Chapter 13
Air Pollution

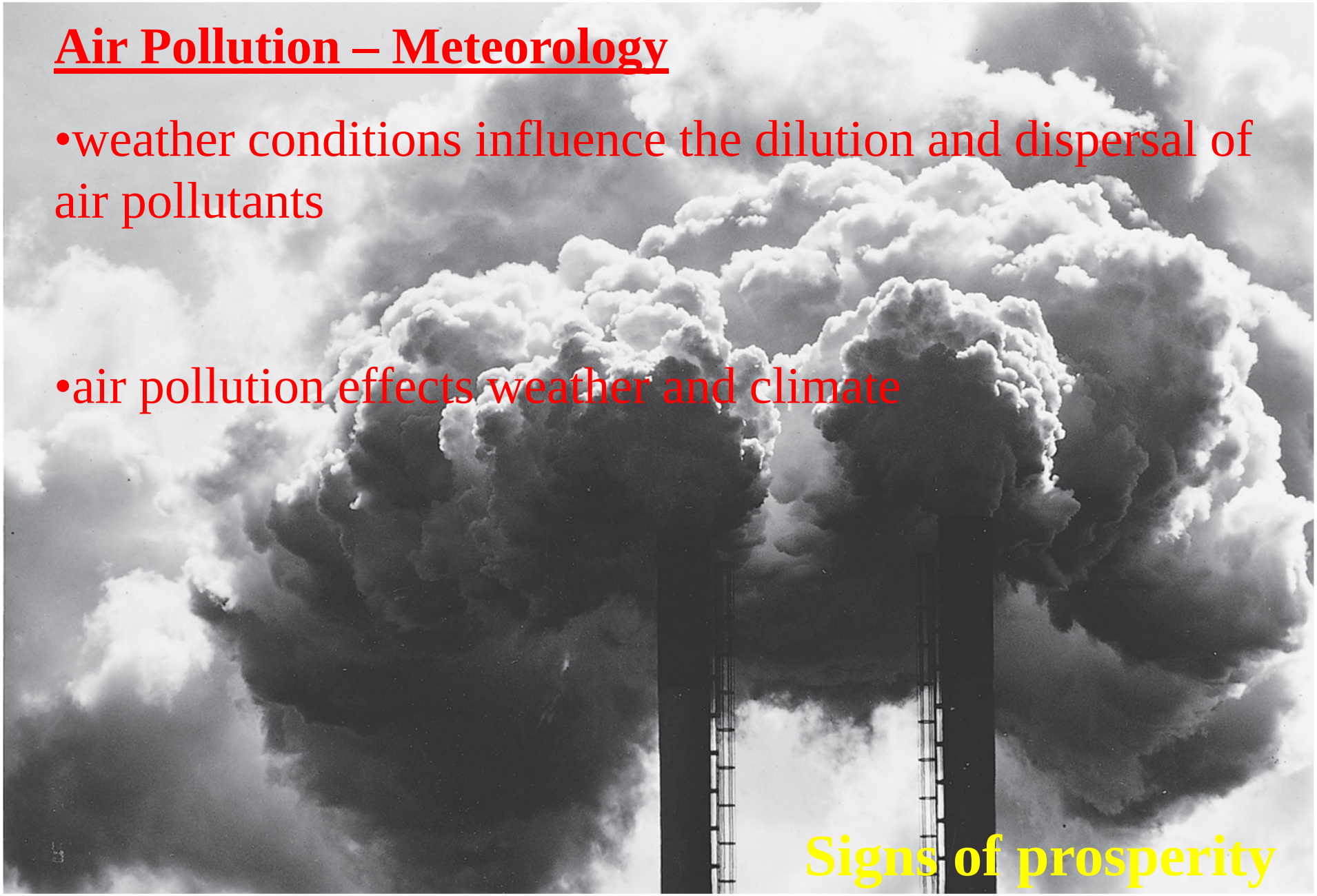
Chapter Outline

- **Historical Perspective**
- **Sources and Types of Air Pollution**
- **Trends in Air Quality**
- **Meteorological Factors Affecting**
- **Acid Precipitation**

Air Pollution – Meteorology

•weather conditions influence the dilution and dispersal of air pollutants

•air pollution effects weather and climate



Air Pollution – Meteorology

- Air Pollution Episodes or Events

  often occur when there is no major change in the output of contaminants

- Quantity of contaminants emitted into the atmosphere

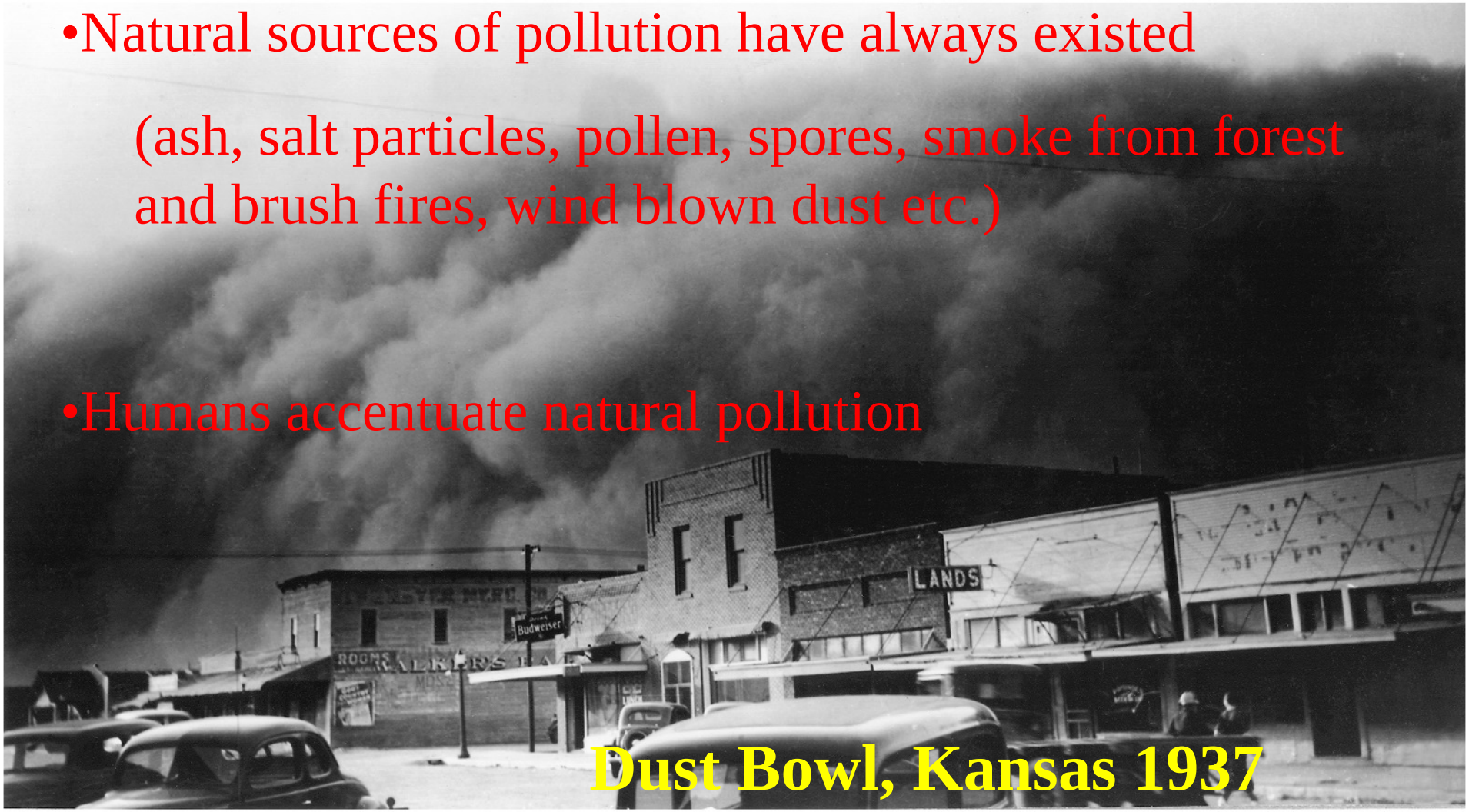
- Atmospheric conditions promote pollution events

