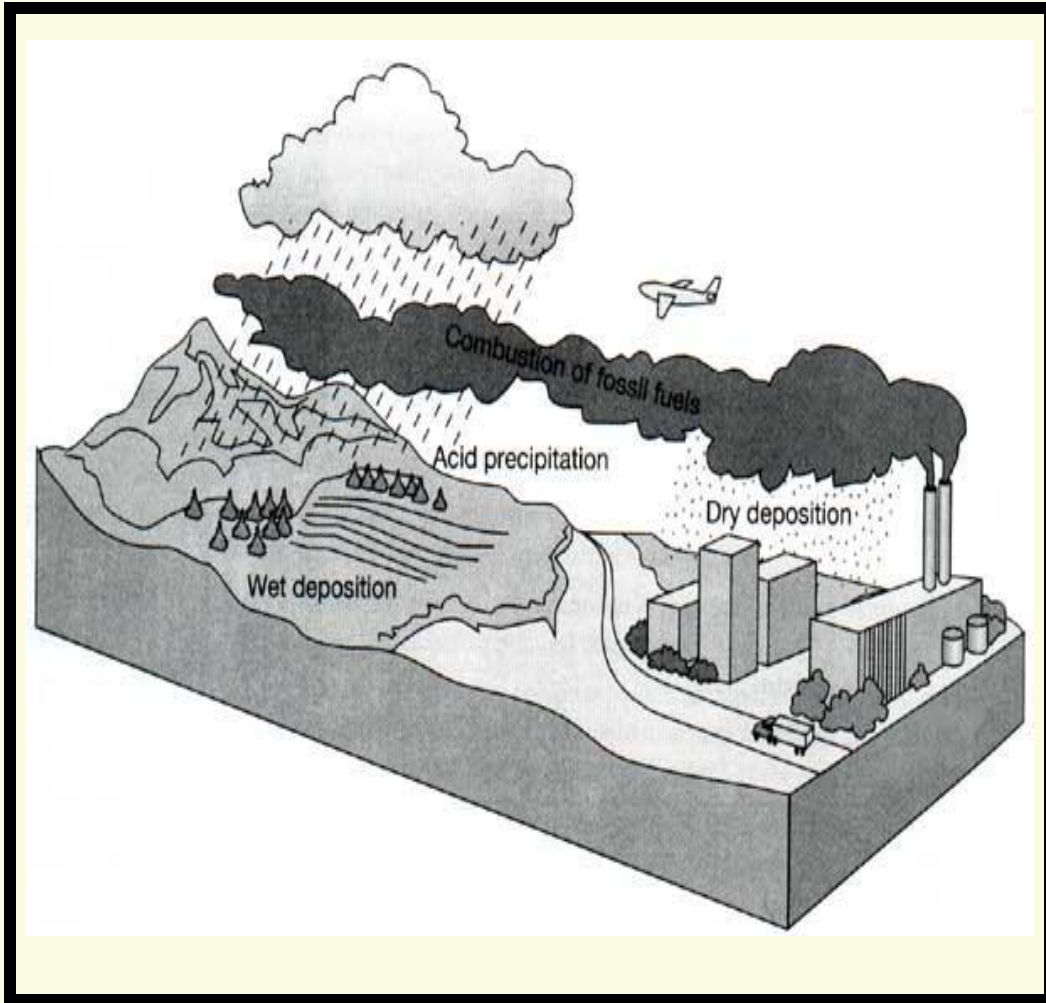
**Help Prevent Stormwater Runoff** - Pollution from stormwater runoff is the most common cause of water pollution today.

**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

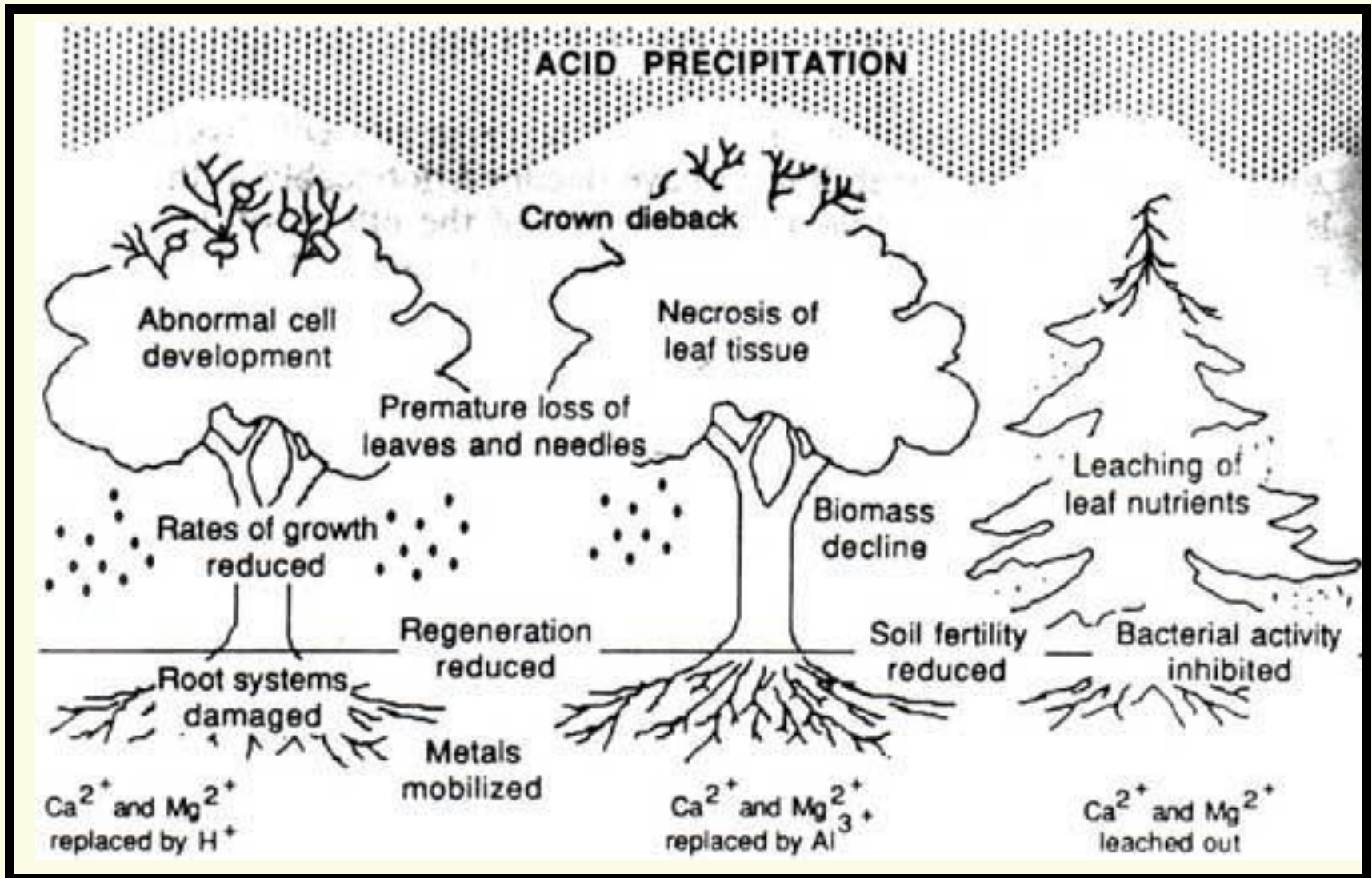


- Reactions to convert to acid take place in ~2 days - travel 1000 miles
- Down wind - Acid rain
- Dry Dep. vs Wet Dep.
- Dry Deposition
  - 50 % of total
  - Can react with plants - strip nutrients
  - Tree dieback





# Acid Rain and Trees





## Forests affected by Acid Rain

Northeast US

Canada

Northern Europe

Asia

*ijkphoto.ch*



# 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



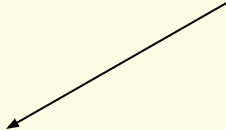
**How acid rain affects stonework.**  
The picture on the left was taken in 1908.  
The picture on the right was taken in 1968

# The US Capitol





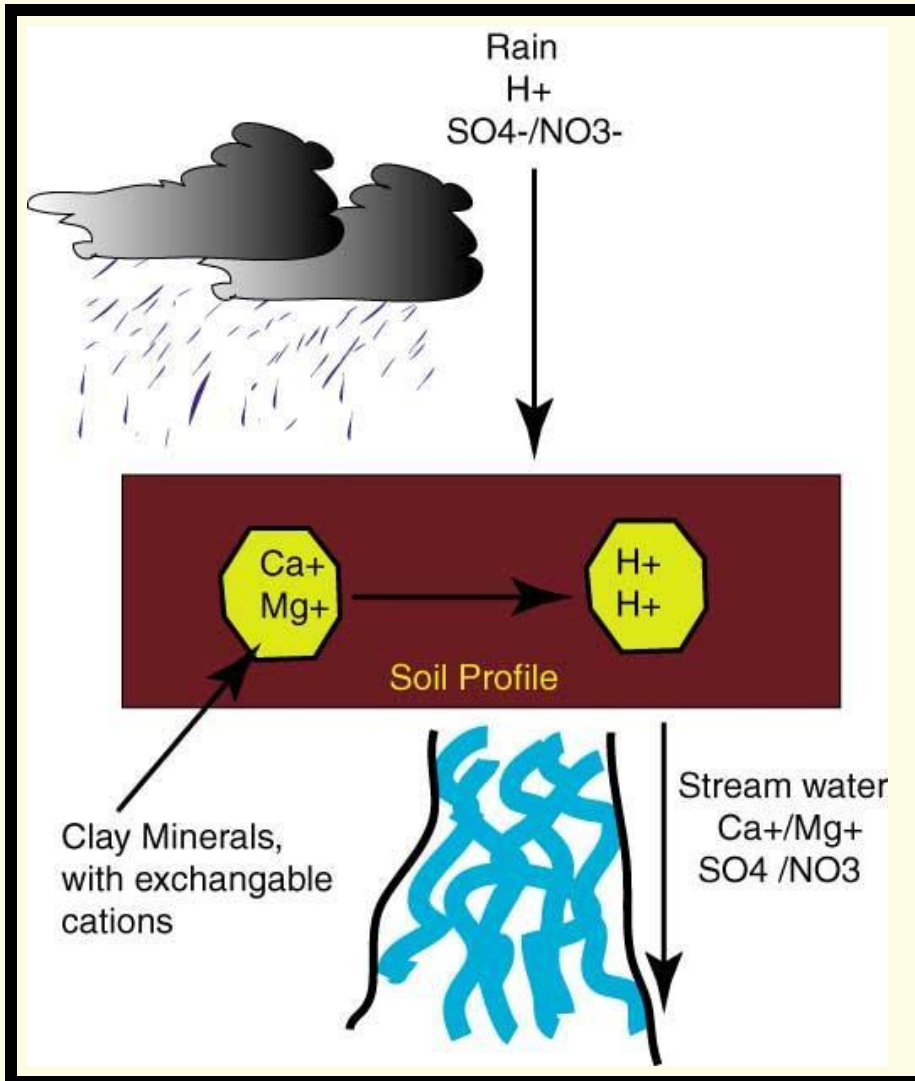
# Human Emissions - Combustion

- $\text{NO}_x$
  - $\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$
  - Forms in high temperatures of combustion engine
  - Converted in the atmosphere to  $\text{HNO}_3$  - nitric acid
- From atm.
- 

# Human Emissions - Fertilizer

- $\text{N}_2 + \text{Energy} + \text{H}^+ \rightarrow \text{NH}_3$
- 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?

