CRS Report for Congress

86031:Acid Rain, Air Pollution, and Forest Decline

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SUMMARY

Certain tree species in several areas of the United States are showing evidence of a decline in productivity, many from unknown causes. Acid rain and other air pollutants are seen as possible causes, or contributing factors, in these declines. The primary pollutants under investigation are sulfur dioxide, nitrogen oxides, reactive hydrocarbons, and ozone. The effect of acid rain and air pollution on trees and forests, both confirmed and disputed, plays a role in the legislative debate over pollutant emission controls.

Few tree declines in the United States can be conclusively attributed to air pollution. The most common hypothesis for declines is one of general stress where natural stresses such as insects or diseases work in concert with one or more anthropogenic factors such as air pollution to cause a decline in productivity. Many other hypotheses exist, including both direct effects of air pollutants on tree foliage and indirect effects from pollution-induced changes in the soil.

Federal research on the effects of acid deposition and air pollution on forests has increased significantly over the past few years. The current forest-related research program is headed by the Forest Service and the Environmental Protection Agency (EPA). The key forestry issues

relating to the debate on pollutant emission controls are whether the problem is so exigent as to warrant immediate controls, and if controls are warranted, which pollutants the program should address. Opponents to pollution control bills state that additional regulation should be postponed until these and other questions can be conclusively answered. Advocates of additional pollution controls contend that delay could cause irreversible and irrevocable damage.

In 1980, an independent, 10-year organization was created, the National Acid Precipitation Assessment Program (NAPAP), to coordinate acid rain research activities and periodically report to Congress on all aspects of the acid rain issue. The NAPAP research program reports expenditures of over $80 million annually. The final report of the 10-year National Acid Precipitation Assessment Program (NAPAP) is now in draft form.

In July 1989, the Bush Administration, having pledged to "protect the air we breathe," submitted a proposal to amend the Clean Air Act (H.R. 3030/S. 1490). The congressional debate has shifted from whether to attempt to curb acid rain to what measures are appropriate to do so. Title V of the legislation addresses acid rain and sets goals for S02 and NOx emissions. H.R. 3030 passed the House May 23, 1990. S. 1630, which combines several bills along with elements from the Administration's proposal, was reported from the Committee on Environment and Natural Resources Dec.20, 1989. A compromise amendment on the reported bill, worked out by Administration officials and ten Members of the Senate, was debated on the Senate floor -- along with other amendments -- and passed Apr. 3, 1990. H.R. 3030 and S. 1630 are in conference (see CBS Issue Briefs 90020 and 89144 for details).

ISSUE DEFINITION

Trees in several areas of the United States are showing evidence of decline. Although U.S. forests have periodically suffered ill health from known causes, there is little scientific consensus explaining the cause and effect relationship for many of the current declines. Acid rain and air pollution generally are suspected agents in some of the declines, but a wide range of interconnected causes may be involved.

This issue brief discusses the nature and extent of forest decline, some explanations for this decline, and the Federal response to address this situation. The central issue is whether acid rain and/or air pollution contributes to the cause of forest decline, and how this factors into the current congressional debate over pollutant emission controls.

BACKGROUND AND ANALYSIS

Forest decline involves a complex set of biological and nonbiological stress factors, as opposed to a plant disease in which death of one species can be attributed to one cause. Symptoms of decline can be obvious or invisible to the naked eye, rapid or progressive, chronic or acute. Resulting damage can include reduced growth, crown and twig dieback, yellowing of leaves and needles, decreased leaf size, thinning and death of leaves and needles, and deterioration of roots.

Most of the attention and research on the possible air pollution effects on forests have been focused on the eastern and southern parts of the United States. Despite documented ozone damage in southern California for Ponderosa and Jeffrey pines, California black oak, and white fir, and despite specific point source pollution problems (e.g., forested areas surrounding smelters), the West has generally been considered less threatened by regional air pollution.

