IMPACT OF AIR POLLUTION ON THE GROWTH OF PONDE

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Air pollution poses a serious threat to the coniferous forests of California. Symptoms of air pollution damage to coniferous species have been observed in forests located north and east of the Los Angeles basin, east of major cities in the Central Valley, and east of San Diego. Damage is especially severe in the San Bernardino Mountains east of Los Angeles.

The patterns of air pollution dispersal are influenced by meteorological conditions. During summer, pollutant-laden air escapes into the San Bernardino Mountains from beneath the inversion layer which develops over the eastern end of the Los Angeles basin. This movement results from the convection of warmer air up the heated mountain slopes.

The amount of pollutants moving into the coniferous forest of the San Bernardino Mountains began to increase significantly after World War II, with the sharp rise in population in the Los Angeles basin and the accompanying widespread use of the automobile. The first symptoms of damage to Ponderosa pine (*Pinus ponderosa* Dougl.) were reported in 1953. These symptoms included loss of all but the current season's needles, reduction in number and size of remaining needles, and yellow mottling of the needles. Initially the cause of the damage was not known. When attempts to identify a fungal or viral pathogen responsible for the damage failed, air pollution was suggested as the cause. Confirmation of air pollution as the cause was established by Miller, Parmeter, Taylor, and Cardiff in 1963. Ozone, a powerful oxidant, is the component of polluted air primarily responsible for the damage.

Ponderosa pine shows acute foliar damage symptoms and mortality in the zones of highest oxidant pollutant concentration in the San Bernardino Mountains. The chlorotic condition of the foliage, together with an increased rate of needle shedding, suggest that growth reduction may be a consequence of high oxidant concentrations. This is a preliminary report on a study to determine the impact of oxidant air pollution on radial and height growth of Ponderosa pine.

The first experiment of the study investigated the radial growth of young trees grown in non-polluted and polluted air. Two populations of 19 trees each were selected, increment cores taken, and ring widths measured. The first population, the non-polluted air treatment, ranged in age from 55 to 71 years in 1971, with an average age of 62. The average annual radial growth was calculated for the rings produced from 1910 to 1940. During this period, the trees became established and grew in the absence of significant levels of air pollution.

The second population, the polluted air treatment, ranged in age from 20 to 39 years in 1974, with an average age of 30. The average annual radial growth was calculated for the rings produced from 1944 to 1974. This growth took place during the period of increasing air pollution in the San Bernardino Mountains.

The two stands from which these populations were selected were located near Rim Forest in the San Bernardino Mountains. Both populations were growing on slightly sloping ground on soil developed on decomposed granite. Distance between the two stands was less than 1 mile. An examination of rainfall records for this area showed no statistically significant difference in average annual precipitation for the two periods.

Records on the level of oxidant air pollutants are not available throughout the entire period 1910-1974. However, records are available for 1968-1974 from a recording station near Rim Forest. Air pollutant levels are measured with reference to the Federal Air Quality Standard. This standard is the level of air quality necessary to protect the public health, and is not to be exceeded more than once per year. The standard for oxidant pollutants is 0.08 ppm for 1 hour. In 1968-1974, for the months of June - September, the average number of hours that the oxidant level exceeded this standard was 1546, or 53% of the time. In other words, oxidant levels were extremely high during this time.

