Acid deposition has stressed trees in areas of the Northeast.

SUMMARY: The 1990 National Acid Precipitation Assessment Program (NAPAP) report to Congress concluded there was insubstantial evidence that acid deposition had caused the decline of trees other than red spruce growing at high-elevations. More recent research shows that acid deposition has contributed to the decline of red spruce trees throughout the eastern U.S. and sugar maple trees in central and western Pennsylvania. Symptoms of tree decline include poor crown condition, reduced tree growth, and unusually high levels of tree mortality.

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DETAILS: Declines of red spruce and sugar maple in the northeastern United States have occurred during the past four decades. Factors associated with declines of both species, have been studied and include important links to acid deposition.

Red Spruce

Since the 1960s, more than half of large canopy red spruce in the Adirondack Mountains of New York and the Green Mountains of Vermont and approximately one quarter of large canopy red spruce in the White Mountains of New Hampshire have died. Significant growth declines and winter injury to red spruce have been observed throughout its range. Acid deposition is the major cause of red spruce decline at high elevations in the Northeast. Red spruce decline occurs by both direct and indirect effects of acid deposition. *Direct effects* include the leaching of calcium from a tree's leaves and needles (i.e., foliage), whereas *indirect effects* refer to changes in the underlying soil chemistry.

Recent research suggests that the decline of red spruce is linked to the leaching of calcium from cell membranes in spruce needles by acid rain, mist or fog. The loss of calcium renders the needles more susceptible to freezing damage, thereby reducing a tree's tolerance to low temperatures and increasing the occurrence of winter injury and subsequent tree damage or death (see Figure 9). In addition, elevated aluminum concentrations in the soil may limit the ability of red spruce to take up water and nutrients through its roots. Water and nutrient deficiencies can lower a tree's tolerance to other environmental stresses and cause decline.

Sugar Maple

The decline of sugar maple has been studied in the eastern United States since the 1950s. Extensive mortality among sugar maples in Pennsylvania appears to have resulted from deficiencies of base cations, coupled with other stresses such as insect defoliation or drought (see Figure 10). According to research studies, the probability of the loss of sugar maple crown vigor or the incidence of tree death increased on sites where supplies of calcium and magnesium in the soil and foliage were the lowest and stress from insect defoliation and/or drought was high. In northwestern and north central Pennsylvania, soils on the

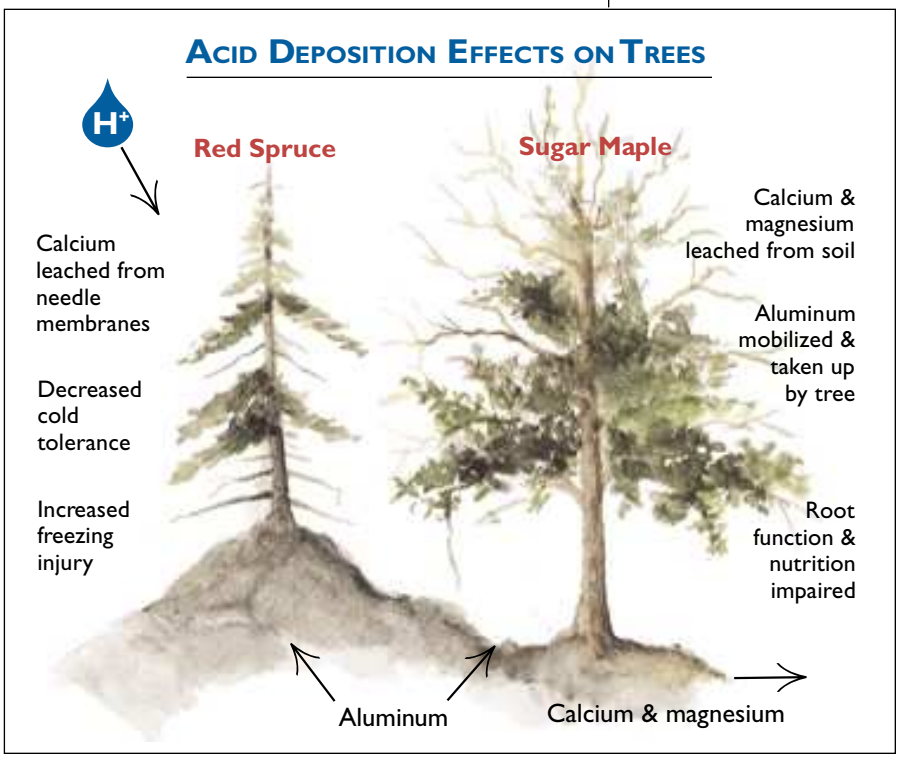

FIGURE 9: *Mechanisms of acid deposition stress to red spruce and sugar maple trees.*