In scattered areas of the Appalachian and Blue Ridge Mountains, damage to eastern white pine has been confirmed. At high elevations, red spruce has also suffered significantly increased mortality and growth reductions for the past 20 to 25 years, but without conclusive links to air pollutants. Loss of foliage and fine roots are the most common visible symptoms, sometimes leading to more susceptibility to damage from insects and disease. Red spruce at low elevations have also experienced growth reductions but without other obvious symptoms.

Forest surveys for the Piedmont regions of Alabama, Georgia, North Carolina, and South Carolina have indicated unexpected growth reductions of approximately 20% for loblolly and shortleaf pines during the last 10 years. An unexpected decrease in rates of tree growth of longleaf and slash pines has also occurred in the coastal plain regions of other southern states.

In the Ohio River valley, white ash, tulip poplar, sugar maple, red oak, white oak and various bark lichens show various symptoms and degrees of damage from the pollution. The health of lichens is often used as an indicator of pollution in a given area.

Forest decline is best understood within the context of the entire forest ecosystem. Generally, the ecosystem has the capability to adjust to change and maintain an equilibrium; if any one of the ecosystem components is substantially altered, as from a natural or man-made stress factor, the entire ecosystem can be affected.

Most forest stresses are familiar, natural substances or situations, encountered and accommodated on a daily basis, which can be cast into three categories: biological, physical, and chemical factors. Biological factors primarily include insects, fungi, and viruses. Physical factors can involve climatic extremes of heat and cold, moisture supply, and high winds; geographic location; age of the forest; wildfires; and human activities such as prescribed burning, logging, or construction damage such as soil compaction. Chemical factors include the natural and anthropogenic (human-origin) gases such as sulfur dioxide, nitrogen, and ozone; potentially toxic metals such as aluminum and lead; acidic substances such as sulfuric and nitric acids; and growth-altering organic chemicals, such as ethylene.

Because of the resiliency of the forest ecosystem, most trees and forests recover from the effects of stress. However, at a critical time, one factor could -- like the straw that broke the camel's back -- push a tree, or an ecosystem, from a weak but stable situation, into a vulnerable and declining condition. Also, each individual tree species and/or forest can respond to these stresses in a different manner. At the same time, various stresses or declines can produce the same symptoms.

Air Pollutants as a Source of Forest Stress

One of the most recent types of stress that trees and forests have had to accommodate is air pollution. Pollutants are generally identified as primary or secondary, depending on how they are formed. Primary pollutants are directly emitted into the atmosphere, predominantly in gaseous forms and include sulfur dioxide (S02), nitrogen oxides (N0x), and reactive hydrocarbons (RHC), which are carbon compounds and mixtures such as ethylene and gasoline. The burning of fossil fuels -- coal, natural gas, and oil -- produces a large portion of these pollutants; industrial, utility, and power plants emit large quantities of the S02 and N0x. Mobile sources, such as transportation vehicles, are responsible for large amounts of N0x and RHCs. Petroleum refining and storage produces reactive hydrocarbons, although the majority are produced from numerous smaller sources such as the use of paint solvents and dry cleaners. Metal ore smelters can release S02, in addition to toxic elements such as lead, cadmium, nickel, and fluoride. Lead can also come from burning leaded gasoline.

Secondary pollutants are formed during chemical reactions in the atmosphere involving the primary pollutants. One of the most commonly known is acidic deposition, which is produced when S02 and sulfur oxides (SO_2) or N0x combines with oxygen in the air to form acidic gases or particulates (dry deposition); in combination with moisture, these processes can cause acid snow, hail, dew, fog, or rain (wet deposition, or "acid rain").

