



Course in Forest Protection  
Master of Science Level  
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- ✓ Air pollution has caused injuries to trees ever since the Industrial Revolution . The main types of air pollutants are gases, particulates, and acid precipitation. The air pollutants affecting plants and their sources .Air pollutants can be classified as primary or secondary. Primary pollutants are those that originate at the source in a form toxic to plants, like  $\text{SO}_2$ ' Secondary pollutants develop as a result of a reaction among pollutants, like  $\text{O}_3$  and other oxidants and acid precipitation .The major gases causing plant injuries are  $\text{SO}_2$  and  $\text{O}_3$ ' Minor gases are  $\text{NO}_x$ , peroxyacetyl nitrate (PAN), hydrogen fluoride (HF), silicon tetrafluoride ( $\text{SiF}_4$ ), ammonia ( $\text{NH}_3$ ), hydrogen chloride (HCl) , chlorine ( $\text{Cl}_2$ ), freon, polyvinyl chlorides (PVCs), hydrogen sulfide ( $\text{H}_2\text{S}$ ), and ethylene ( $\text{C}_2\text{H}_4$ ) .Carbon monoxide (CO), a major pollutant gas affecting humans and animals, is not considered to be a problem to plants in the open atmosphere. Carbon dioxide, a major contributor to global warming, has not been considered a pollutant gas up to this point.

# Types of Air Pollutants

**Primary Pollutants:** Sulfur dioxide is the main primary air pollutant gas, but the other gases listed above also cause problems. Nitrogen oxides, the precursors to O<sub>3</sub> are emitted in automobile and truck exhausts. The source of HF is aluminum smelters, and NH<sub>3</sub> comes from urea fertilizer plants, tanker spills, and agricultural activities such as feed lots, particularly from pigs. Chlorine gas usually results from industrial leaks or from swimming pools, and freon comes from refrigeration and air-conditioning leaks (it is not used in modern air conditioners). Sulfur dioxide occurs naturally in the atmosphere from volcanic activity and other sources, but industrial sources such as copper smelters and the burning of coal for power generation are more important in causing plant damage.

**Secondary Pollutants:** The major secondary pollutants are  $O_3$  and acid precipitation and associated excess nitrogen (N). Ozone is now the major air pollutant affecting forests worldwide. There is some confusion with respect to the beneficial and negative influences of  $O_3$  in the atmosphere.

## Dispersion of Air Pollutants

The concentration of pollutants downwind from a source depends on the type of source, concentration at the source, height of the source above the ground surface, the terrain, and meteorological conditions, such as windspeed and atmospheric stability .Sulfur dioxide is typically emitted in a plume from a point source such as a smokestack. Maximum dispersion and lowest concentrations at the ground occur when the atmosphere is unstable and wind speeds are high, a condition known as "looping." Dispersion also is good under "coning" conditions. Minimum dispersion occurs when the atmosphere is stable and wind speeds are low. Temperature decreases with height in the atmosphere.

# Damage Caused by Air Pollutants

Air pollution damage is classified as either acute or chronic .Acute damage implies that necrotic symptoms are present, whereas chronic damage (e.g., reduced growth) is more subtle. Air pollutants can affect cell membrane permeability, accelerate respiration, decrease photosynthesis and growth, and inhibit enzymes .Chronic damage can occur at the level of the individual leaf or needle, the tree, or the ecosystem. Trees may be weakened so that they are more susceptible to root diseases, bark beetles, and insect defoliators. Chronic air pollution injury now is more common than acute air pollution injury.

**The degree of damage due to gaseous pollutants is related to the following factors:**

- (1)the concentration of the gas.
- (2)the exposure or dose.
- (3)the species of plants involved.
- (4)the macro- and micrometeorology of the location .



# Effects of Acid Precipitation

A massive research program into the effects of acid precipitation on forest eco-systems in the United States and Europe was mounted in the 1980s. The main conclusions were that (1) aquatic systems were adversely affected in areas where streams and lakes had low acid-neutralizing capacity; (2) fish populations were lowered or even decimated, where the bedrock is low in bases such as Ca and Mg; (3) Sand N deposition caused adverse impacts on certain highly sensitive ecosystems, especially high-elevation spruce-fir ecosystems; and (4) gradual leaching of soil nutrients, especially Ca, Mg, and K, from sustained inputs of acid rain could eventually affect the nutrition and growth of trees.

**Original hypotheses on forest effects** were that increased acidity in rain and fog would (1) decrease soil pH and the availability of nutrient ions; (2) increase soil Al concentrations, resulting in the killing of fine roots and mycorrhizas resulting in forest decline; and (3) leach cations from foliage and soils, causing poor growth and increased susceptibility to Armillaria root disease .

# Management of Air Pollution Problems

Air pollution injuries of forests can be managed by

1. Controlling emissions at the source
2. Using resistant species or varieties
3. Using chemical protectants
4. Forecasting air pollution episodes



# Herbicides

Herbicides are used in forestry to control competing vegetation during stand establishment, especially for conifers. They fall into two groups: those used for broad-leaved vegetation and those used for grasses and herbs. Triclopyr, 2,4-D, and dicamba are in the first group and act as plant hormones that disrupt normal growth forms. but conifers may outgrow the problem within one or two years. Other symptoms include cupped leaves, curled leaf margins, swollen buds, and many others. These herbicides are sprayed aerially or from the roadside and can cause injury to nontarget plants, because they can drift away from the target. The amount of drift depends on release height, droplet size, and wind velocity.

## Mechanical Injuries

- ✓ Mechanical injuries to trees are caused by wind, snow and ice, hail, lightning, and equipment used during thinning operations but should not strictly be considered as causing disease because of their short time action. Pruning also may cause mechanical injuries.
- ✓ Although many tree species are adapted for handling heavy snow loads (e.g., high-elevation or high-latitude spruces and firs, which have a pyramidal shape that reduces snow accumulation), snow can cause tree damage, particularly in low-elevation species.
- ✓ Ice buildup on branches can cause breakage because of the increase in weight. Long needle conifers are especially susceptible to glaze injury, and trees may have their branches stripped, or they may be uprooted, bent over, or broken off.