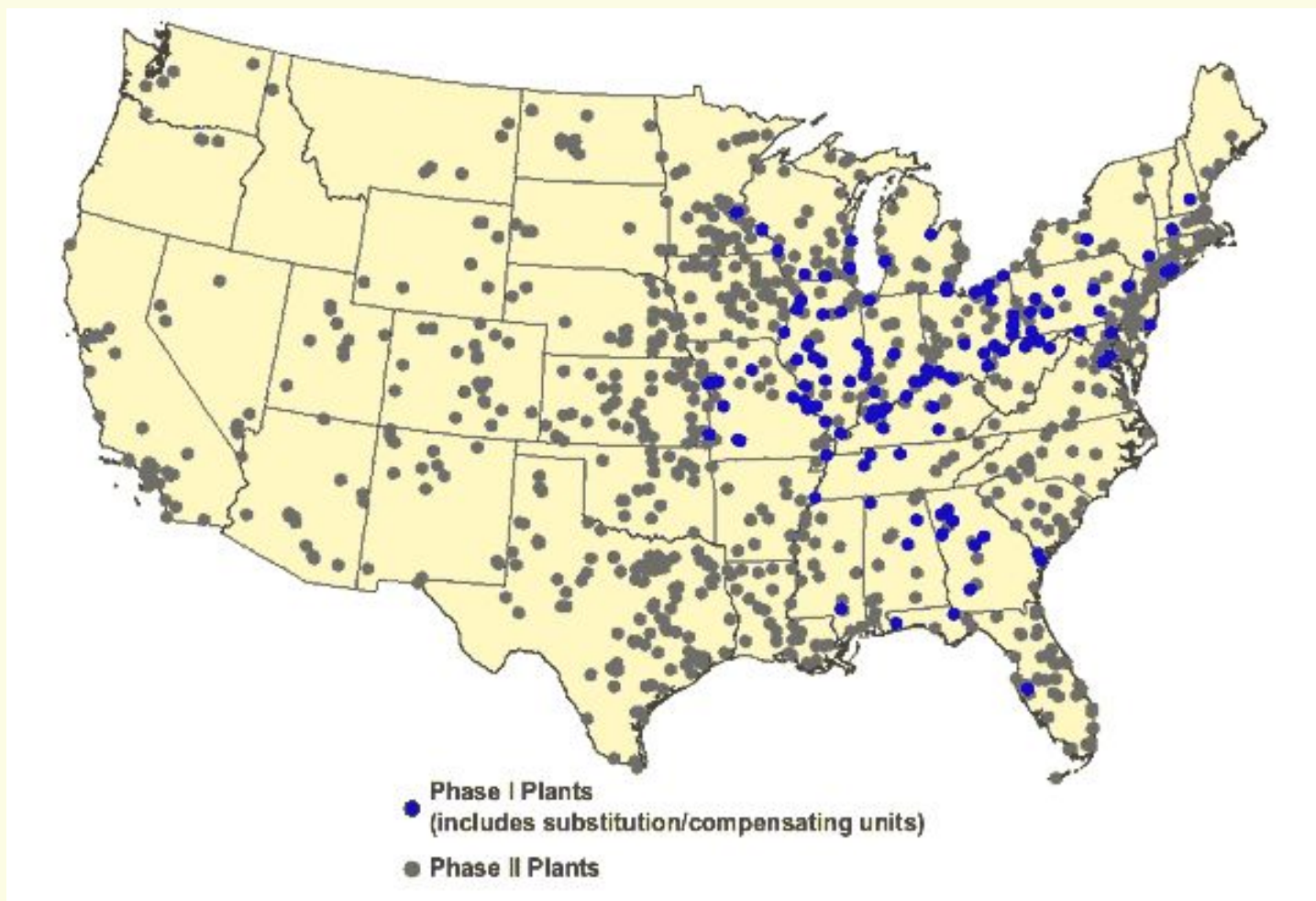
~ 55% come from agriculture

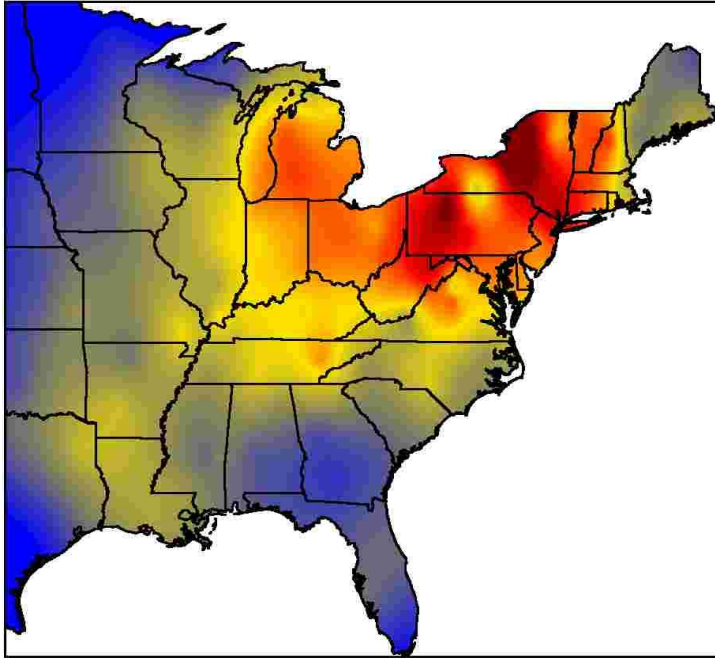
~ 25% come from industry – e.g. coal fired power plants

~ 20% come from automobiles



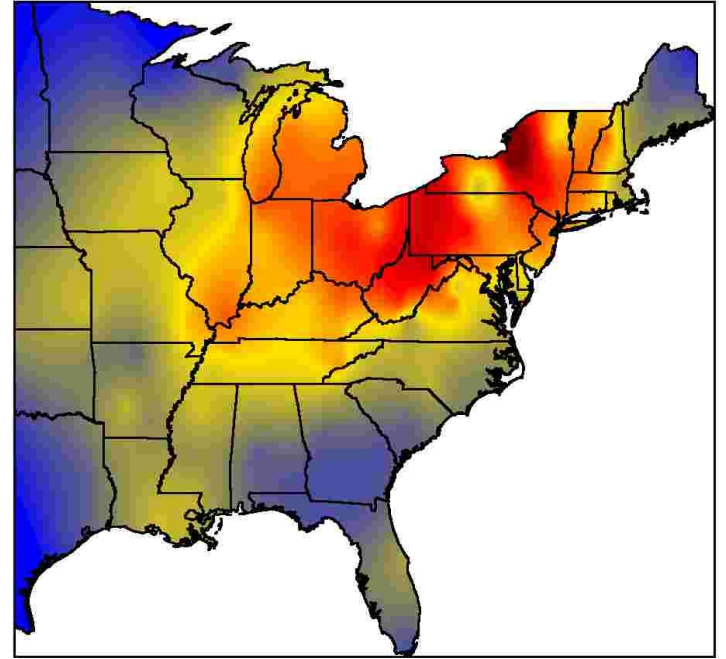
# Major powerplants – sources of N emissions – Acid rain





