Killing with Kindness: Trees and Excess Nitrogen

The winter of 1983-84 "clobbered" Vermont's mountain forests, says botanist Hubert W. Vogelmann of the University of Vermont in Burlington. On these windswept, cloud-wreathed slopes, thousands of red spruce and other trees suffered unexpectedly heavy frost damage. "The trees didn't show the winter hardiness that they would normally show," says Vogelmann.

Researchers are beginning to suspect that an oversupply of nitrogen, deposited as ammonium or nitrate ions carried by windblown dust and by rain or snow, may have exacerbated frost damage not only in Vermont but also elsewhere in the world in recent years. These nitrogen pollutants are emitted by sources as diverse as heavily fertilized fields, feedlots, motor vehicles and power plants.

Coniferous trees like red spruce and balsam fir have received so much fertilizing nitrogen, the theory goes, that plant cells continue to grow late into the year. The elongated, thin-walled cells that result cannot cope when caught by severe winter weather.

Usually, nitrogen compounds are thought of as among the most important nutrients for plants. "Nitrogen is very active, cycling along virtually every biochemical pathway," says Robert I. Bruck, a forest pathologist at North Carolina State University in Raleigh. But in the case of high-elevation, coniferous forests, "potentially, what you're doing is fertilizing an ecosystem that ... never asked to be fertilized," he says.

Similar hypotheses are emerging to account for the even more alarming forest devastation in northern and central Europe (SN: 4/7/84, p. 215). In the current AMBIO (Vol. 14, No. 1), Swedish researcher Bengt Nihlgård of the University of Lund lists the buildup of nitrogen in soils and plants as one of several factors that may have contributed to the dieback of trees in Europe's forests. "Excess nitrogen may make the trees more productive in the beginning," reports Nihlgård, "but also more sensitive to other air pollutants, frost and biological enemies."

Evidence that excess nitrogen can have deleterious effects has been around for a long time. Farmers have sometimes noticed tree damage within woodlots next to heavily fertilized fields from which ammonia, for example, can evaporate. Attempts to fertilize conifer plantations in the 1930s revealed damage to microorganisms associated with tree roots.

Recently, Bruck and his colleagues showed that there was enough nitrogen in the simulated acid rain solutions they used "to perturb" the symbiotic relationships between fungus and root. This influences the way trees take in water, phosphorus and other nutrients.

For trees and forest ecosystems, attention is now shifting away from the deposition of sulfur compounds, an early worry, to the damaging effects of other air pollutants. These pollutants include ozone and other oxidants, combined with the effects of excess nitrogen, acidification, mobilization of metals like lead and aluminum and the deposition of various organic, potentially growth-altering compounds that may number in the hundreds.

"These forests are being hammered by all of them," says Vogelmann. "It's pretty hard to isolate one and suggest that it is more of a cause than all of the rest. One year, one thing hits them; another year, another thing hits them." This past winter, for instance, early indications show that Vermont's mountain forests did not suffer an unusually high rate of frost damage, says Vogelmann. Nevertheless, his studies reveal that over the long term almost every tree species, including those at lower elevations, is generally less productive now than it was decades ago.

"It all adds up to air pollution being the focus," says Bruck, "but not a specific pollutant." Moreover, because so many different types of trees in a variety of soils and locations are showing reduced growth or are dying, he warns, "All hypotheses and all scenarios don't necessarily pan out for all locations."

In West Germany, scientists are looking specifically at ozone working in tandem with other factors. Ozone, created when nitrogen oxides and hydrocarbons react with oxygen in the air, damages leaves by rupturing surface cells. "The leaves become leaky," says forest ecologist John D. Aber of the University of Wisconsin in Madison. These "leaky membranes" allow the leaching out of magnesium and calcium nutrients, a process that may be speeded up by acid rain.

Yet nitrogen is probably involved too. Not only do nitrogen oxides lead to the formation of ozone but late-growing plant cells, elongated and weakened because of excess nitrogen fertilization, are likely to be more susceptible to ozone damage.

"It's such an incredibly complex problem," says Bruck. "We're talking about dominoes. We're talking about one thing affecting many others." — *I. Peterson*

Parkfield quake prediction certified

For the first time, an earthquake forecast has been given an official stamp of approval. Dallas Peck, director of the U.S. Geological Survey (USGS), announced last week that a prediction of a magnitude 5.5 or 6 earthquake occurring near Parkfield, Calif., within the next eight years has been endorsed by the National Earthquake Prediction Evaluation Council (NEPEC), a scientific review panel established by Congress in 1977 to advise USGS. NEPEC's counterpart in California also gave its blessing to the prediction.

The only other prediction ever presented to NEPEC for evaluation was a forecast for Peru, and this was turned down by the council in 1981 (SN: 7/4/81, p. 5). Unlike the Peru prediction, the Parkfield forecast specifies an exact epicenter, magnitude and time window and in this sense represents a fundamental advance in the scientific understanding of the earthquake process — at least in some regions. It is also helping scientists to place equipment around the fault so that they can zoom in on the details of earthquake dynamics and precursors of future quakes.

The Parkfield prediction was originally made last spring by Thomas McEvilly at the University of California at Berkeley, with William Bakun and Allan Lindh at USGS in Menlo Park, Calif. They noted that quakes have occurred on the San Andreas fault near Parkfield about every 22 years, and since the last one struck in 1966, another was due soon. But what really strengthened their forecast was the observation that seismograms painted an essentially identical picture of the last three quakes, indicating that the same part of the fault had ruptured in the same way each time. Bakun adds that historical data on two earlier quakes in 1881 and 1901 are consistent with these seismograms.

All this enabled the researchers to construct a model of a characteristic Parkfield quake and in so doing to make a detailed and precise prediction about a future quake with a 95 percent probability. A previous forecast for Parkfield, based on a statistical analysis of the relative probabilities of quakes along the fault, gave a 75 percent chance that a moderate quake would happen within two decades (SN: 12/24/83, p. 404).

Along with its endorsement of the prediction, NEPEC gave qualified support to a suggestion of Kerry Sieh at Caltech in Pasadena and Richard Janhs (now deceased) that a future Parkfield quake might either trigger a second quake to the southeast or itself extend farther in that direction. — *S. Weisburd*