Historical Perspective

- Air is never perfectly clean
- Natural sources of pollution have always existed

  (ash, salt particles, pollen, spores, smoke from forest and brush fires, wind blown dust etc.)

- Humans accentuate natural pollution



Dust Bowl, Kansas 1937

Similarities among Disasters

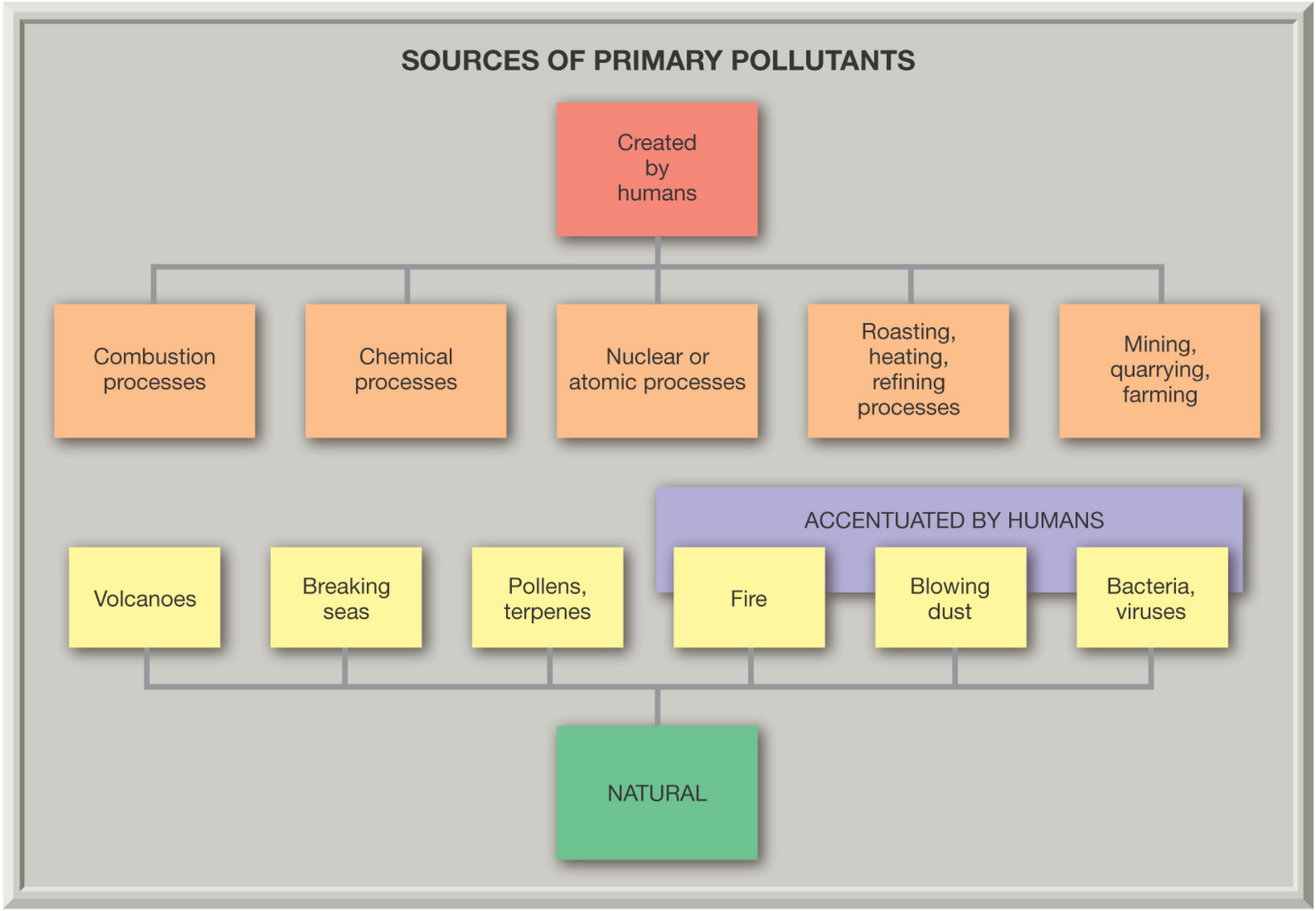
- Winter months
- Dense population
- Heavy industrialization
- Often valley
- Temperature inversion
- Stagnant air
- Accident, or mixtures from non-accidents

Sources and Types of Air Pollution

Air pollutants: airborne particles and gasses that occur in concentrations that endanger the health and well-being of organisms or disrupt the orderly functioning of the environment