<6.0 7.6 9.2 10.8 12.4 14.0 15.6 17.2 18.8 20.4 >22.0

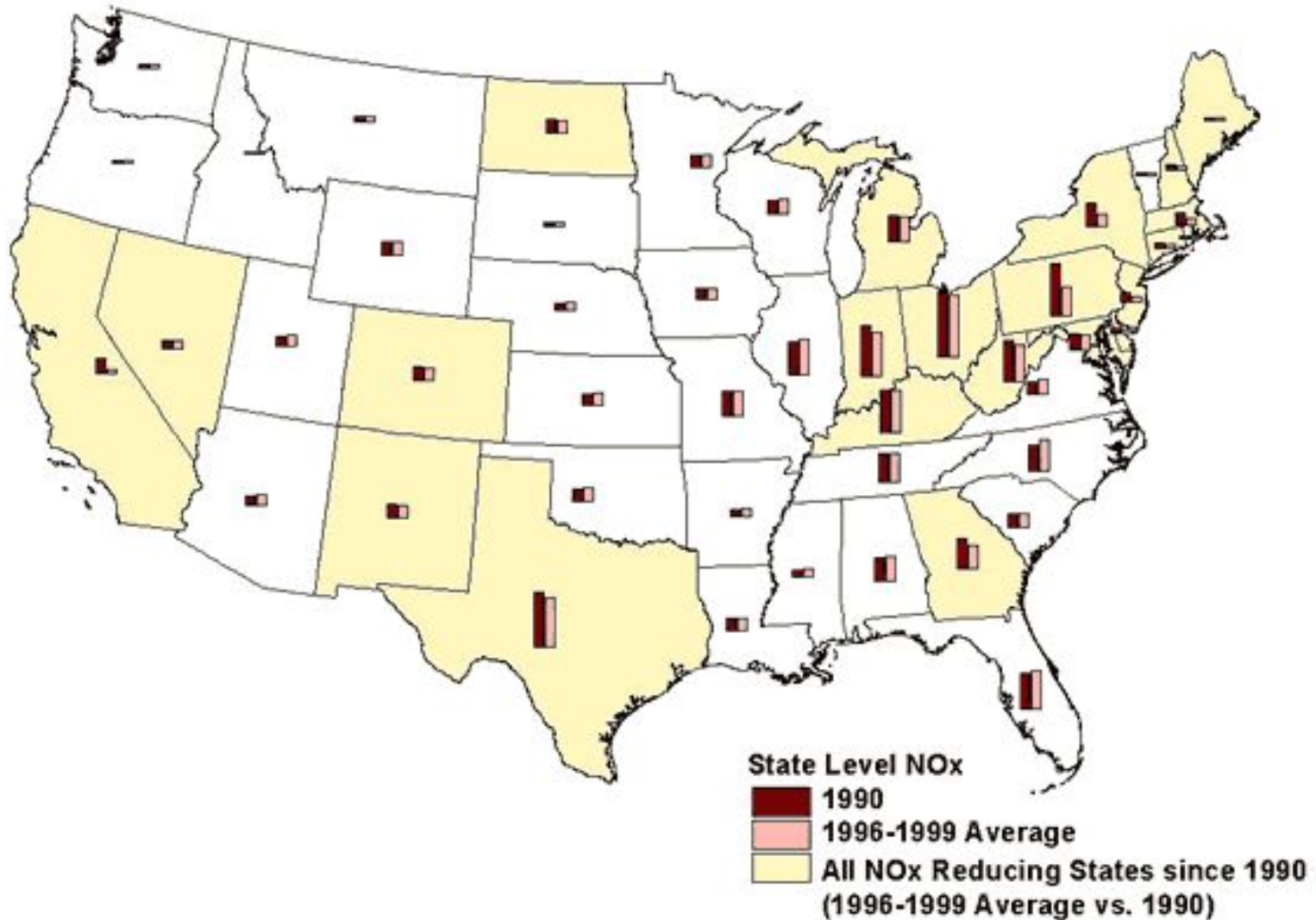
Nitrogen deposition 1989 - 1991



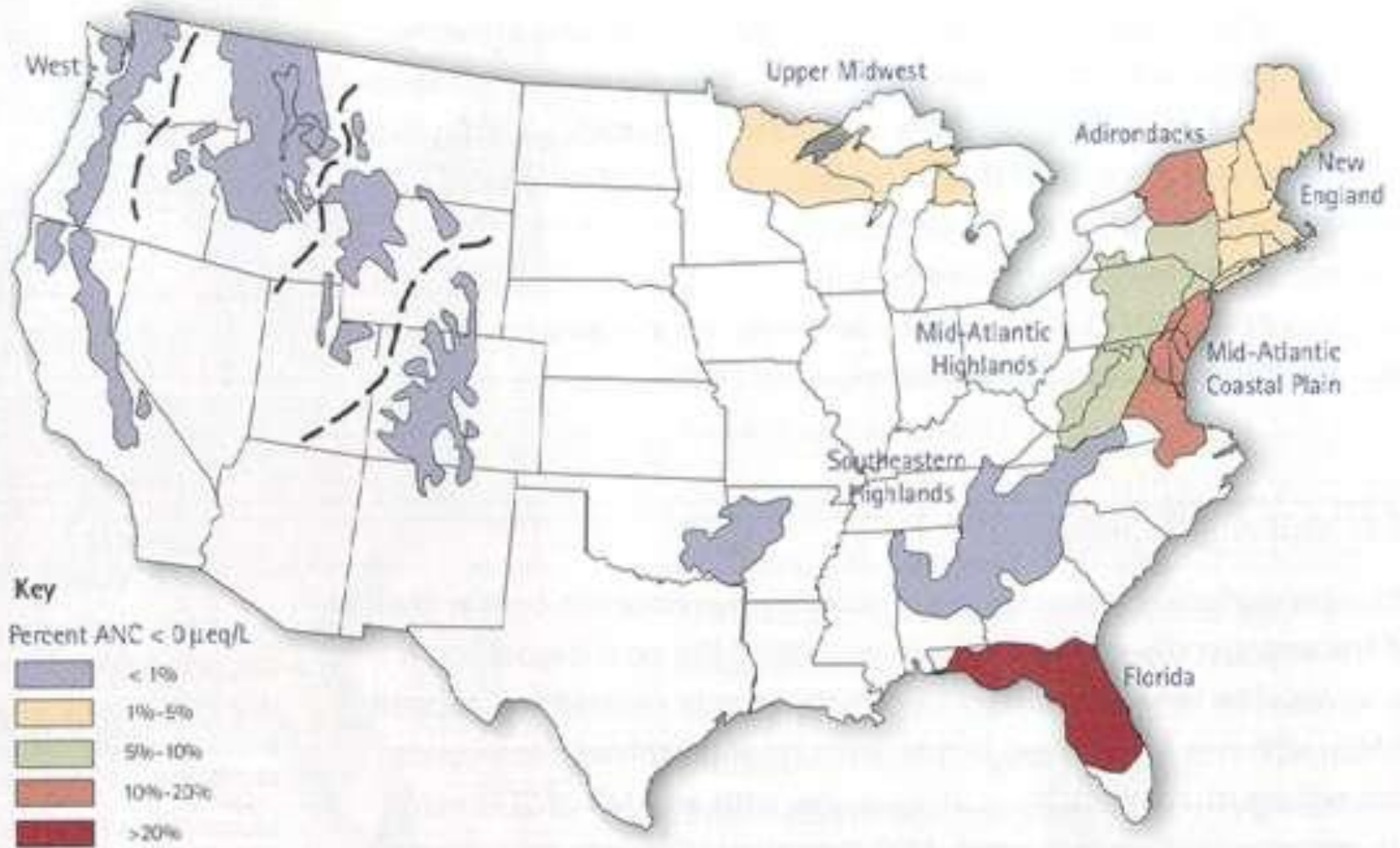
<6.0 7.6 9.2 10.8 12.4 14.0 15.6 17.2 18.8 20.4 >22.0

Nitrogen deposition 1995 - 1998

# Change in NOx emissions 1990 - 1999



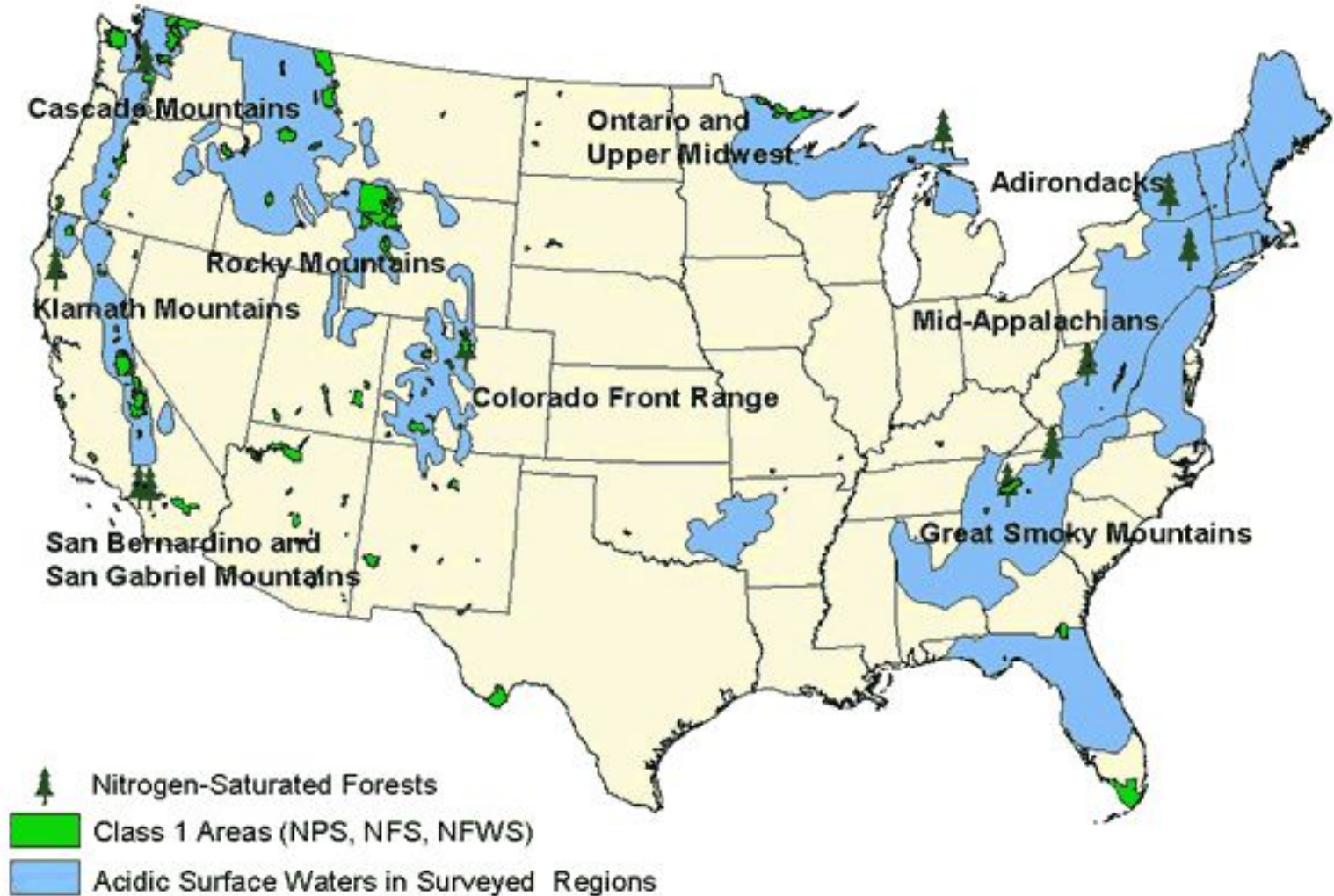
# Surface water sensitivity to Acid Deposition - known in 1990



Source: NAPAP, 1991, 1990 Integrated Assessment Report.

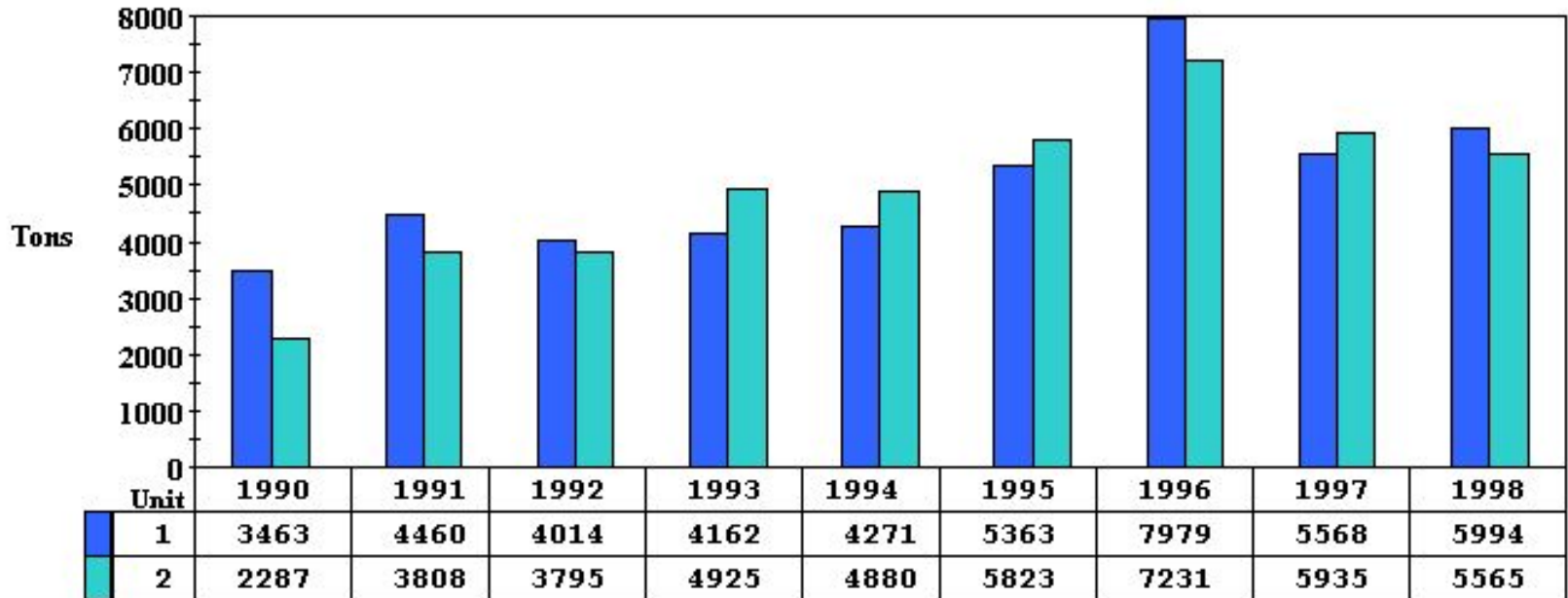


# Surface water sensitivity to Acid Deposition - known in 1998



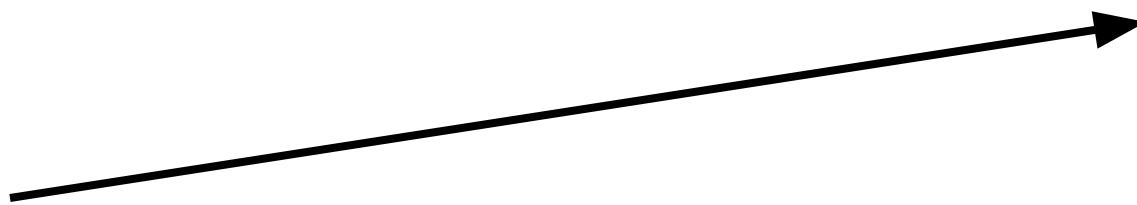
# Emissions increasing in the western US