A comparison of average radial growth, based on a 30-year period,

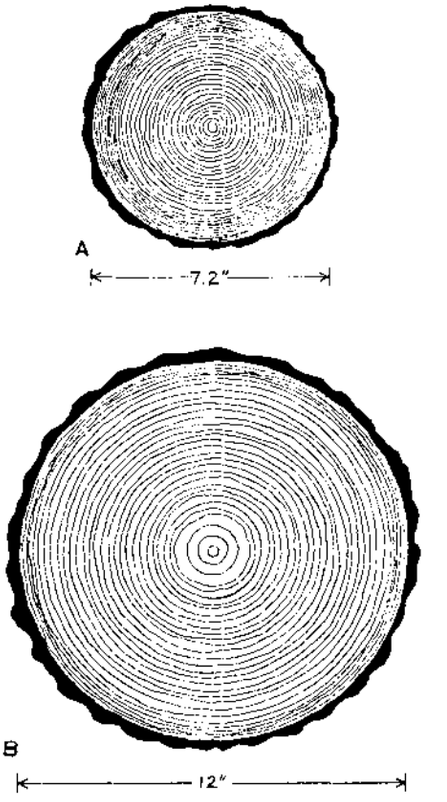

Fig. 1. Cross-section of 30-year-old Ponderosa pine at breast height. (A) grown in polluted air; (B) grown in non-polluted air.

ROSA PINE

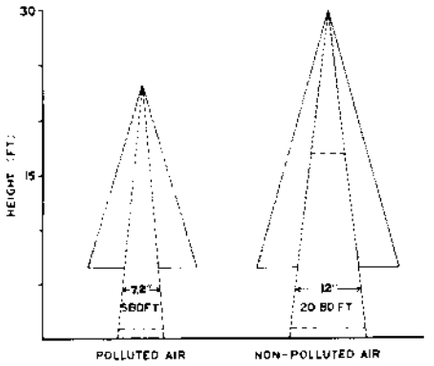

Fig. 2. Growth of 30-year-old Ponderosa pine in polluted and non-polluted air. Board foot volume based on Scribner Decimal C log rule for logs having minimum diameter of 6 inches.

Fig. 3. Air pollution moving into the San Bernardino Mountains.

for trees in non-polluted versus polluted air shows a statistically significant decrease from 0.20 to 0.12 inches. This results in a decrease in diameter of average 30-year-old trees from 12.0 to 7.2 inches (see fig. 1).

The second experiment used in this study was designed to measure the impact of air pollution on height growth of Ponderosa pine. This study was located near the air pollution monitoring station. A portable greenhouse was erected over a group of five Ponderosa pine saplings. The greenhouse was equipped with an air filtration system that removed ozone from ambient air drawn into the greenhouse by a fan. A similar greenhouse, but without the air filtration system, was set up over a second group of five saplings. Ambient air was drawn into this greenhouse by a fan. Growth difference between the two greenhouse treatments could be attributed to the difference in air quality.

Average height growth was measured in each treatment from 1969 to 1973. The trees within the filtered air greenhouse showed a recovery from symptoms of foliar damage each year of the experiment. The progressively more luxuriant foliage of these saplings supported an increased amount of height growth each year. Because of this recovery phenomenon, only the last 3 years of height growth were used in comparing the two treatments. In the filtered air treatment the average annual height increment from 1971 to 1973 was 5.9 inches, while in the ambient air greenhouse it was 4.3 inches, a statistically significant difference. This difference of 26% in height growth between the two treatments can be attributed to air pollution.

The impact of air pollution on volume growth can be calculated from the measurements obtained in these two experiments. The accompanying graph (fig. 2) illustrates the calculated size of 30-year-old trees grown in polluted and non-polluted environments. The height of the polluted-air tree is based on field observations of 30-year-old trees growing in the high air-pollution zones of the San Bernardino Mountains. The greater height of the non-polluted air tree is calculated from the results of the height-growth experiment. The merchantable volume of the tree grown in the polluted environment would be 5 board feet. The merchantable volume of the tree grown in the non-polluted environment would be 20 board feet.

The reduction of growth in Ponderosa pine demonstrated in this study is of important magnitude and has implications for forest management in areas where air pollution levels are high or are increasing. The forest manager is faced with a dilemma due to the uncertainty of air pollution abatement programs. One alternative is to continue management programs aimed at producing Ponderosa pine timber under the assumption that effective air pollution abatement will occur. Other alternatives are to initiate selection and breeding programs to develop pollutant resistant Ponderosa pine, or to shift management emphasis to tree species which are more resistant to air pollution.

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