Primary pollutants: emitted directly from identifiable source

Secondary pollutants: produced in the atmosphere through chemical reactions

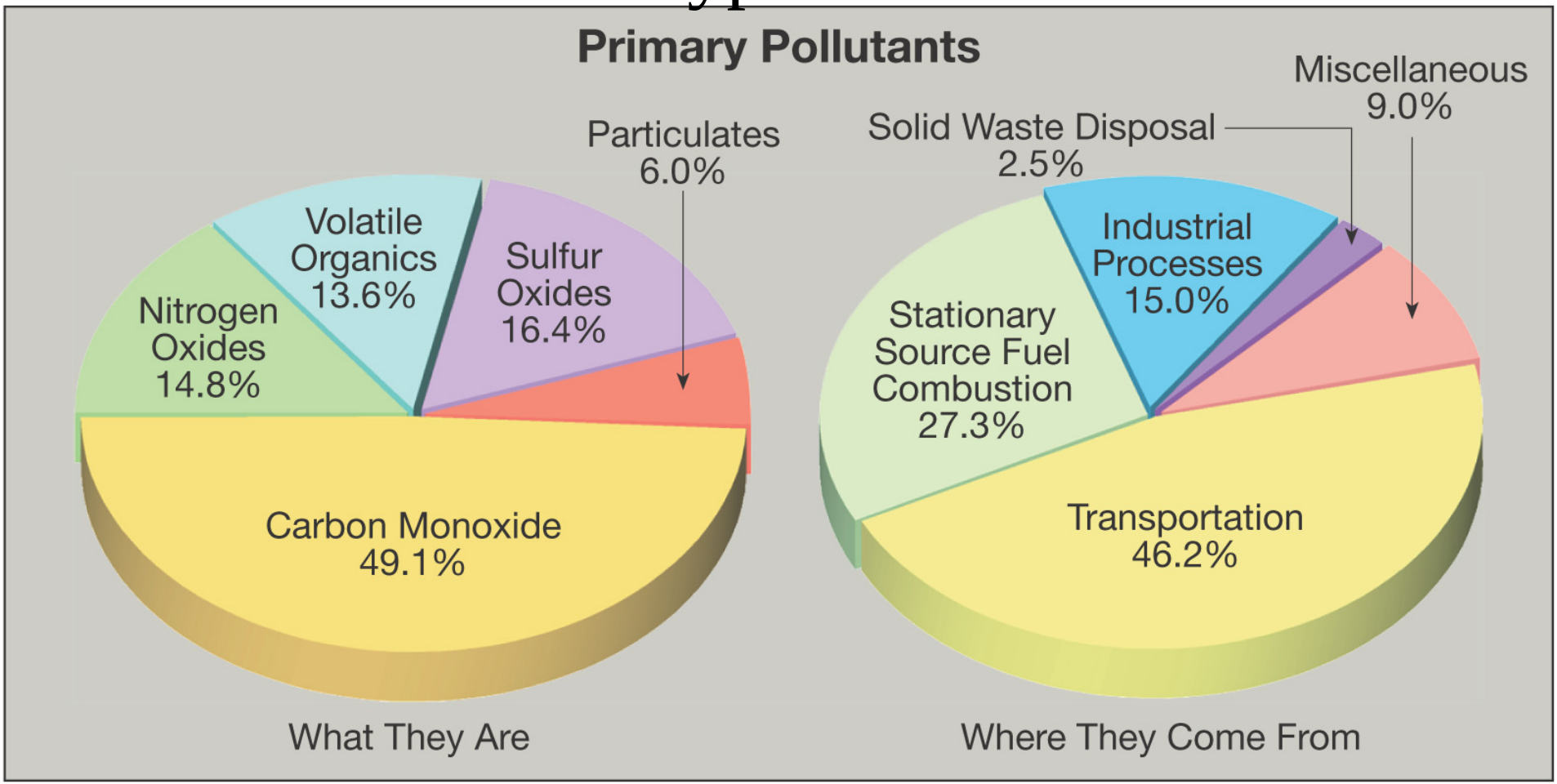

SOURCES OF PRIMARY POLLUTANTS
Created by humans
Combustion processes
Chemical processes
Nuclear or atomic processes
Roasting, heating, refining processes
Mining, quarrying, farming
ACCENTUATED BY HUMANS
Volcanoes
Breaking seas
Pollens, terpenes
Fire
Blowing dust
Bacteria, viruses
NATURAL

Sources and Types of Air Pollution

Primary pollutants:

Point sources	factories, power plants
Mobil sources	transportation, lawn mowers etc.
Biogenic sources	all nonanthropogenic sources (trees, vegetation, gas seeps etc.)
Area sources	small and individual sources (dry cleaners)

Sources and Types of Air Pollution



Primary pollutants

1. Particulate matter:

    - solid particles and liquid droplets found in air
    - Fine particles ($PM_{2.5}$) = combustion (fuel, wood)
    - Coarse particles (PM_{10}) = aeolian (wind blown), crushing/grinding processes
    - Most obvious form of air pollution (reduce visibility, leave film on surfaces)

Primary pollutants

2. Sulfur Dioxide (SO_2):

- Colorless, corrosive gas
- Combustion of sulfur-containing fuels (coal, oil)
- Acid precipitation (H_2SO_4)
- Reduced lung function (short-term exposure)

Primary pollutants

3. Nitrogen Oxides (NO_x):

- High-temperature Combustion (power plants, motor vehicles)
- Acid precipitation (HNO_3)
- Smog Formation

Primary pollutants

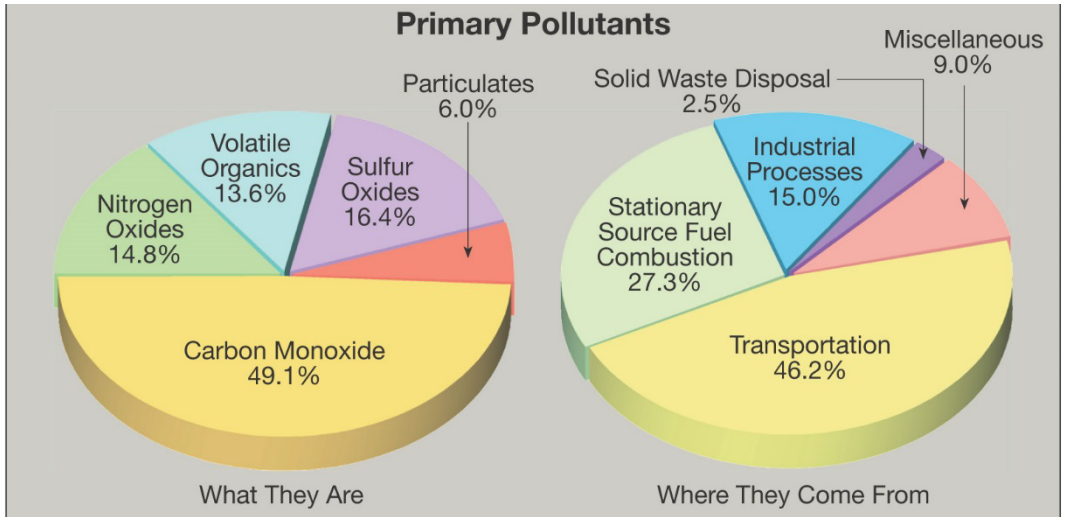
4. Volatile Organic Compounds (VOC):