## Springerville AZ Units 1-2 Annual NOx Mass Emissions (1990-1998)



02/28/00

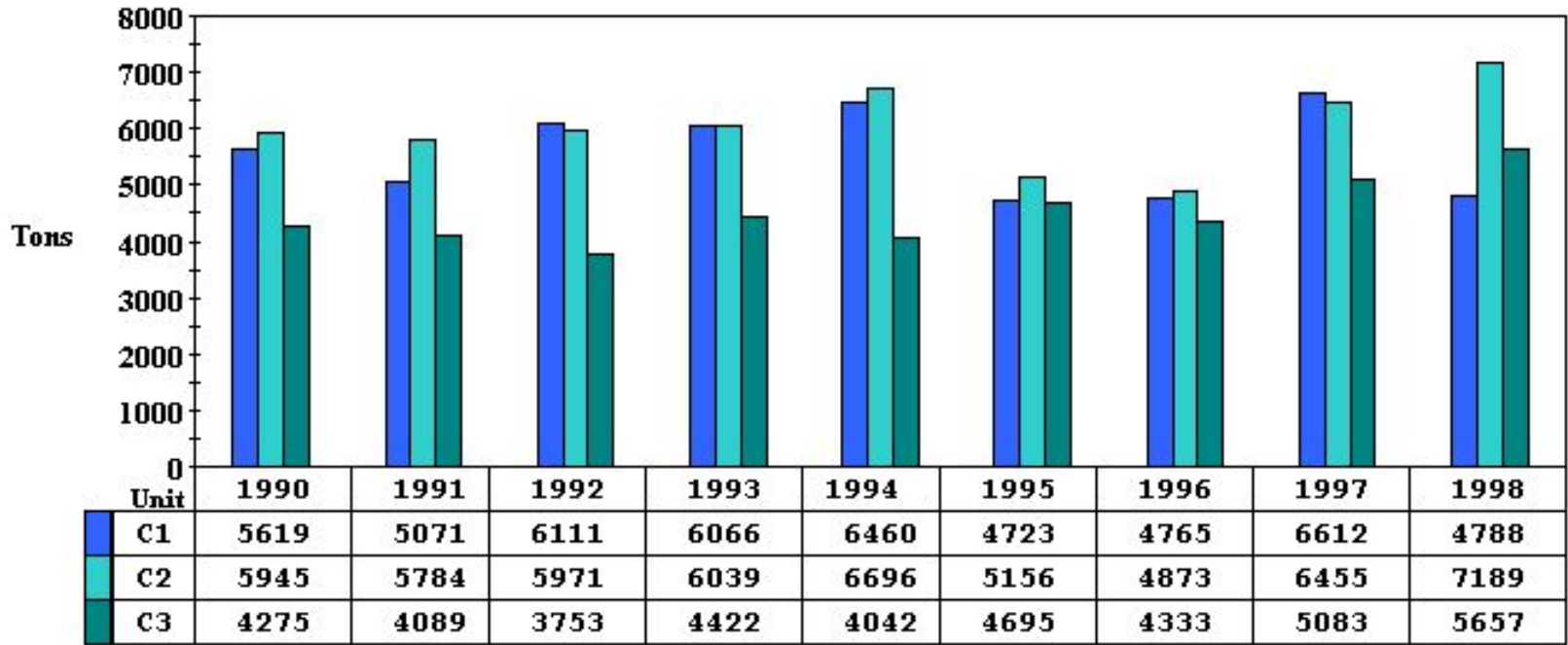
1990  
5,700



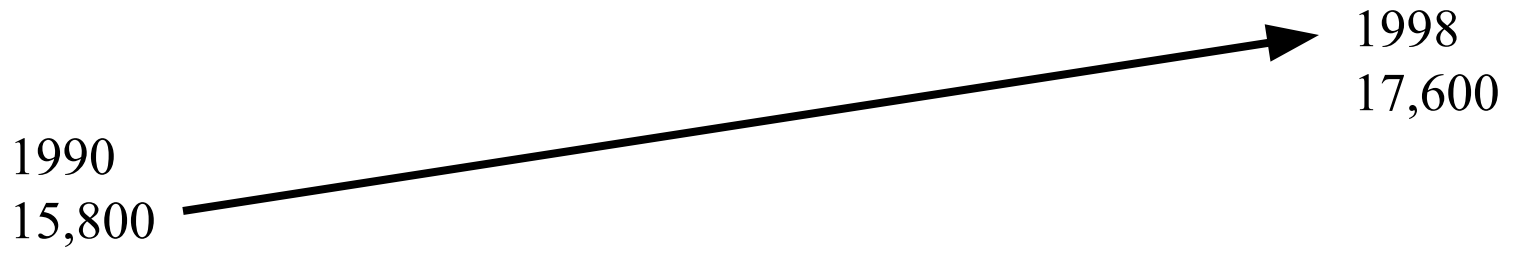
1998  
11,600

# Emissions increasing in the western US

**Craig CO Units C1-C3  
Annual NOx Mass Emissions (1990-1998)**

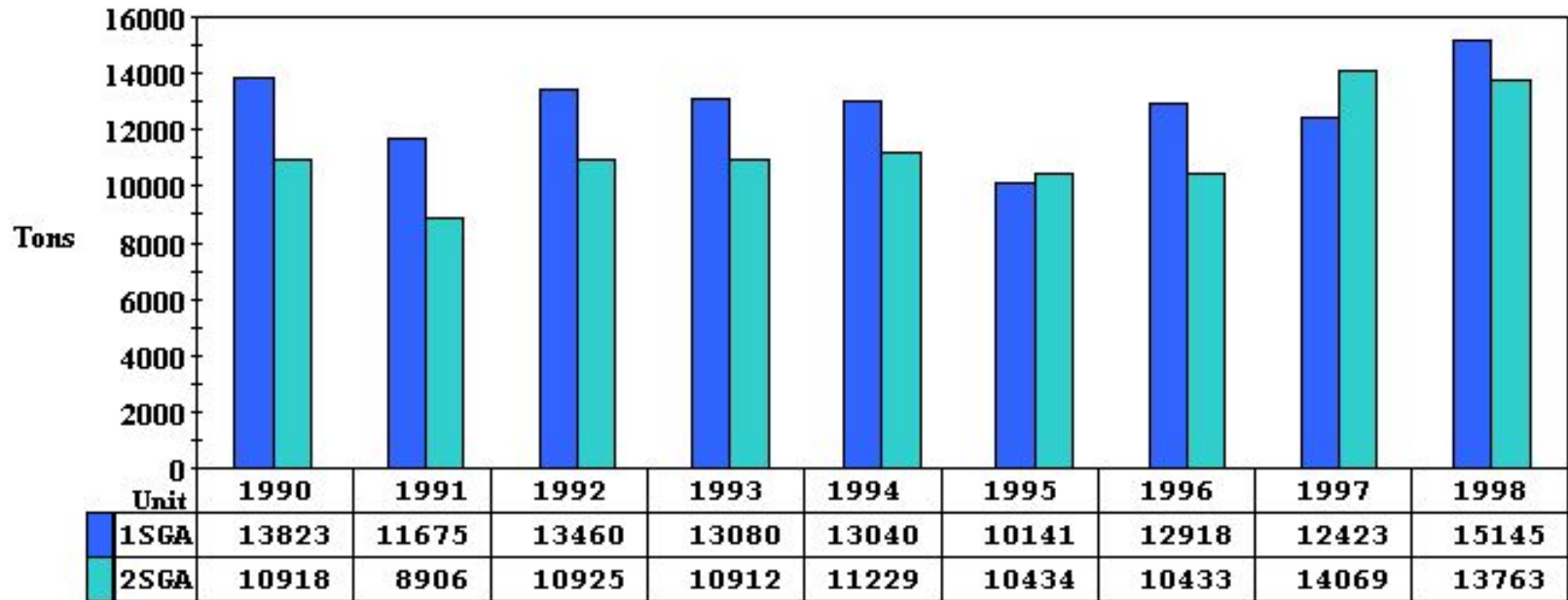


02/28/00



# Emissions increasing in the western US

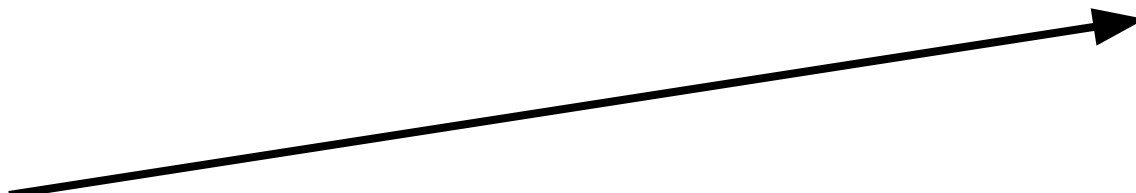
## Intermountain UT Units 1SGA-2SGA Annual NOx Mass Emissions (1990-1998)



