

## ACID RAIN

### What is acid rain?

- More accurate term may be acid d\_\_\_\_\_
- Occurs in two forms
  - ▶ w\_\_\_\_\_ deposition (acidic rain, fog, and snow)
  - ▶ d\_\_\_\_\_ deposition (acidic gases and particles)
- Principal c\_\_\_\_\_ are  $\text{SO}_x$  and  $\text{NO}_x$
- About \_\_\_\_\_ of  $\text{SO}_x$  and \_\_\_\_\_ of  $\text{NO}_x$  comes from power plants (most are coal burning)

### How do we measure?

- pH of “natural” rain water is \_\_\_\_\_ ( $\text{pK}_{a1} \text{H}_2\text{CO}_3$  is 6.35)
- m\_\_\_\_\_ by two networks, both supported by EPA
  - ▶ The National Atmospheric Deposition Program measures w\_\_\_\_\_ deposition, and its Web site (<http://nadp.sws.uiuc.edu/>) features maps of pH
  - ▶ The Clean Air Status and Trends Network (CASTNET) measures d\_\_\_\_\_ deposition (<http://www.epa.gov/castnet/>)

### Effects of acid rain:

- damage to forests and soils, fish and other living things, materials, and human health.
  - ▶ acidification of l\_\_\_\_\_ and s\_\_\_\_\_

In a National Surface Water Survey (NSWS)

– effects of acidic deposition in over 1,000 lakes larger than 10 acres and in thousands of miles of streams believed to be sensitive to a \_\_\_\_\_

– acid rain caused acidity in \_\_\_\_\_ percent of the acidic lakes  
 – acid rain caused acidity in about \_\_\_\_\_ percent of the acidic streams  
 – U.S. regions containing many of the s\_\_\_\_\_ w\_\_\_\_\_ sensitive to acidification include:

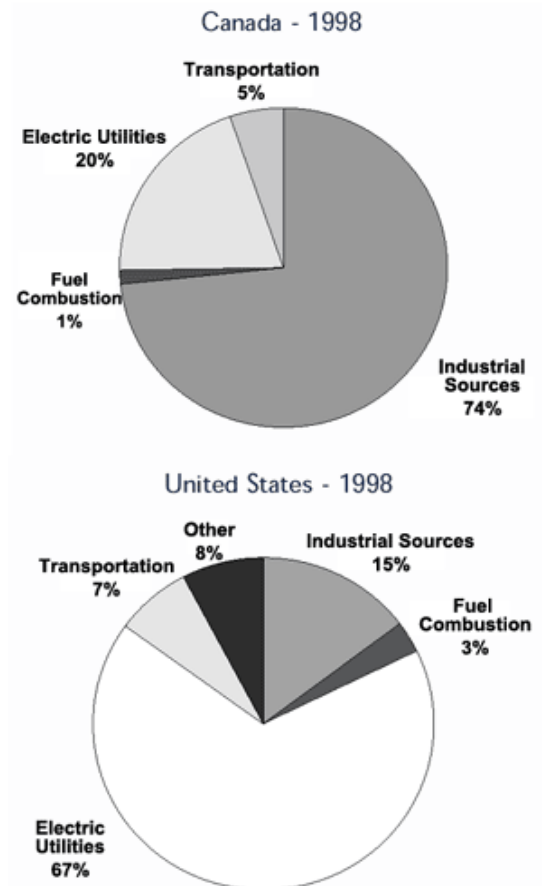
- the Adirondacks and Catskill Mountains in New York state,
- the mid-Appalachian highlands along the e\_\_\_\_\_ c\_\_\_\_\_
- the upper M\_\_\_\_\_, and mountainous areas of the Western

United States.

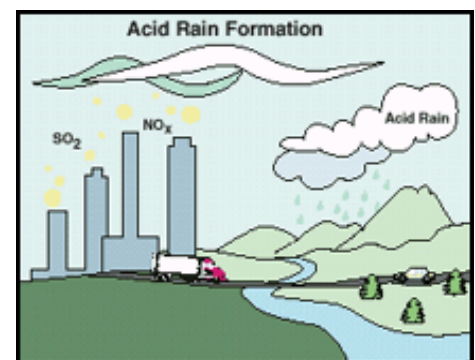
– In areas like the Northeastern United States, where s\_\_\_\_\_ buffering capacity is poor, some lakes now have a pH value of less than \_\_\_\_\_.

- One of the most acidic is Little Echo Pond in Franklin, NY with a pH of \_\_\_\_\_.
- also a problem in lakes smaller than 10 acres that were not included in the NSWS (may increase the number up to f\_\_\_\_\_ - fold).

