



# ENV 207 Environmental Degradation and Pollution

## Lecture 3

### Smog and Acid Rain

# Lecture Outline

- Air Pollution, Smog and Acid Rain

## Recommended Book:

*Understanding Environmental Pollution, By Marquita K Hill. Cambridge University Press. 2010.*

# Urban Air Pollution - SMOG

- Smog is air pollution that **reduces** visibility. The term smog was first coined in 1905 in a paper by Dr. Henry Antoine Des Voeux to describe the combination of **smoke** and **fog** that had been plaguing London during that time.
- The smoke usually came from burning coal. Smog was common in industrial areas and remains a familiar sight in some cities today.

The tallest towers of Shanghai, China, rise above the haze. Shanghai's smog is a mixture of pollution from coal, the primary source of energy for most homes and businesses in the region, as well as emissions from vehicles.



# Types of Smog

- There are 2 types of smog: **Industrial Smog** (London) and **Photochemical Smog** (Los Angeles)

Today, most of the smog we see is photochemical smog.

- Photochemical Smog (ex: Los Angeles below)
  - Brownish-orange haze formed by chemical reactions involving sunlight, nitrogen oxide, and hydrocarbons



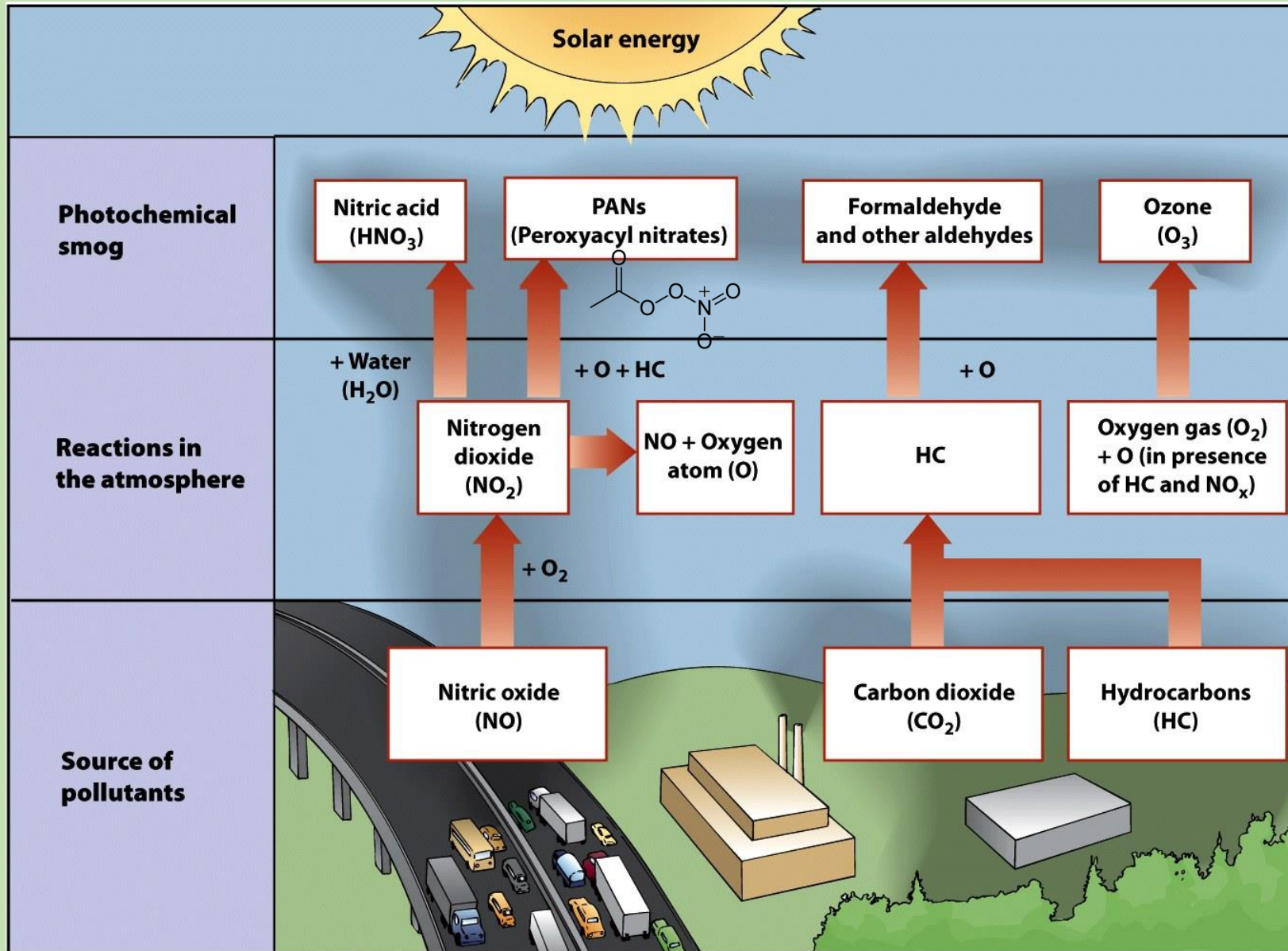
# Photochemical Smog

- This was first observed in Los Angeles, California, United States, in the 1940s.