- Hydrocarbons (carbon and hydrogen)
- Methane (CH_4)
- Incomplete combustion of gasoline
- React with NO_x to form secondary pollutants

Primary pollutants

5. Carbon Monoxide (CO):

- Colorless, odorless, poisonous
- Incomplete burning of carbon in fuels
- Most abundant primary pollutant



Primary pollutants

6. Lead (Pb):

- Industrial sources
- Automotive sources (leaded gasoline)
- Bio-accumulates in blood, bones, soft tissues
- Damages nervous systems (children high risk)

Secondary pollutants

form as a result of reactions between primary pollutants (acid precipitation, smog)

Smog: 1905 “smoke” & “fog”

a. London, “Classical” (coal burning, high humidity: smoke and sulfur dioxide)

b. Los Angeles “Photochemical”

Sunlight triggers secondary reactions

Ozone major component of photochemical smog

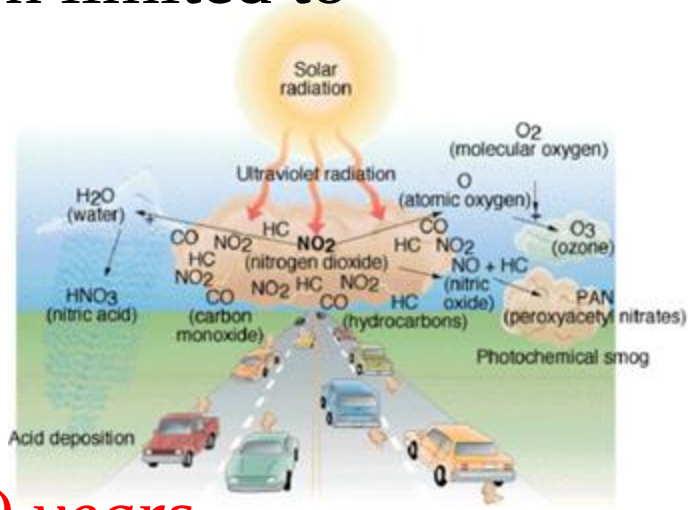
Secondary pollutants

- Ozone-photochemical smog-formation limited to daylight hours

  acute: *reactions within hours/days*

  -decreased lung function

  -chest pain



  chronic: *gradual deterioration (O) years*

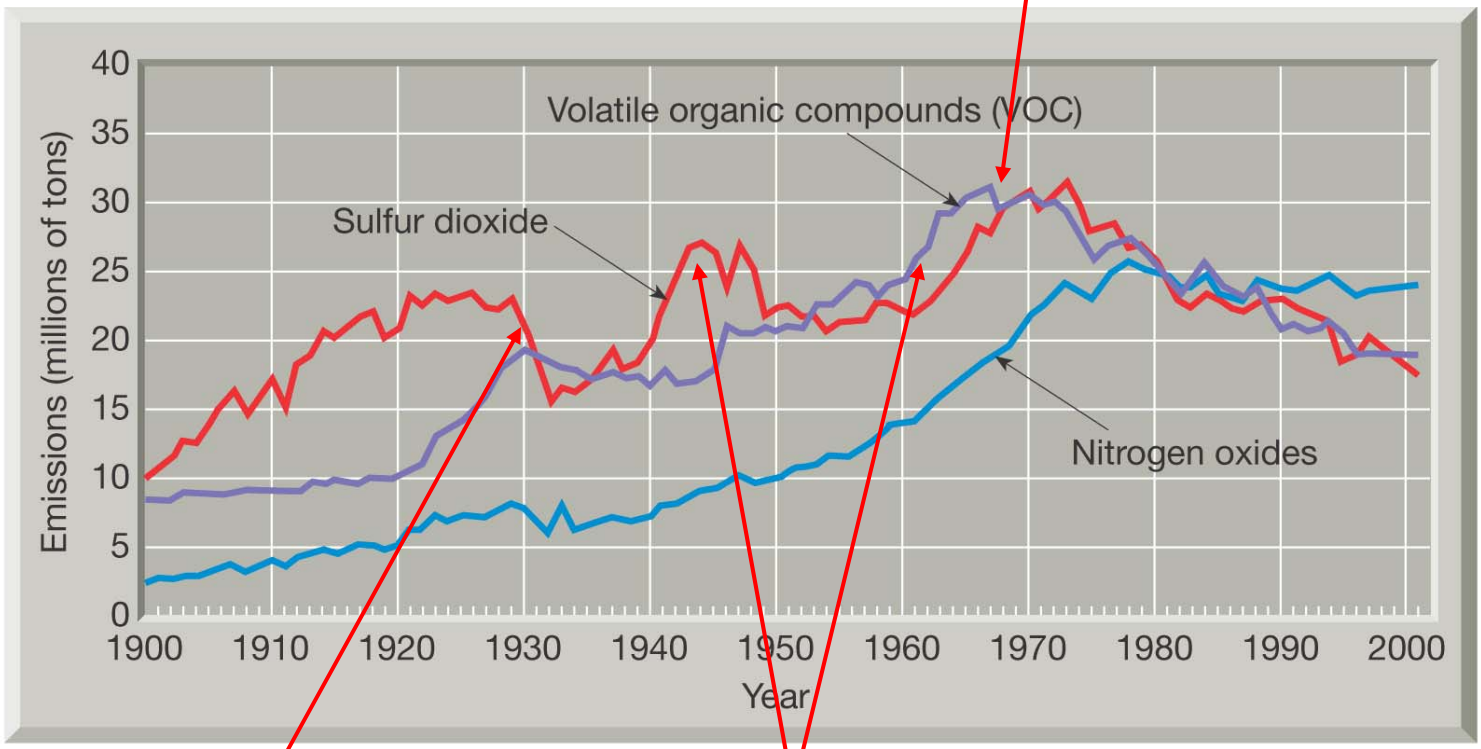
  -premature aging of lungs

  -reduction in agricultural crop and commercial forest yields

  -overall weakening of forest ecosystems (disease, growth, reproduction)