02/28/00

1990  
24,700

1998  
28,800





# 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

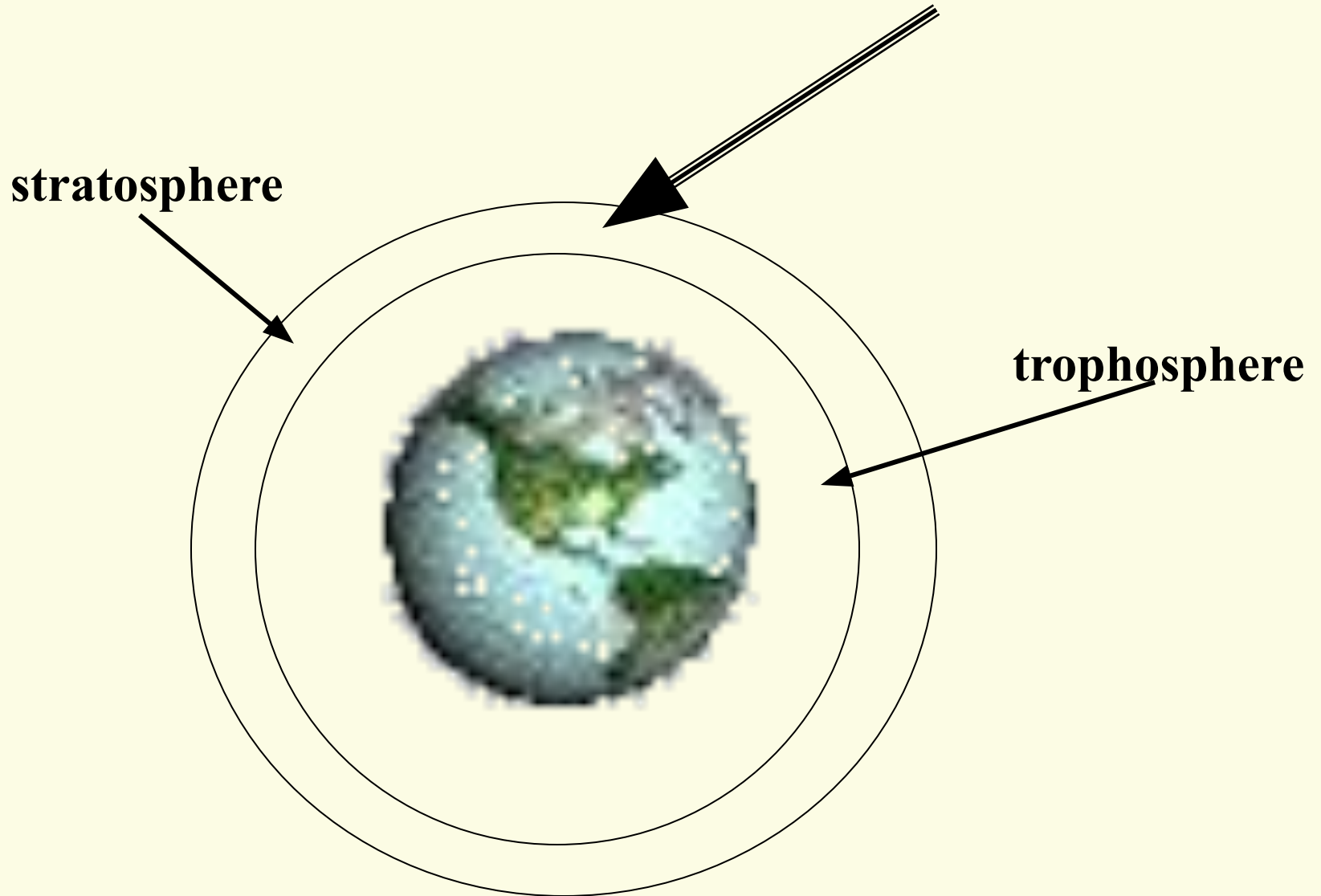
sulfur – SO<sub>x</sub> – has been a relative success story

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

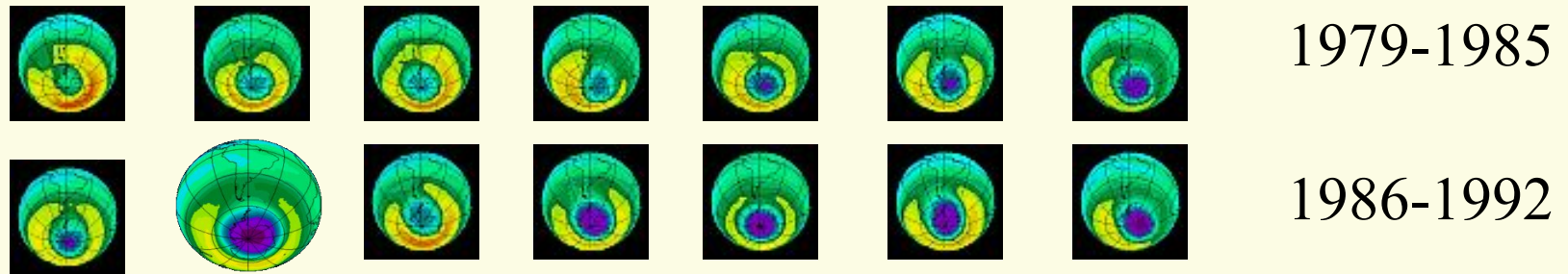
# Where is ozone the “good guy”?



# 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?



Nimbus – 7  
Total Ozone Mapping  
Spectrometer (TOMS)  
Images

**Deeper purple color means  
Less ozone above  
Antartica**



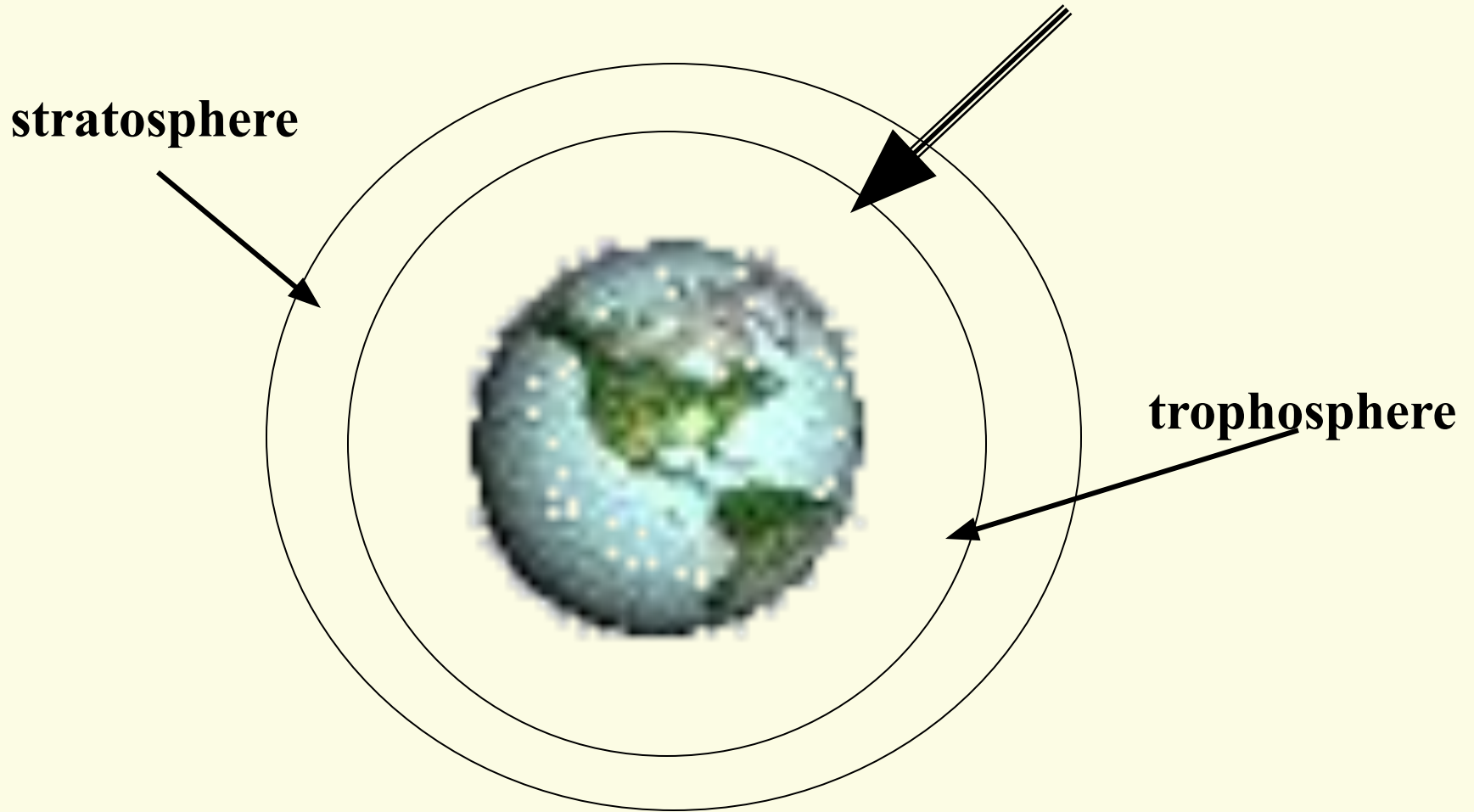
# Why?

- 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

Nitrogen Dioxide ( $\text{NO}_2$ ) + Sunlight

Nitrogen Dioxide ( $\text{NO}_2$ ) + Oxygen ( $\text{O}_2$ )

Nitric Oxide ( $\text{NO}$ ) + Atomic Oxygen ( $\text{O}$ )

Ozone ( $\text{O}_3$ ) + Nitric Oxide ( $\text{NO}$ )

Ozone ( $\text{O}_3$ )