- Cities located in basins surrounded by mountains may have smog problems because the smog is trapped in the valley and cannot be carried away by wind. LA and Mexico City, Mexico, both have high smog levels partly because of this kind of landscape.
- Photochemical smog is produced when **sunlight** reacts with **NO<sub>x</sub>** and at least one volatile organic compound (**VOC**) in the atmosphere to form airborne particles and ground-level ozone – or smog.
  - **NO<sub>x</sub>** come from car exhaust, coal power plants, and factory emissions.
  - **VOCs** are released from gasoline, paints, and many cleaning solvents.

# Composition of PC Smog

- Nitrogen oxides
  - Ozone
  - Aldehydes
  - Unreacted carbon
  - Particular matter
  - Peroxyacetyl nitrate (PAN)
- 
- Source of PC smog – mainly automobile pollution

# Formation of Photochemical Smog



# Industrial Smog

- Source: Industries that burn impure coal and oil. In other words, coal and oil that contain sulfur.
- Clean air laws passed in 1956 have greatly reduced smog formation in the United Kingdom; however, in other parts of the world London-type smog is still very prevalent. The main constituent of London-type smog is **soot**; however, these smogs also contain large quantities of **fly ash, sulfur dioxide, sulfur trioxide, sodium chloride and calcium sulfate particles**. If concentrations are high enough, sulfur dioxide can react with atmospheric hydroxide to produce **sulfuric acid**, which will precipitate as acid rain.