Another type of secondary air pollutant -- photochemical oxidants -- is produced when energy provided by sunlight triggers reactions involving N0x and atmospheric oxygen. Ozone (O_3), the most common oxidant, is a gas that is extremely toxic to both plants and humans. Like primary pollutants, secondary pollutants can travel long distances. Secondary pollutants can best be controlled by limiting their precursors, or by restricting other chemical compounds that may control the precursor rate of transformation. For example, production of ozone is highly dependent on the ratio of hydrocarbons to N0x in the atmosphere -- thus control of ozone could theoretically be accomplished by limiting either hydrocarbons or N0x to meet the correct ratio, though N0x can be controlled more easily than hydrocarbons.

Hypotheses to Explain the Role of Air Pollutants in Forest Decline

Many studies have shown that local (point source) air pollution can harm vegetation including forest growth. However, the effects of regional air pollution on forest growth are not as well documented. Regional air pollutants may have direct effects on trees through the leaves and stems, and indirect effects, primarily through the soil.

Many forest scientists also believe that air pollution could make a tree or forest more susceptible to natural stresses, such as insects, diseases, drought, or winter frost damage. Consequently, the most common theory advanced to explain the cause of current forest declines, called the general stress hypothesis, is that varying combinations of climate extremes, pests and pathogens, or other natural stresses, in concert with one or more anthropogenic factors, may be responsible. Very few of the American forest declines can be conclusively attributed, in whole or in part, to air pollution.

Many hypotheses exist in addition to this general stress hypothesis. These include both direct effects of air pollutants on tree foliage and indirect effects from pollution-induced changes in the soil. Appendix 1 summarizes the leading hypotheses derived from a survey of scientific literature. Possible U.S. forests of concern are also indicated, although the effects are likely to vary with the tree species, soils, climate, and the variety and concentration of pollutants found at any individual site.

The following general points can be derived from reviewing Appendix 1 regarding the link between air pollutants and forest decline: (1) the wet deposition of acidic solutions of sulfur and nitrogen oxides (commonly referred to as acid rain) is only one of several possible forest damaging effects of pollution; (2) "dry" sulfur dioxide may enter tree leaves and then react with cell moisture to form acids; (3) several hypotheses do not involve any acidic effects from pollution; and (4) the hypotheses are not mutually exclusive.

Federal Research Activities

The USDA Forest Service has been researching certain forest declines and possible effects of air pollution on forests for many years. In 1980, an independent, 10-year organization was created, the National Acid Precipitation Assessment Program (NAPAP), to coordinate acid rain research activities and periodically report to Congress on all aspects of the acid rain issue. The NAPAP research program reports expenditures of over $80 million annually.

The final report of the 10-year National Acid Precipitation Assessment Program (NAPAP) is now in draft form. Report #16, "Changes in Forest Health and Productivity in the USA," reaches five conclusions about forest health and air quality:

"(1) The vast majority of forests in the United States and Canada are not affected by decline (see Section 1.7 and 11.1 for definition of decline). (2) There is experimental evidence that acidic deposition and associated pollutants can alter the resistance of red spruce to winter injury; through this mechanism, acidic deposition may have contributed to dieback and mortality of red spruce at high elevations in the northern Appalachians. (3) Natural stresses are important factors contributing to recent declines of sugar maples. (4) Natural stresses are important factors contributing to growth reductions in natural pine stands in the Southeast. (5) Ozone is an important factor in a decline of pines in southern California and is the pollutant of greatest concern with respect to possible regional scale impacts on North American forests."

The Terrestrial Effects Task Group of NAPAP is a multi agency effort to explore the effects of acid ~eposition on crops and forests. The majority of work focuses on forest effects. The NAPAP research budget for forestry research has increased significantly over the past few years from about $1 million in FY84 to over $19 million in FY89. Most of the forest related research coordinated through NAPAP is supported by the Forest Service and the Environmental Protection Agency (EPA) in an organization called the Federal Management Group. This research is conducted through four, 5-year Cooperatives focused on specific forest types. The National Council of the Paper Industry for Air and Stream Improvement (NCASI), the research arm of the forest products industry, and scientists from many universities also co