RESEARCH LABORATORY TECHNICAL REPORT

Air Pollution Injury

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A number of airborne chemicals can damage trees and shrubs. Ozone (O_3) is the most common of the group. It is a photochemical (requires light for its formation) pollutant formed by the reaction between nitrogen oxides and hydrocarbons coming largely from car exhaust and industrial sources. Damage often occurs below the ozone concentrations that trigger public health ozone warnings.

Sulfur dioxide (SO_2) is another chemical that can damage plants. It primarily originates with fossil fuel combustion for the generation of electricity, refining and ore smelting. A number of other air contaminants such as fluoride, ethylene and chlorine can damage plants, but this happens infrequently and is usually confined to a limited area downwind from industrial sources.

One of the most common situations that results in tree damage is associated with high temperatures ($\geq$90°F, 32°C) and high humidity ($\geq$ 90%). These conditions are often associated with temperature inversions--when a layer of warm air forms in the normally cool upper levels preventing the upward movement of pollutants, thus concentrating them close to the earth surface. During these episodes, sulfur dioxide and ozone can accumulate to the point of causing plant damage.

Ozone (O_3)

Moderate levels of ozone exposure results in damage symptoms, including mottled green and yellow patches on leaves or yellow bands on conifers needles. You may first see injury at leaf tips but it can eventually cover the entire leaf or needle. Occasionally, yellow patches form closer to the base of the needle. Damaged needles from the previous year may drop prematurely. If ozone concentrations are high, or if the plant is particularly sensitive, the tip or the entire needle will turn brown and die.

Figure 1: Ozone damage on a tulip poplar

This is considered 'acute damage.' Intermediate symptoms on broadleaves are typically seen as small, yellow or bronze flecks or stipples on the upper surface. Ozone seldom damages the lower surface. These distinct flecks can coalesce to form large yellow, tan or reddish/bronze areas covering a good portion of the leaf (Figure 1). Leaves frequently drop prematurely. New leaves which develop after an ozone episode will not be symptomatic. Plant symptoms often peak in areas within 50 miles of large cities.

Sulfur Dioxide (SO_2)

Sulfur dioxide enters plants along with normal air components moving into the leaves and reacting with cells inside the leaf. Symptom expression can take as little as one day to develop. On conifers, injury may be seen as yellowing of scattered needles with occasional brown needles (Figure 2). In more severe episodes, a tan to reddish-brown discoloration may indicate death of all or a portion of the needle. The injured portion may at first be restricted to the tip or base of the needle. On broadleaved trees, injury is seen as an interveinal or marginal chlorosis or necrosis, similar to leaf scorch. The veins frequently remain green.

Figure 2: Sulfur dioxide damage on *Pinus strobus* Photo courtesy of Joseph O'Brien, USDA Forest Service Bugwood.org

Mimicking Symptoms

Many factors in the environment cause plant symptoms which mimic those caused by specific air pollutants. High temperatures and dry soil cause leaf scorch, a symptom which resembles fluoride or SO_2 damage. Winter injury on broadleaf evergreens often appears as marginal necrosis, which can resemble SO2 or fluoride injury. Drought injury on conifers may resemble needle browning caused by various pollutants. Some nutrient deficiency symptoms show up as chlorosis between the veins whereas, other deficiencies appear as a general leaf chlorosis similar to symptoms of low level, chronic exposure to an air pollutant.

Insects such as mites, aphids and leafhoppers cause leaf symptoms nearly identical to those due to O_3. Occasionally, misapplication of certain pesticides may cause injury to plants which resembles air pollution damage.

Relative Tolerances

Tree species, varieties, cultivars and individuals within a species react differently to a given air pollutant. White pine, for example, is listed as being highly sensitive to O_3 pollution; yet, there are individual trees which are more resistant. Therefore, several pines on a property may show symptoms whereas, one or two may not. This is true of other species as well.

Some of the more sensitive species to ozone injury include big-leaf linden, fastigiate English oak, 'Imperial' honeylocust, Kentucky coffee tree, London plane 'Bloodgood', sycamore, tulip poplar, zelkova and white pine. Maples, birches, and other oak and honeylocust varieties are generally quite tolerant of ozone.

Prevention and Control

There are no remedial steps for needles and leaves already damaged by pollution. However, fertilizing trees can make them less susceptible to further injury from SO_2 and O_3. In areas with chronic, high concentrations of pollutants, consider planting species which are tolerant to those pollutants.

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