# Industrial vs. Photochemical Smog

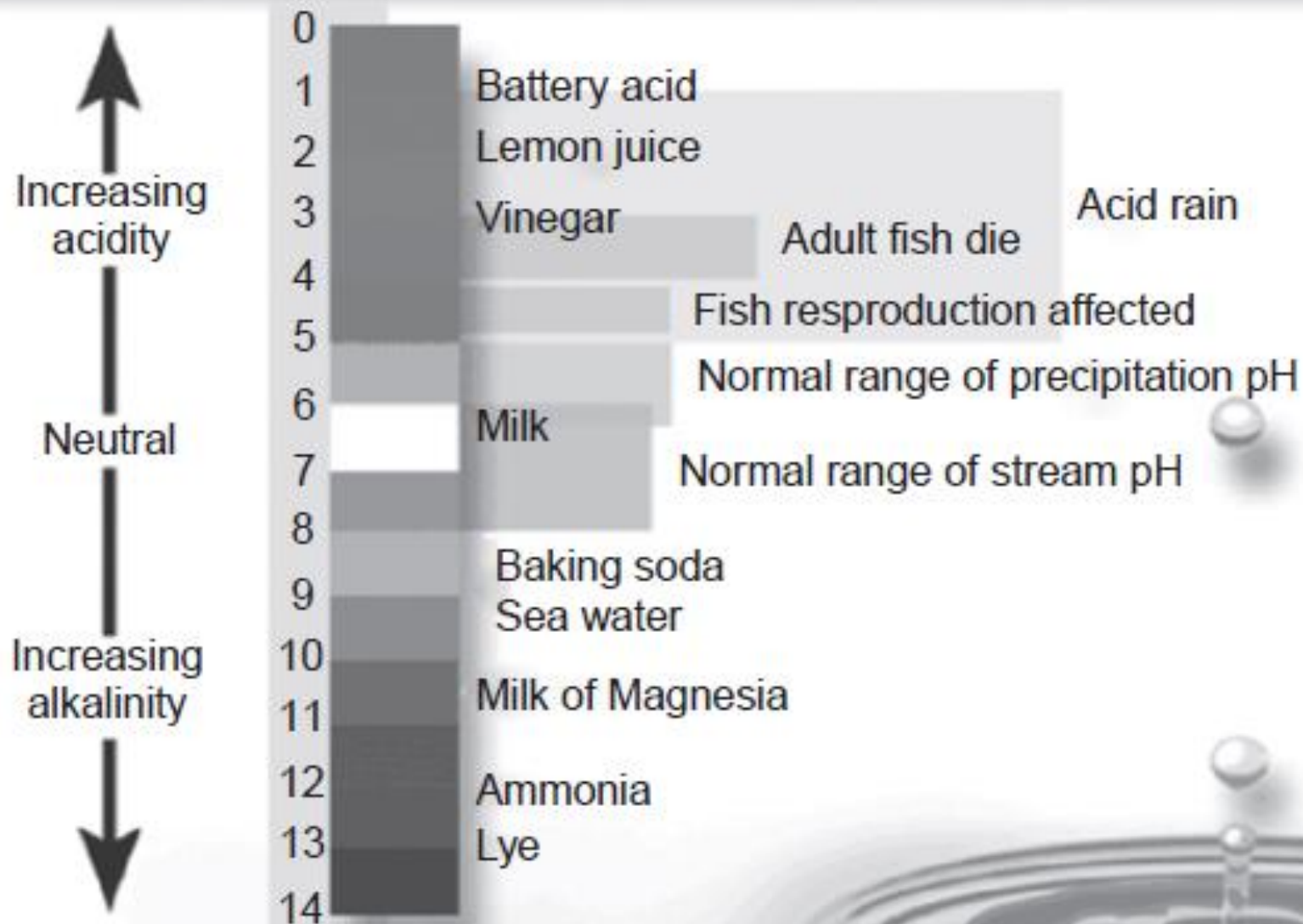
Characteristics	Industrial smog	Photochemical smog
Climate	Cool and humid	Warm and dry / sunny
Pollutants	SO <sub>x</sub> , particulates	NO <sub>x</sub> , O <sub>3</sub> , aldehydes, PAN, etc.

Continued..

<b>Characteristics</b>	<b>Industrial smog</b>	<b>Photochemical smog</b>
Major sources	Industrial and household burning of coal oil	Motor vehicles
Times when worst episodes occur	Winter months (especially in early morning)	Summer months (maximum effect around noon)