**VOCs break  
Cycle, allowing  
PAN to form from  
 $\text{NO} + \text{VOC}$**

PAN = Peroxyacetyl nitrate

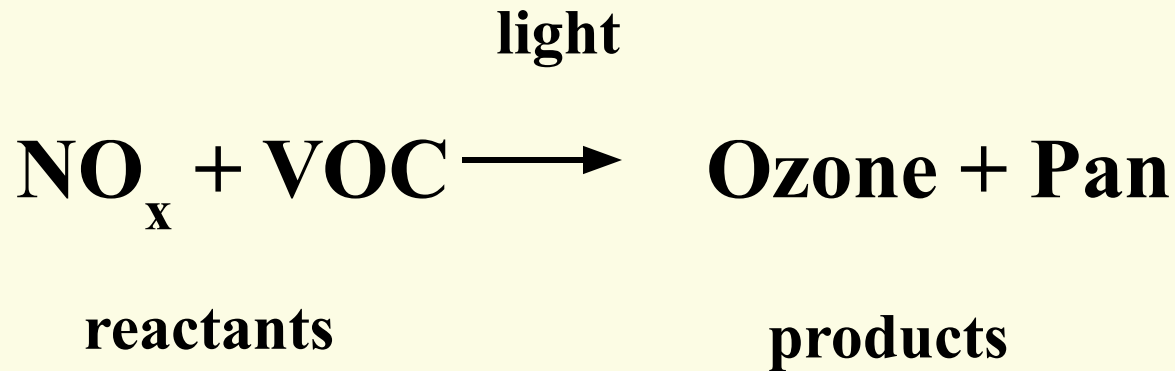
# Examples of Smog





# Chemical Equation for Photochemical Smog

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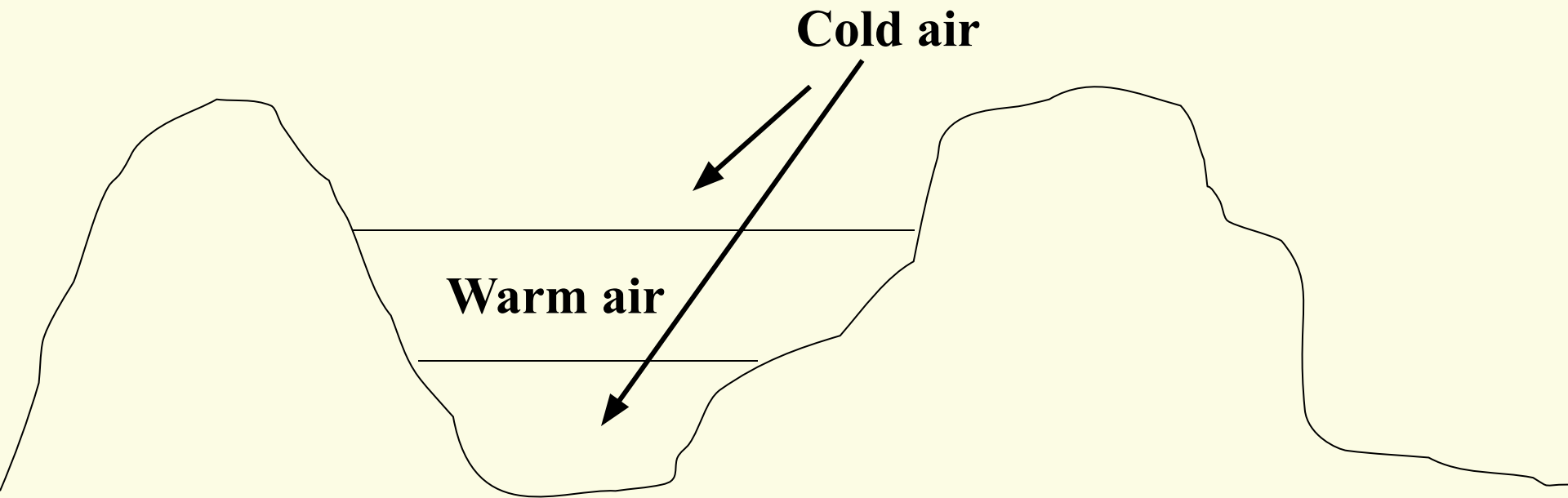


PAN = Peroxyacetyl nitrate

# Where reactants come from

- $\text{NO}_x$  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

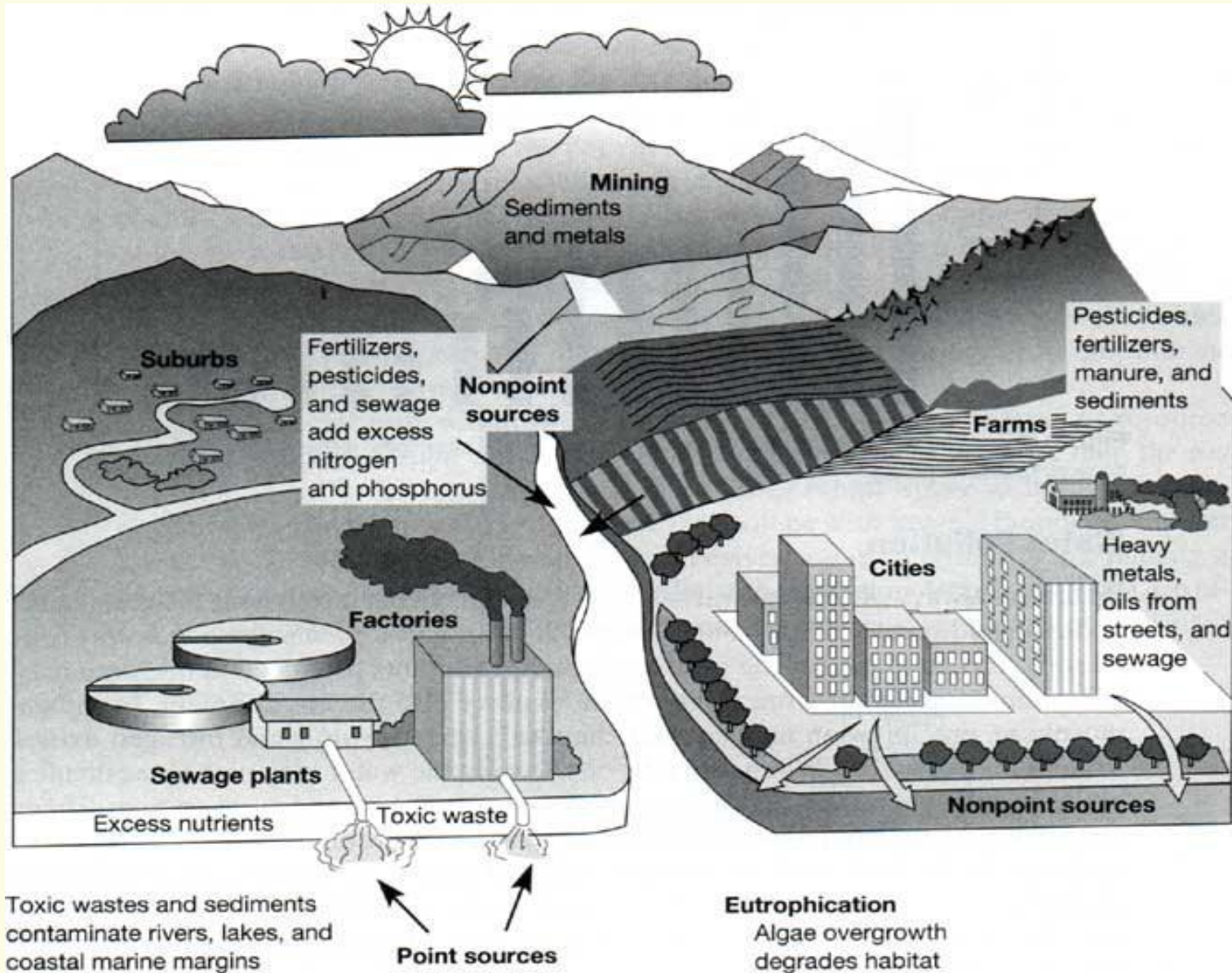
As they cycle they can either

collect pollution from other sources, or

be cleaned by passing through functioning ecosystems



# Water Pollution



# Water Pollution

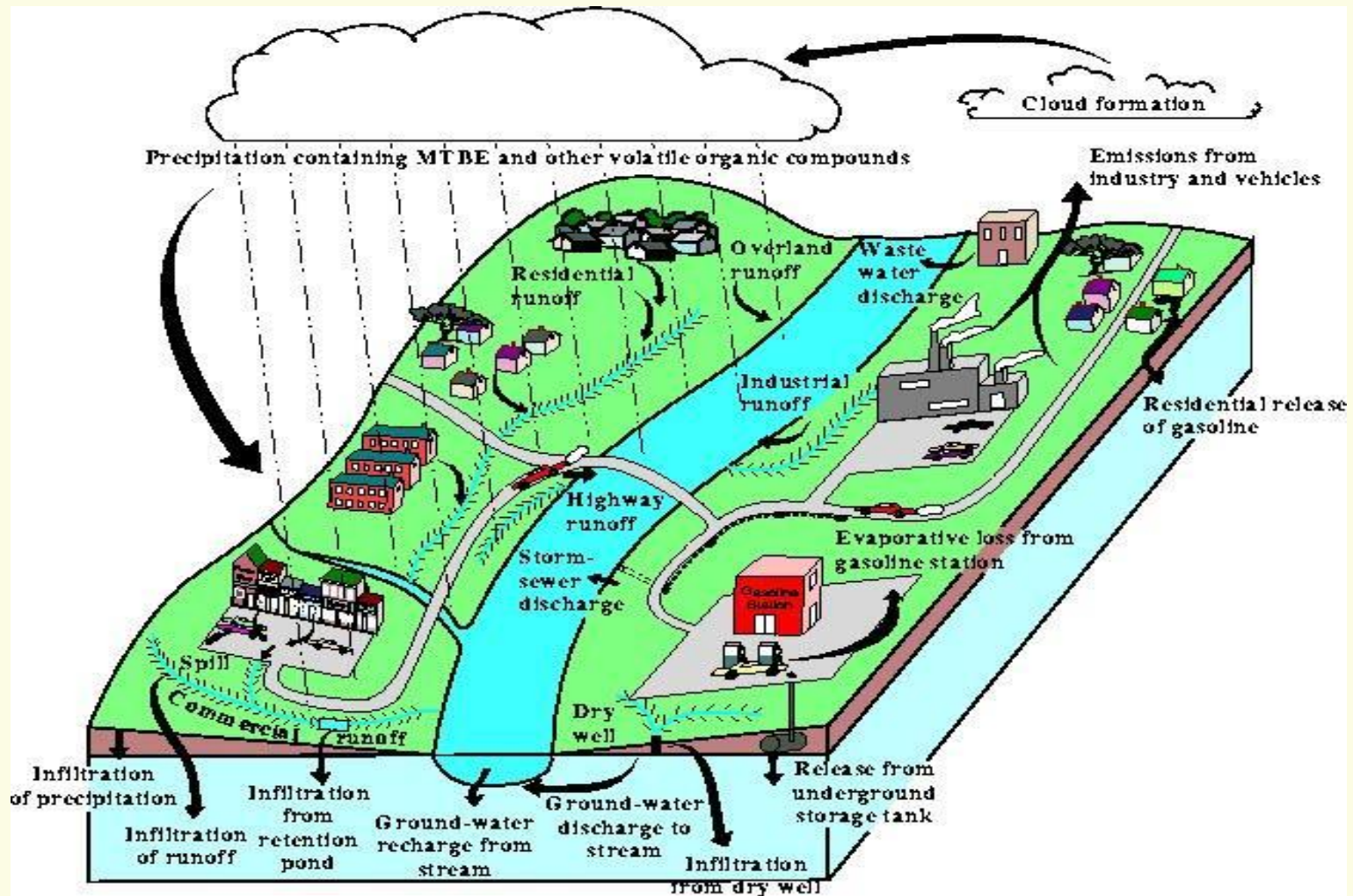


Figure 1. Movement of MTBE and other volatile organic compounds in the hydrologic cycle.