Trends in Air Quality

- economic activity
- population growth
- meteorological conditions
- regulatory efforts

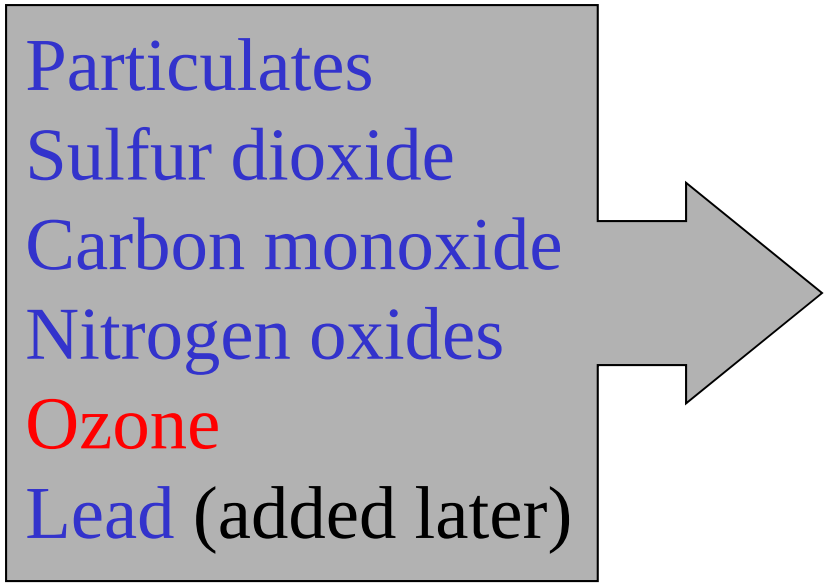


Clean Air Act 1970 Est. EPA

Great Depression

WWII, Baby Boomers Drive

Clean Air Act of 1970



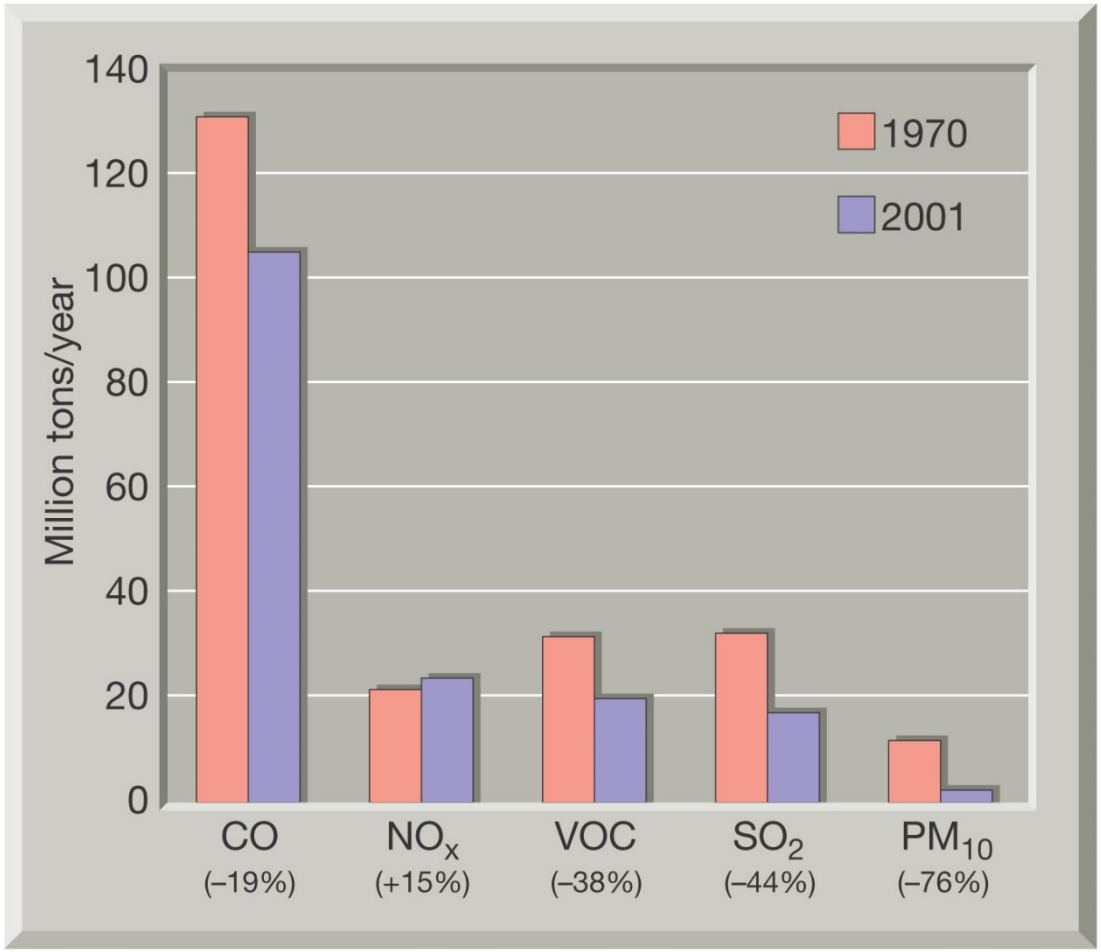
criteria pollutants

National Ambient Air Quality Standards (Table 13-3)

Example Calculation:

CO	9 ppm	8-hr average
	35 ppm	1-hr average

Comparison of 1970 & 2001 Emissions



1970 223 million tons

2001 170 million tons

24% Reduction

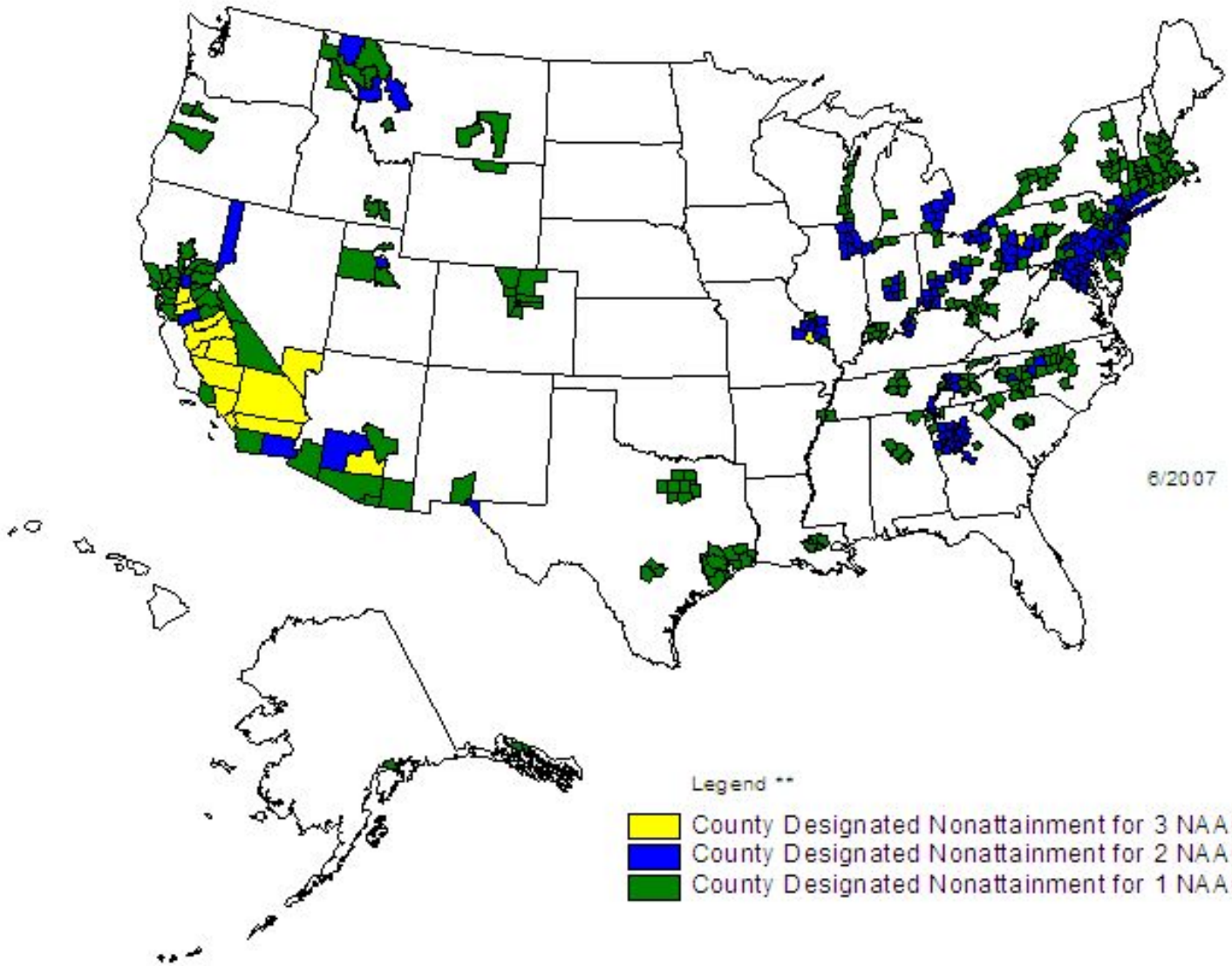
Keep In Mind

Population Increase

Miles driven/yr

Counties Designated "Nonattainment"

for Clean Air Act's National Ambient Air Quality Standards (NAAQS) *



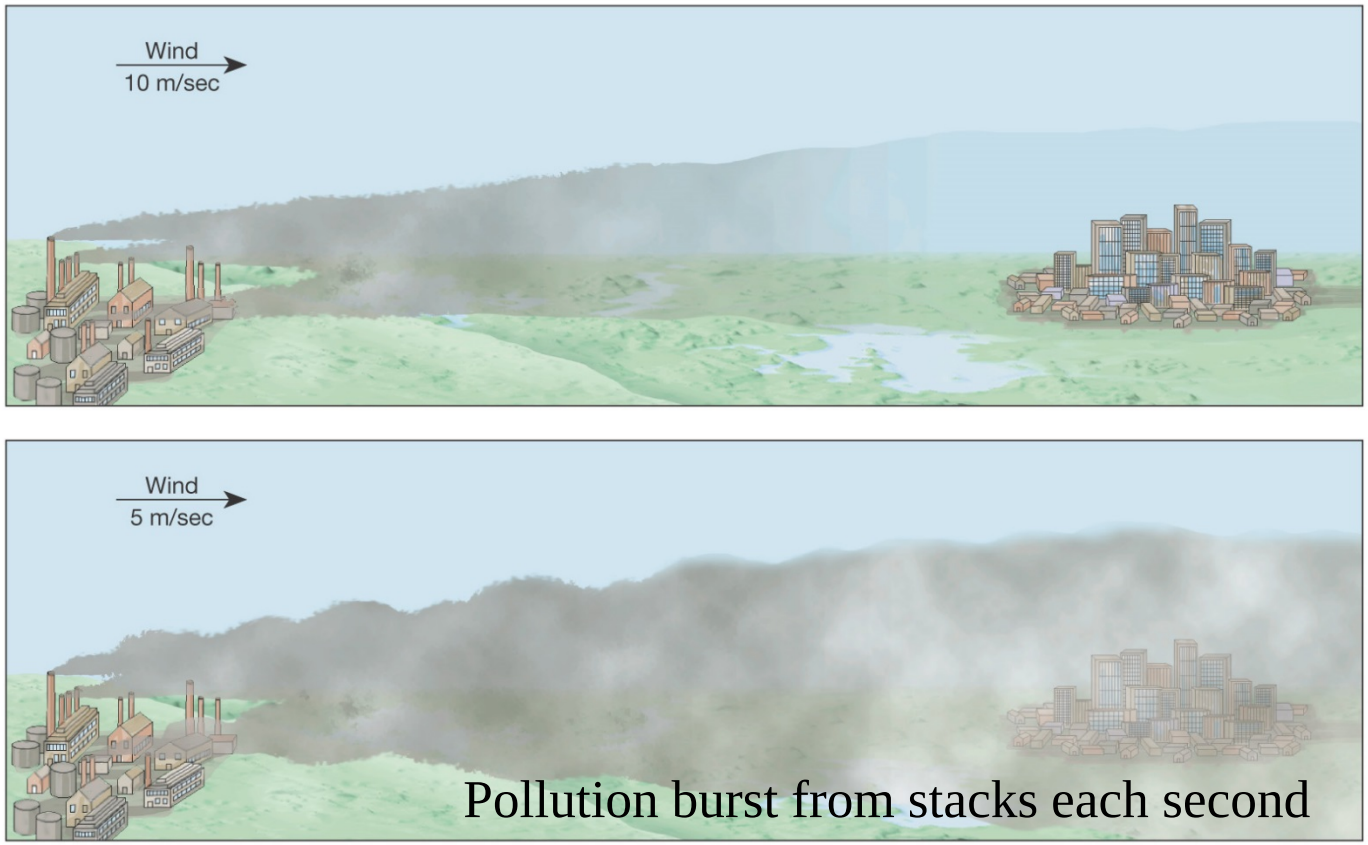
Meteorological Factors Affecting Air Pollution