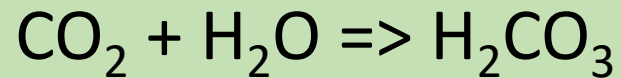
ACID RAIN

## The pH scale



# What is Acid Rain?

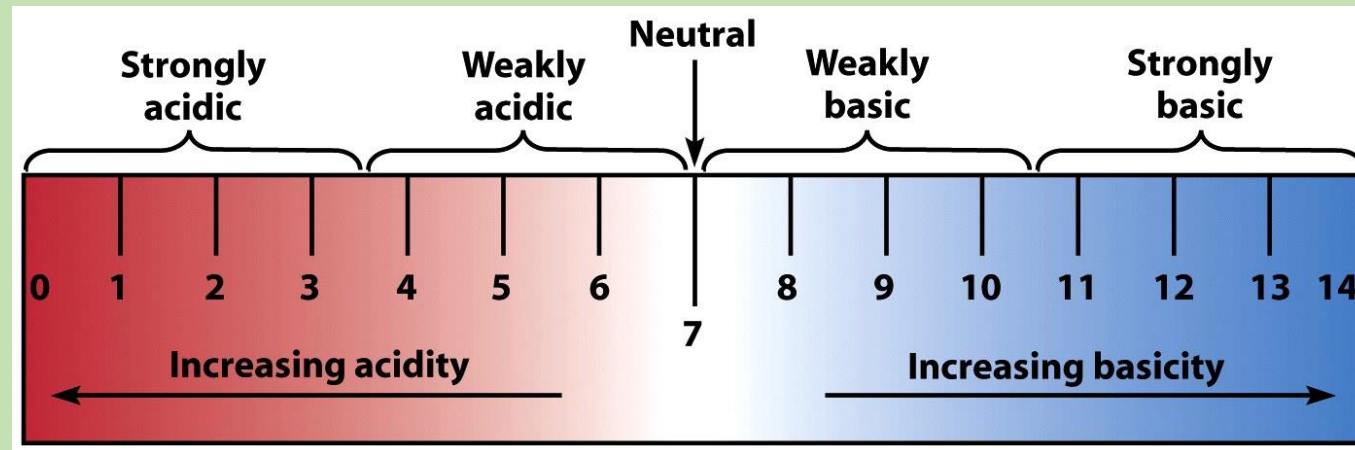
- Unpolluted rainwater is slightly acidic (pH 5.6) because of the carbon dioxide from air dissolved in it.



- Rainwater with a pH as low as 2.5 has been recorded in some parts of the world. They are commonly known as acid rain.