# Water Pollution

## Two major classifications

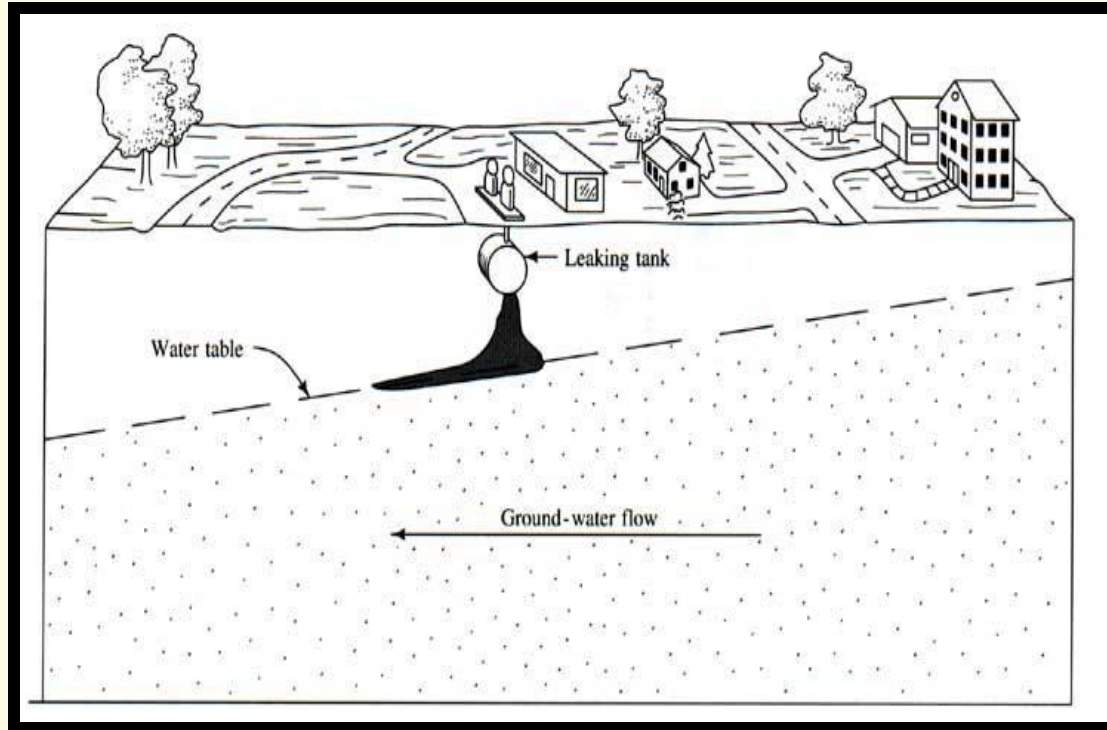
- Point Source
- Non-point Source

# 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



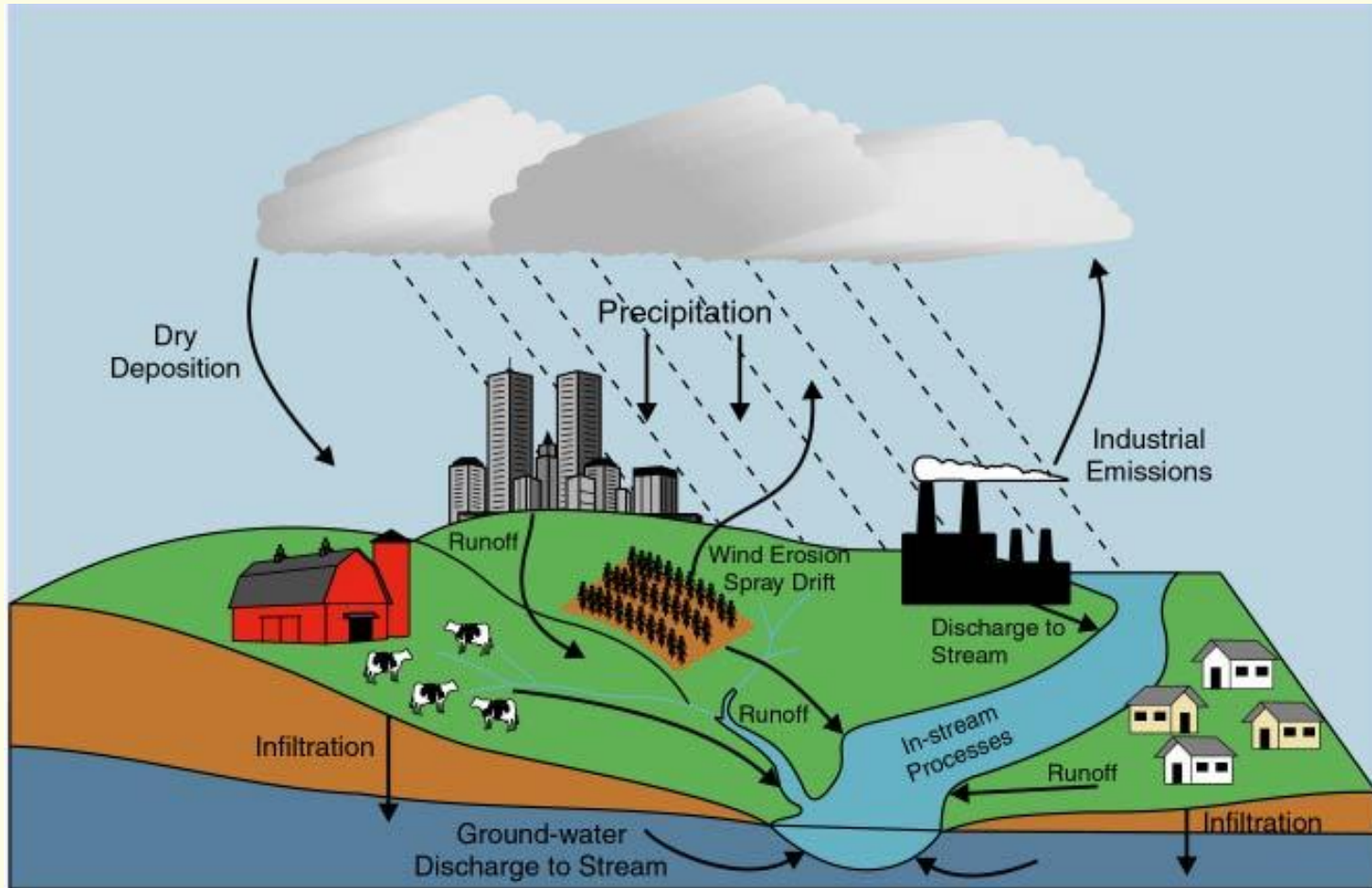
- Non-point Sources

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

# Non point source examples



# Non-point source pollutants - nutrients

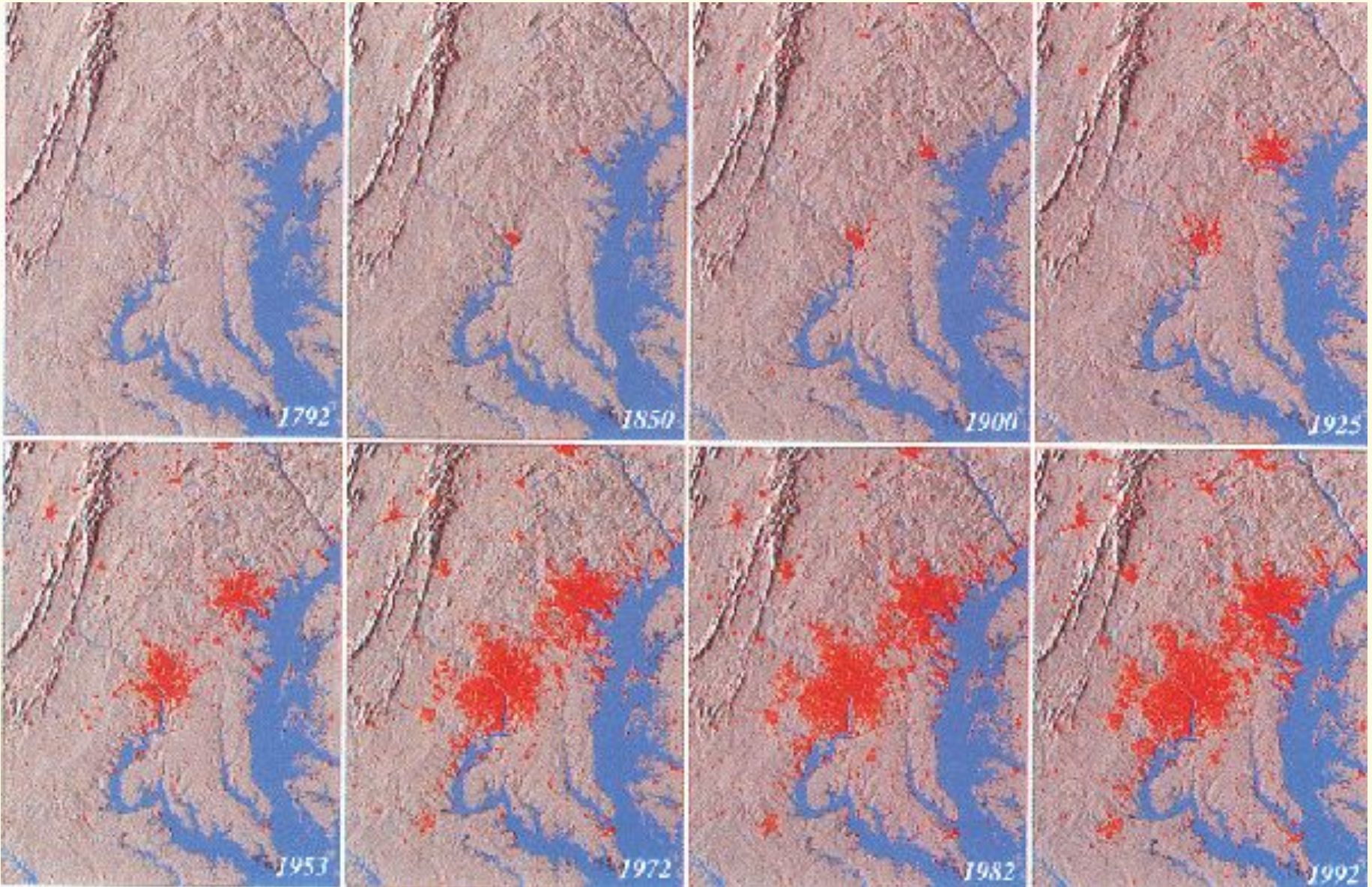


**Figure 2.** Nutrient movement in the hydrologic cycle.



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

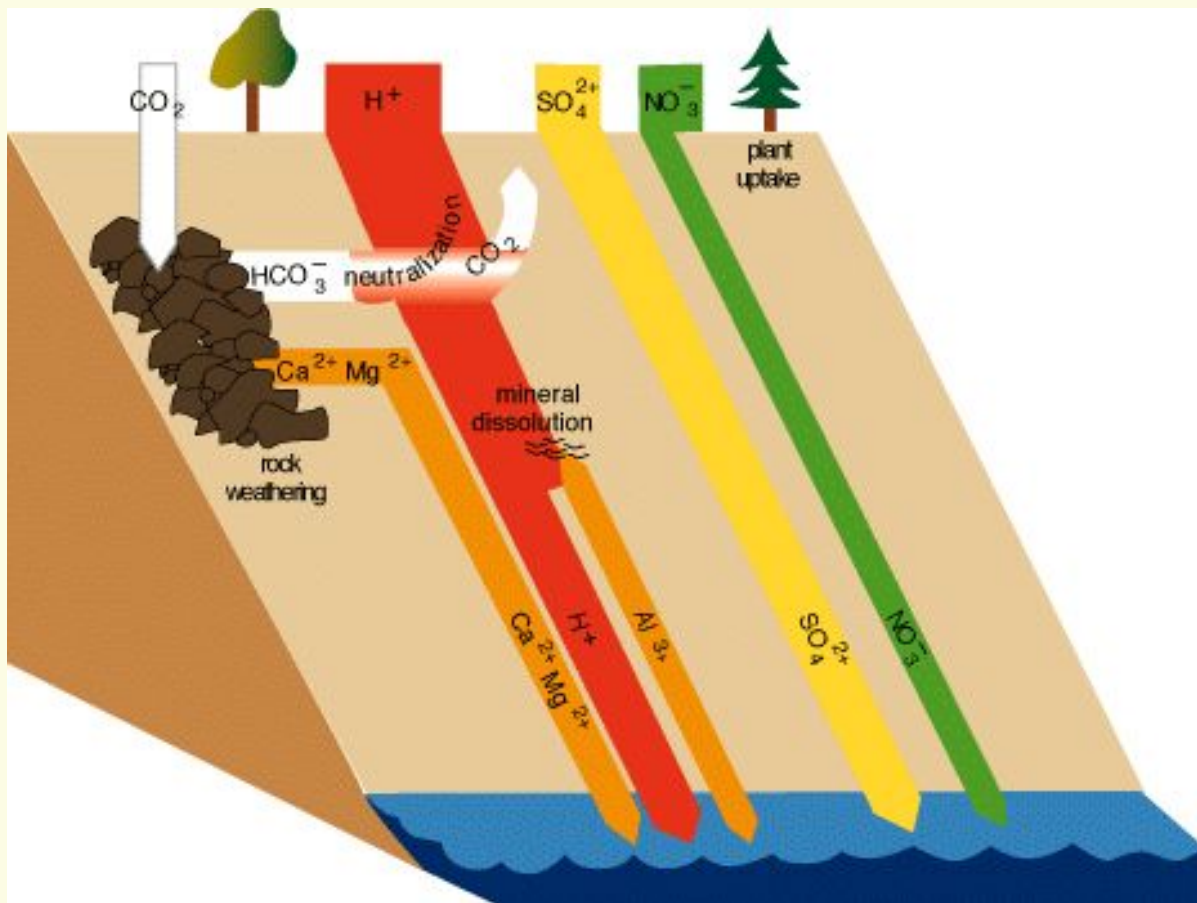
Local sports persons

## Government Representatives

Bureau of Land Management

California Representative who introduced the legislation





# 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

	pH 6.5	pH 6.0	pH 5.5	pH 5.0	pH 4.5	pH 4.0
TROUT	Survives	Survives	Survives	Survives	Does not survive	Does not survive
BASS	Survives	Survives	Survives	Does not survive	Does not survive	Does not survive
PERCH	Survives	Survives	Survives	Survives	Survives	Does not survive
FROGS	Survives	Survives	Survives	Survives	Survives	Survives