Wind: dilution of pollutants

Atmospheric stability

- Surface temperature inversions
- Inversions aloft

Wind Speed and Dilution of Pollutants



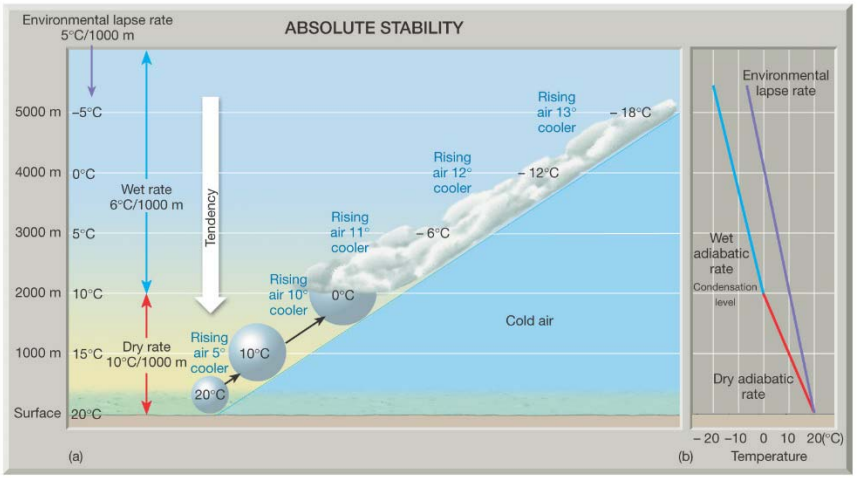
Pollution Episodes more common during calm atmospheric conditions

High wind speed = more turbulent air = rapidly mixed with non-polluted air

Atmospheric stability

-determines the extent to which vertical motions will mix the pollution with cleaner air above

-**Mixing depth** = vertical distance between Earth's surface and the height to which convectional movements extend



thick mixing depth = cleaner air

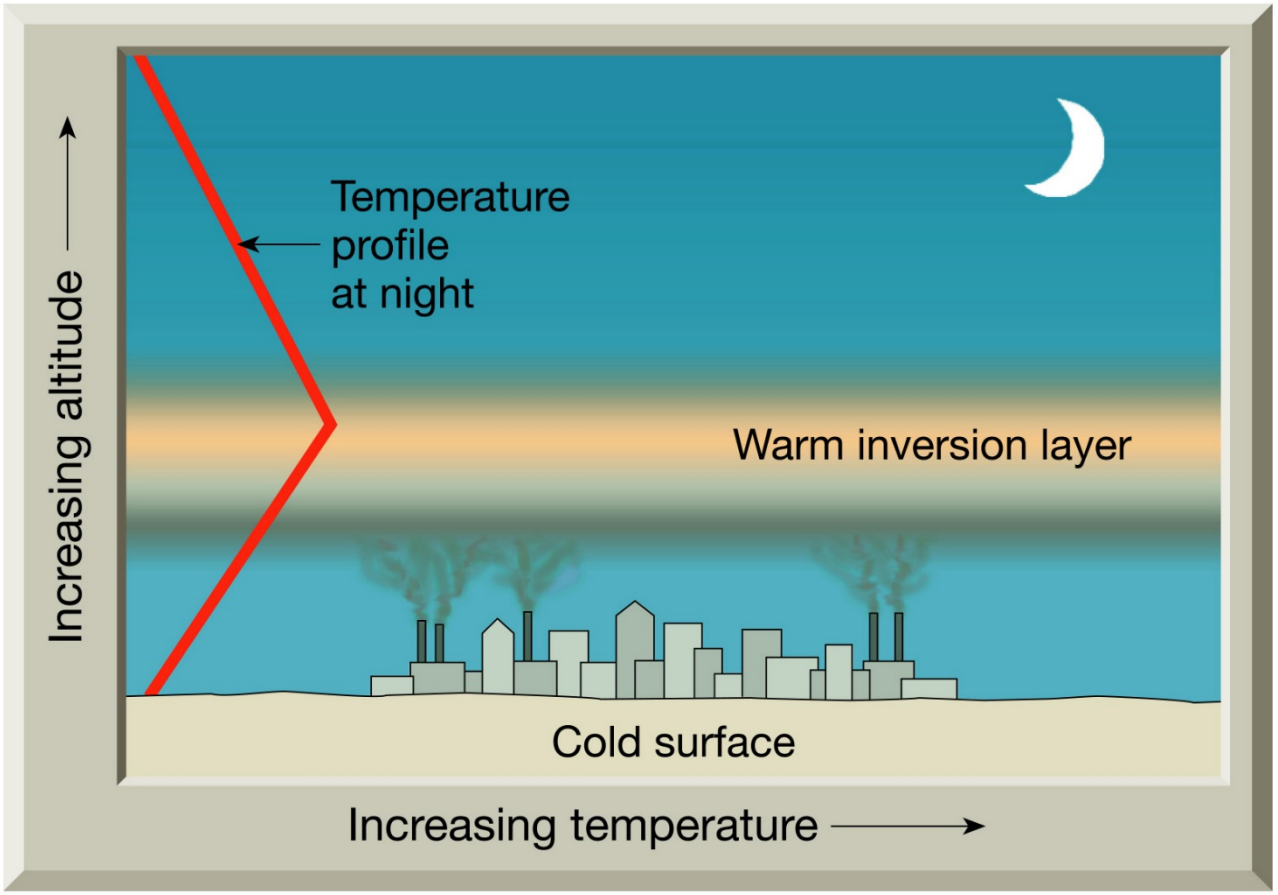
Stable air suppresses convectional motions

absolute stability: environmental lapse rate is less than the adiabatic wet rate

Atmospheric stability

-Mixing depth = greatest during summer ‘intense solar heating’