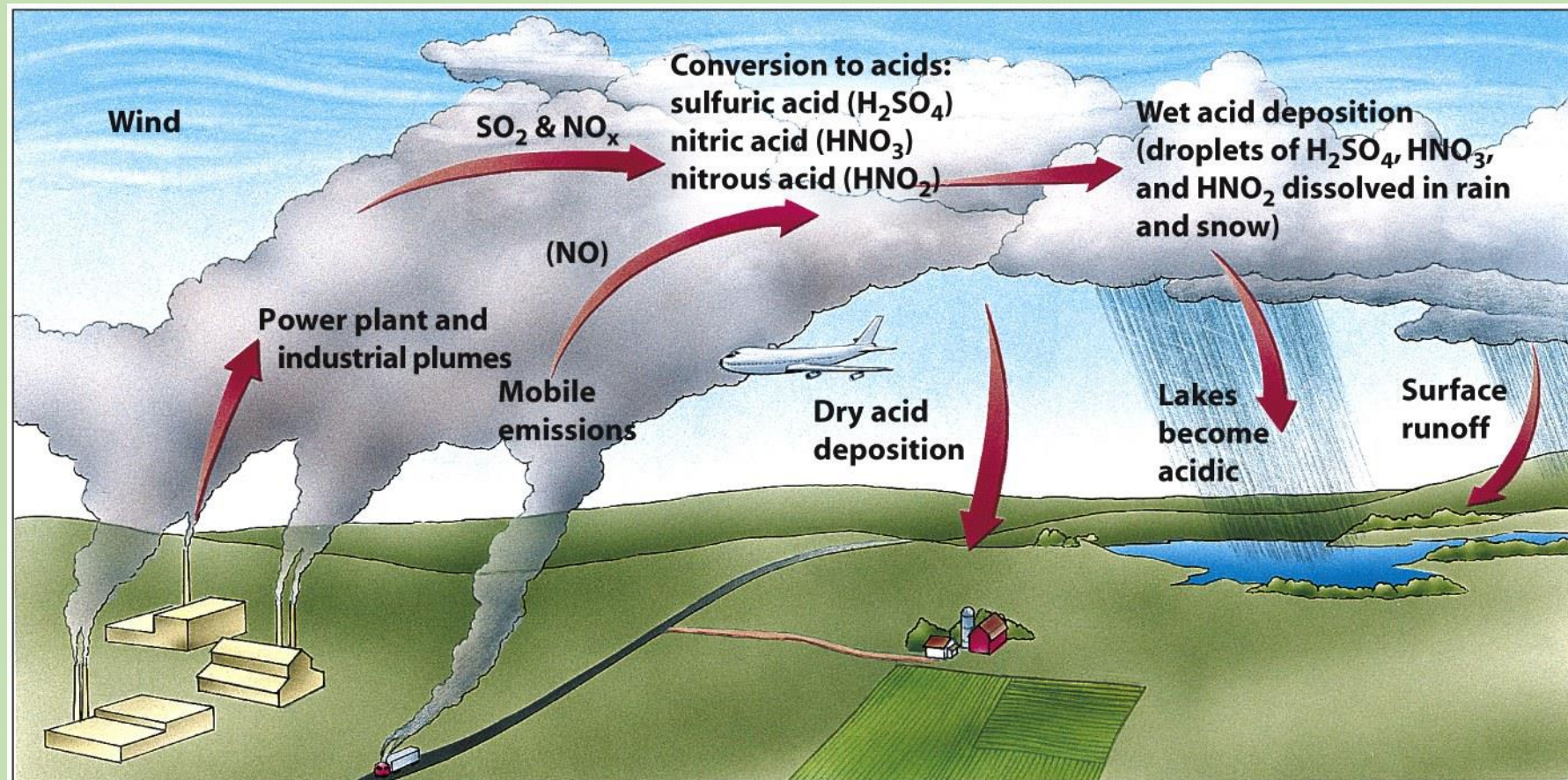
# Acid Deposition

- Sulfur dioxide and nitrogen dioxide emissions react with water vapor in the atmosphere and form acids that return to the surface as either dry or wet deposition
- pH scale





# How Acid Deposition Develops



# Effects of Acid Rain

- Acid rain is a form of environmental pollution that damages buildings, monuments and marble statues by dissolving marble and building materials