SALAMANDERS	Survives	Survives	Survives	Survives	Does not survive	Does not survive
CLAMS	Survives	Survives	Does not survive	Does not survive	Does not survive	Does not survive
CRAYFISH	Survives	Survives	Survives	Does not survive	Does not survive	Does not survive
SNAILS	Survives	Survives	Does not survive	Does not survive	Does not survive	Does not survive
MAYFLY	Survives	Survives	Survives	Does not survive	Does not survive	Does not survive



# Watersheds – Large areas thought to be nitrogen saturated



Created by EPA using information from Table 1 of Fenn et al., "Nitrogen Excess in North American Ecosystems: Predisposing Factors, Ecosystem Responses, and Management Strategies" (1998).

# Land - Sensitive Ecosystems to Nitrogen Deposition

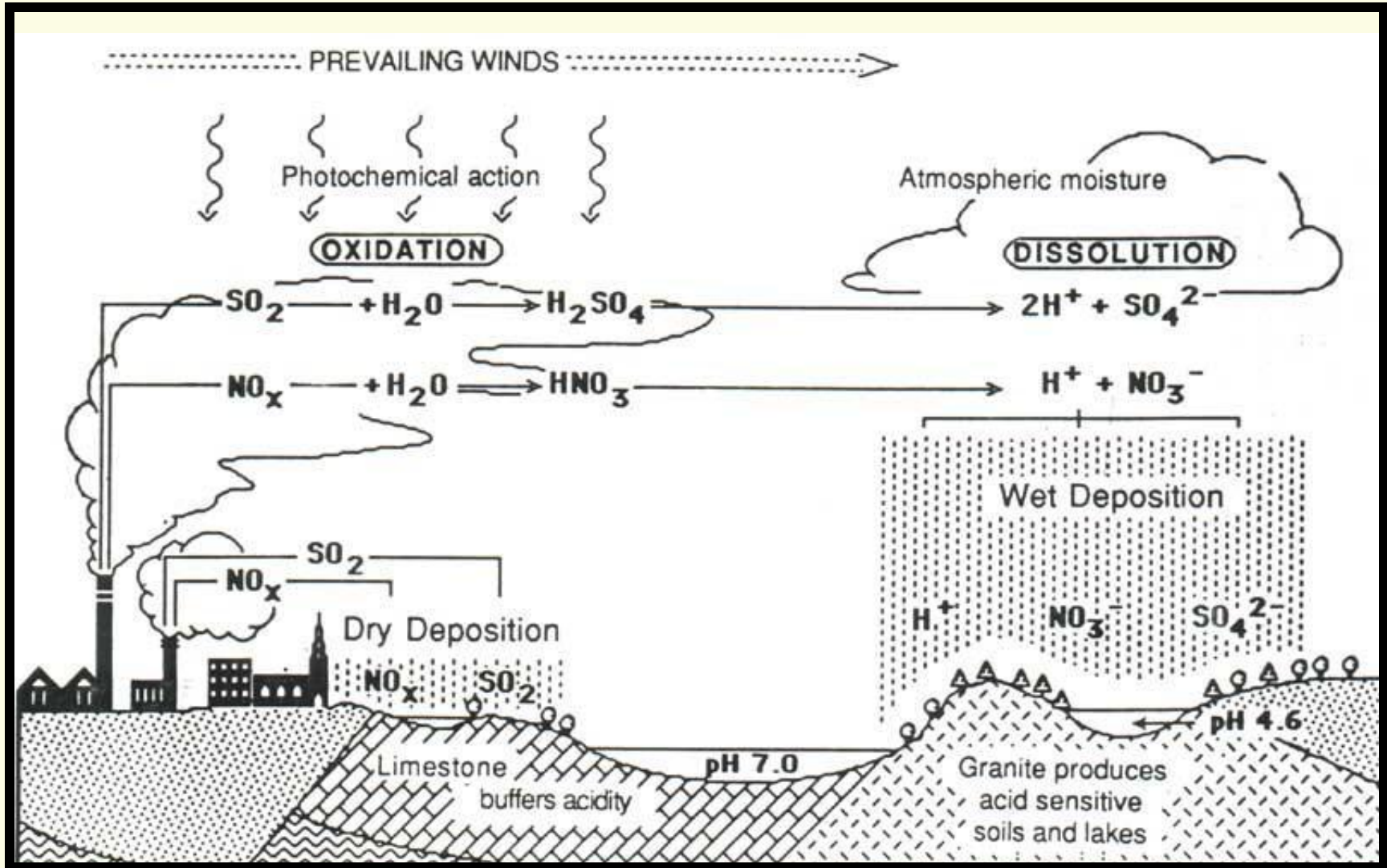


Four major forest types assessed by NAPAP.

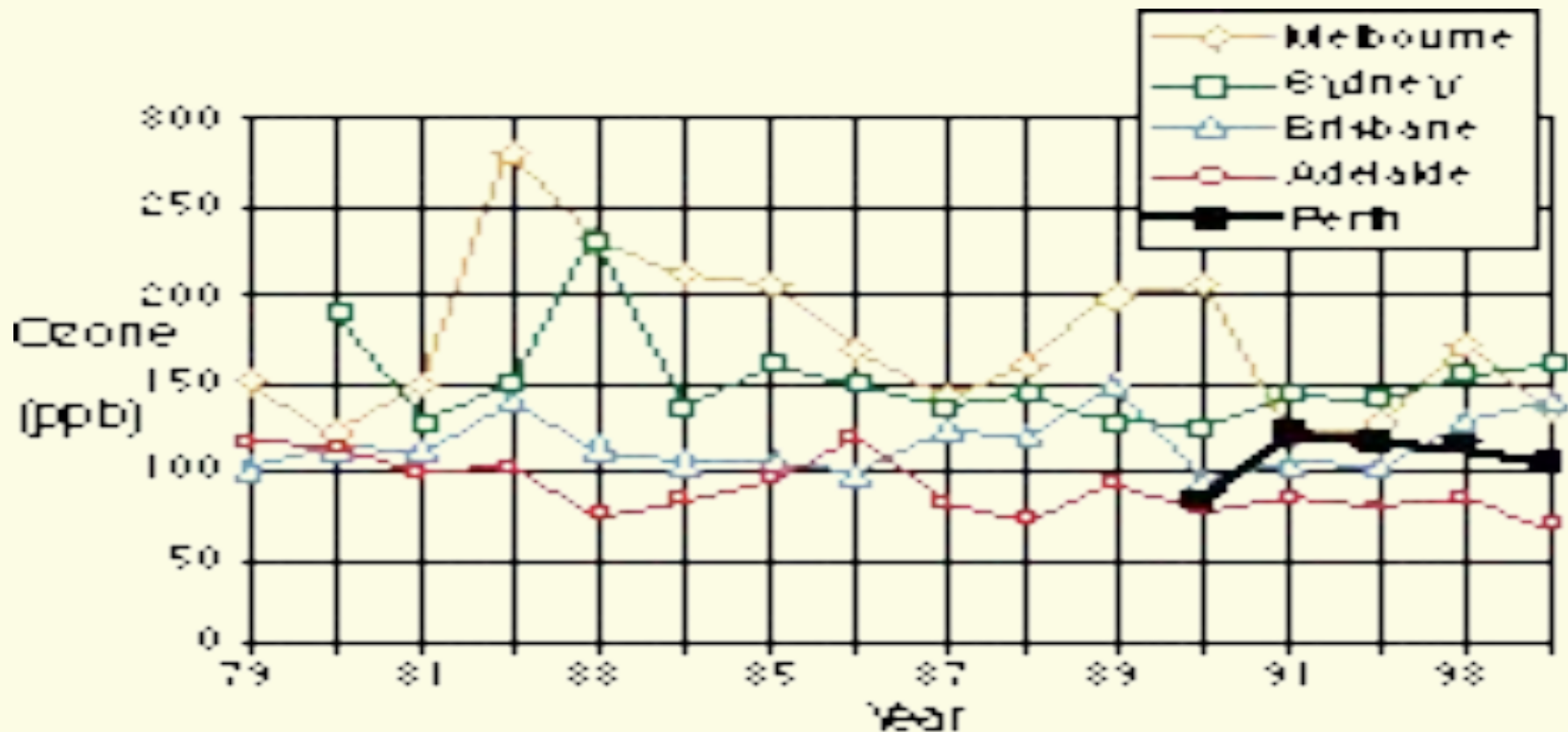
Source: NAPAP. 1996. *NAPAP Biennial Report to Congress: An Integrated Assessment*, National Science and Technology Council Committee on Environment and Natural Resources.



# 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.*