-Winter stability enhanced by temperature inversions



Atmospheric stability

-**Mixing depth** = greatest during summer ‘intense solar heating’

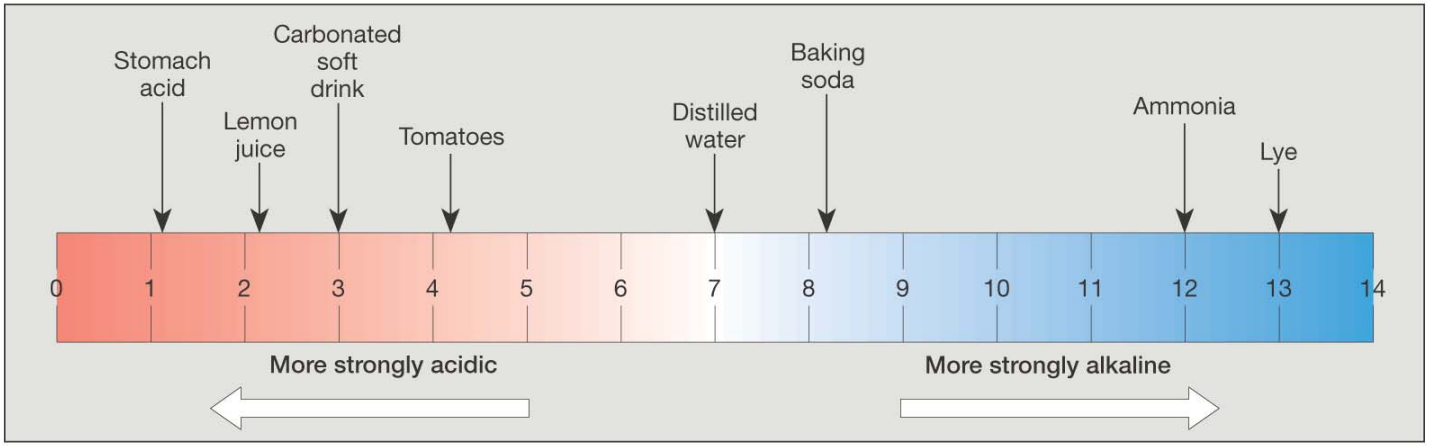
-Winter stability enhanced by temperature inversions

Los Angeles smog on 29 January 2004

Acid Precipitation (Sulfur & Nitrogen Oxides)

Extent and potency of acid precipitation

Effects of acid precipitation

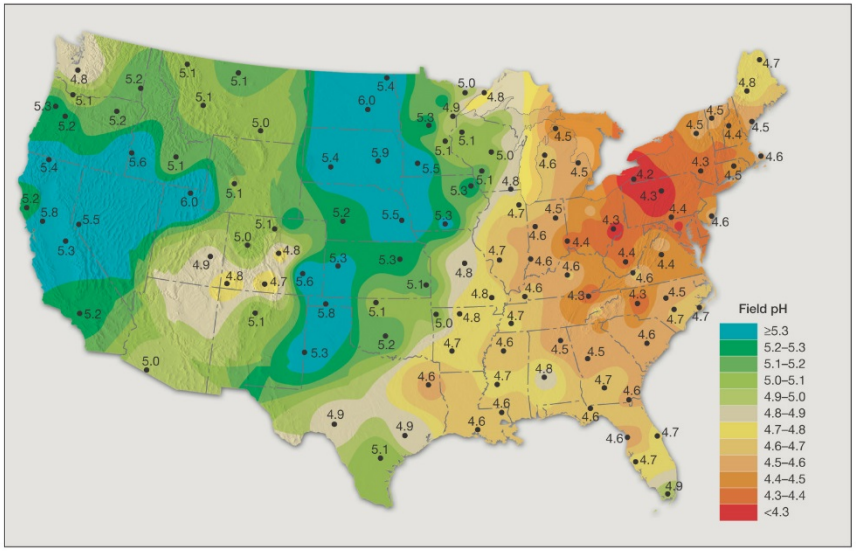


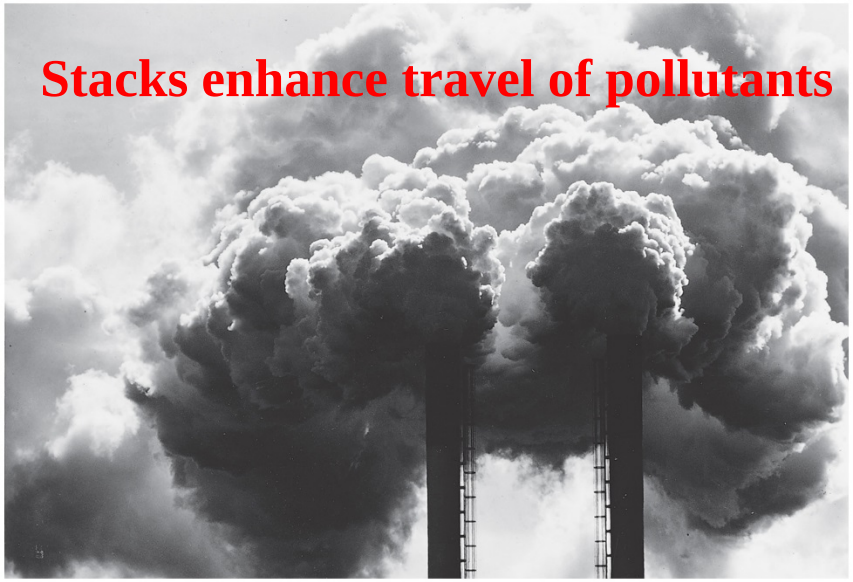
Precipitation pH ranges between 5 - 6

Effects of Acid Precipitation

Human: upper respiratory deterioration, bronchitis among children

Environment: pH increase in lakes, leaching of toxins from soils, fish die off, reduction in crop yields, impair forest productivity





Victims of acid rain - dead and dying Red Spruce in Maine. Photo by Paul Donahue