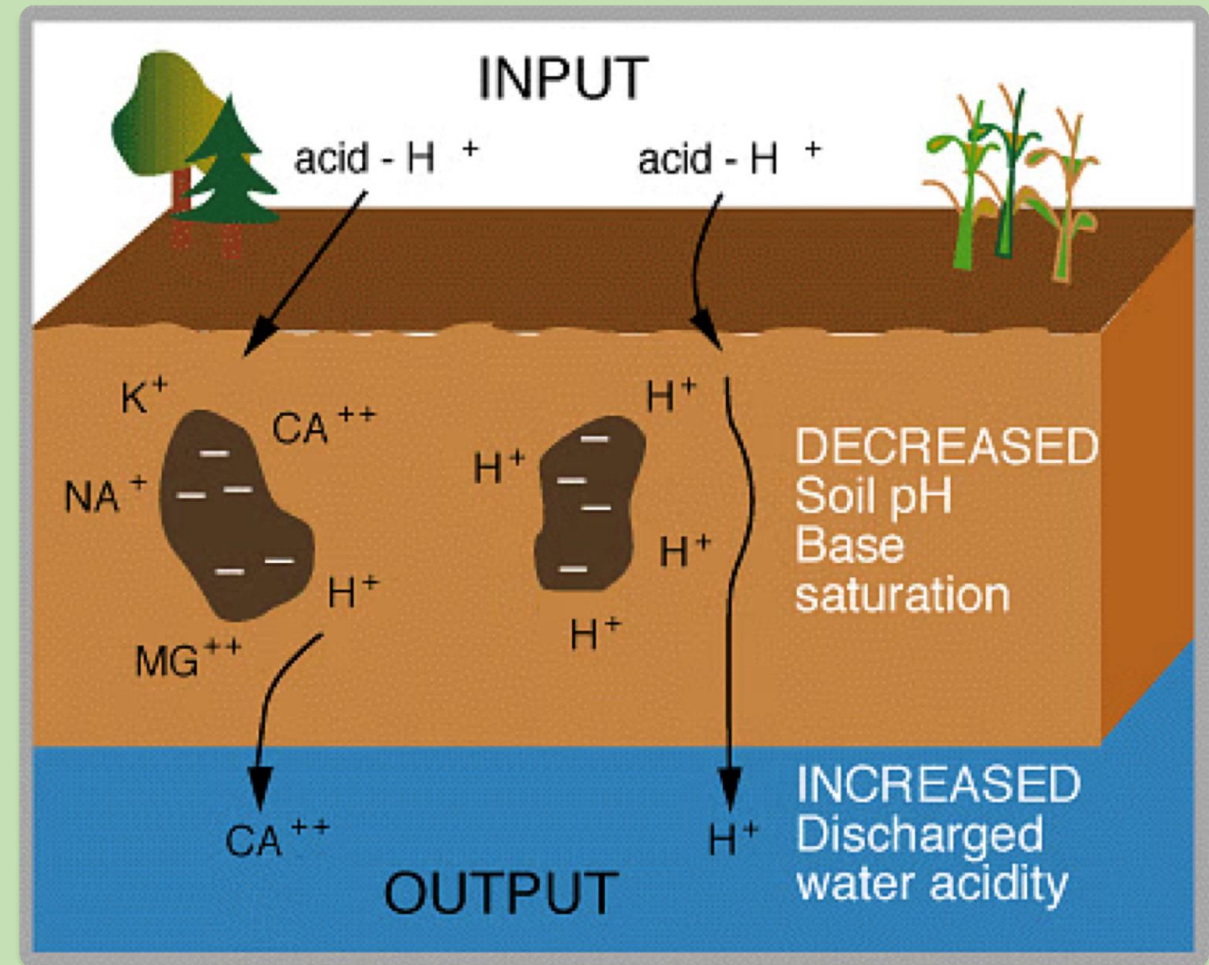


The statue in the pic was destroyed by acid rain in Westphalia, Germany. The picture on the left was photographed in 1908 and the right was taken in 1968.



# Effects of Acid Rain

- Acid rain can leach toxic metals (e.g. arsenic) from the soil into ground water, lakes and rivers, poisoning fish and plant roots.
- The sulfates and hydrogen sulfates in acid rain can leach essential plant nutrients such as calcium and magnesium, from the soil.



