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DeHayes, D.H., P.G. Schaberg, G.J. Hawley, and G.R. Strimbeck. 1999. Acid Rain Impacts on Calcium Nutrition and Forest Health. ***BioScience*** *49 (10): 789-800.*

Acid deposition is a global phenomenon affecting forest ecosystems of North America, northern Europe, and much of Asia, including tropical regions. Despite a downward trend in sulfate concentrations due to reductions in sulfur dioxide emissions, there has been no appreciable decrease in the acidity of precipitation. This is especially true in the northeastern U.S., where cloud water pH as low as 2.1 has been recorded. Acid deposition has contributed to the documented decline of montane red spruce forests in the northeastern U.S. over the past 40 years, and much of this decline has been associated with an enhanced frequency and severity of foliar freezing injury. Acid rain also disrupts the calcium cycle in forests. NRI-funded DeHayes and colleagues provide evidence that disruption of the calcium cycle results in increased susceptibility of red spruce foliage to freezing injury. More specifically, acid deposition on leaves leads to a depletion of calcium associated with leaf cell membranes. Calcium is essential for the normal functioning of these membranes. DeHayes' research showed that red spruce needles exposed to acidic mists exhibited up to 10-fold increases in foliar calcium leaching and a significant reduction in the physiologically critical membrane-associated calcium. Although a decrease in soil calcium reduced total foliar calcium concentrations, it did not alter the amount of membrane-associated calcium. They concluded that red spruce freezing injury was due primarily to direct acid-induced disruption of the membrane-associated calcium in red spruce needles. Foliar calcium leaching has broader applicability than its effects on red spruce; it has also been demonstrated in white spruce, yellow birch, eastern white pine, and red and sugar maples. The depletion of calcium from cell membranes can also enhance plant susceptibility to environmental stresses other than low temperature, such as pathogens, drought, and salinity. As such, acid-induced disruption of membrane-associated calcium could predispose forests to a range of secondary stresses. A better understanding of the impacts of acid rain on plant stress response systems is needed to effectively assess the threat posed to forest health and sustainability.

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