- ▶ approximately \_\_\_\_\_ percent of sensitive lakes in the Adirondacks are at risk of e\_\_\_\_\_ acidification (brief periods of low pH)
- ▶ low b\_\_\_\_\_ streams: \_\_\_\_\_ of the streams in the Mid-Atlantic Coastal Plain are acidic, in the New Jersey Pine Barrens, over \_\_\_\_\_ percent of the streams are acidic (highest rate of acidic streams in the nation), and over \_\_\_\_\_ of the streams in the Mid-Atlantic Highlands (mid-Appalachia) are acidic, primarily due to acidic deposition.
- ▶ Canadian government has estimated that \_\_\_\_\_ lakes in eastern Canada are acidic.



<http://www.ec.gc.ca/acidrain/acidfact.html>



## Affects Fish and Aquatic Species

- ▶ acid rain causes a c\_\_\_\_\_ of effects that harm or k\_\_\_\_\_ individual fish, reduce fish p\_\_\_\_\_ numbers, e\_\_\_\_\_ fish species, and decrease b\_\_\_\_\_
- ▶ increased a\_\_\_\_\_ levels cause chronic stress that may not kill individual fish, but leads to lower body weight and smaller size and makes fish less able to compete for food and habitat.
- ▶ generally, the y\_\_\_\_\_ of most species are more sensitive to environmental conditions than adults. At pH 5, most fish e\_\_\_\_\_ cannot hatch. At lower pH levels, some adult fish die.

	pH 6.5	pH 6.0	pH 5.5	pH 5.0	pH 4.5	pH 4.0
TROUT						
BASS						
PERCH						
FROGS						
SALAMANDERS						
CLAMS						
CRAYFISH						
SNAILS						
MAYFLY						

## Tree and Forest Damage

- ▶ damage of trees at high e\_\_\_\_\_ (for example, red spruce trees above 2,000 feet) and many sensitive forest soils.

## Water Quality Impacts

- ▶ n\_\_\_\_\_ impacts on water quality due to eutrophication (o\_\_\_\_\_ depletion, a\_\_\_\_\_ blooms, d\_\_\_\_\_ in the health of fish and shellfish, loss of s\_\_\_\_\_ beds and c\_\_\_\_\_ reefs, and ecological changes in food webs): 10-45 percent of the nitrogen produced by various human activities that reaches e\_\_\_\_\_ and coastal e\_\_\_\_\_ is transported and deposited via the atmosphere. \_\_\_\_\_% of nitrogen in the Chesapeake Bay comes from atmospheric deposition.

## Materials and Building Decay

- ▶ a\_\_\_\_\_ the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage.
- ▶ acid rain can s\_\_\_\_\_ automotive coatings
- ▶ Acid rain and the dry deposition of acidic particles contribute to the c\_\_\_\_\_ of metals (such as bronze) and the deterioration of paint and s\_\_\_\_\_ (such as marble and limestone).
- ▶ some car manufacturers use acid-resistant paints, at an average cost of \$\_\_\_\_\_ for each new vehicle (\$61 m total/y)

Air Quality Concentrations	
1981-00	50% decrease
1991-00	37% decrease
1999-00	4% decrease
Emissions	
1981-00	27% decrease
1991-00	21% increase
1999-00	6% increase

Worth Noting:  
SO<sub>2</sub> concentrations have been reduced by over 50% over the past 20 years (1982-2001) and approximately 35% over the more recent 10-year period (1992-2001) nationwide. Reductions in SO<sub>2</sub> concentrations since 1990 are due, in large part, to controls implemented under EPA's Acid Rain Program beginning in 1995.

## Affects visibility (as in photochemical smog from NO<sub>x</sub>)

- ▶ Sulfate particles account for \_\_\_\_\_ percent of the visibility reduction in the eastern part of the United States

## Acid Rain Reductions

- ▶ EPA's Acid Rain Program caps SO<sub>2</sub> emissions from power plants at \_\_\_\_\_ million tons/yr
- ▶ 1990 Acid Rain Program under the Clean Air Act set goal to achieve reductions of \_\_\_\_\_ million tons of sulfur dioxide (SO<sub>2</sub>) and \_\_\_\_\_ million tons of nitrogen oxides (NO<sub>x</sub>).
- ▶ When fully implemented by the year 2010, the public health benefits of the Acid Rain Program are estimated to be valued at \$\_\_\_\_\_ billion annually, due to decreased m\_\_\_\_\_, h\_\_\_\_\_ admissions, and emergency room visits. (for more details see: <http://www.epa.gov/airmarkets/progress/arpreport/acidrainprogress.pdf>)