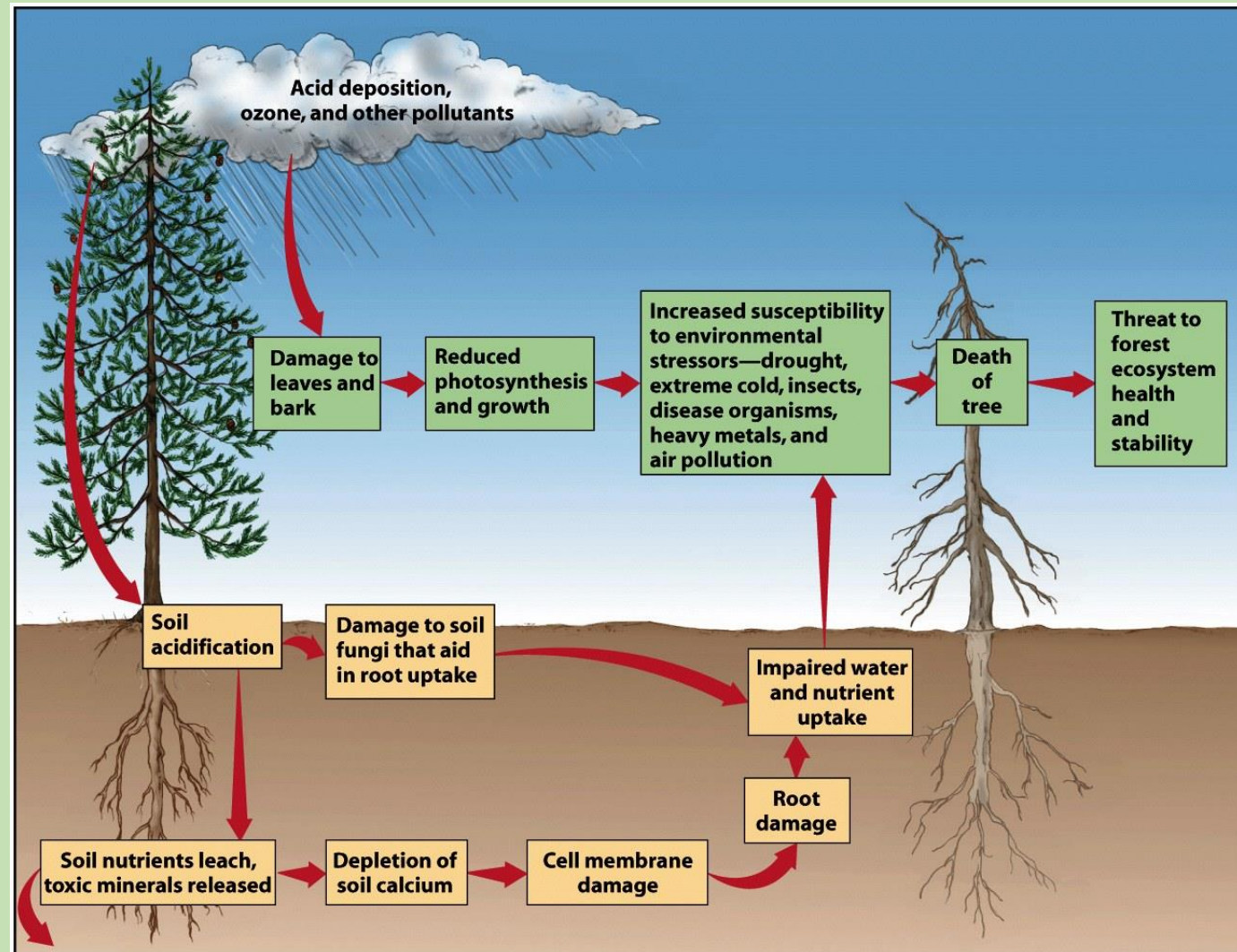
# Effects of Acid Rain

- **Forest decline**
  - Ex: Black forest in Germany (50% is destroyed)
- Acid rain disrupts the process of photosynthesis resulting in damage to plant life and causes mass defoliation of pine forests.
- It blocks the production of chlorophyll, leading to death of plants.














# Acid Deposition and Forest Decline



# Effects of Acid Rain

- **Declining Aquatic Animal Populations**
- **Thin-shelled eggs prevent bird reproduction**
  - Because calcium is unavailable in acidic soil
- Some organisms are sensitive to changes of acidity in water which can affect their ability to reproduce and, in some cases, may kill them.

Critical pH Levels for Aquatic Organisms		
<u>Animal</u>		<u>Critical pH Level</u>
Snails		6
Clams		6
Bass		5.5
Crayfish		5.5
Mayfly		5.5
Trout		5
Salamanders		5
Perch		4.5
Frogs		4

This figure illustrates the pH level at which key organisms may be lost as their environment becomes more acidic. Not all fish, shellfish, or the insects that they eat can tolerate the same amount of acid.