The Hot and the Classic

THE DECLINE OF SUGAR MAPLES (ACER SACCHARUM)

Sugar maples across the northeastern US and eastern Canada are in decline. The problem is not new, but the incidence and severity of maple decline have increased markedly in recent decades to include urban, sugarbush, and forest environments (Horsley et al., 2002). Symptoms include reduced foliage and reduced twig growth, and the eventual dieback of branches in the upper canopy. The first noticeable symptom is usually premature yellowing or reddening of the foliage. The exact causes of sugar maple decline are hard to pinpoint. The current consensus is that maple decline is a progressive disease condition that begins when the trees are altered initially by stress and continues as they become invaded by organisms of secondary action (Bauce and Allen, 1992). It is the activity of these secondary pathogens on an already weakened tree that eventually leads to the death of the tree. Sugar maple decline does not spread like a disease, but if one tree is affected because of environmental conditions, chances are that other trees near it are, or will become, affected. There are cases, however, possibly due to differences in soil topography (Sauvesty et al., 1993), where the relative declines of adjacent trees vary dramatically. This month's Hot and Classic examines some of the controversies surrounding the cause of sugar maple decline and its ecological consequences.

Ecological Consequences

In addition to its importance to the maple syrup industry and in horticulture, sugar maple is a keystone species in the forests of the northeastern and midwestern United States and eastern Canada. The decline in the health and numbers of sugar maples appears to be altering the local ecology of those areas affected. For example, leaf flycatchers (*Empidonax minimus*) nestlings are thermally stressed in declining sites because of canopy foliage loss. Their parents have to work more (i.e. provide more feeding and brooding) to maintain breeding success (Darveau et al., 1993). The abundance, total biomass, and biodiversity of earthworms are also reduced in declining stands compared to healthy stands (Coderre et al., 1995). Similarly, the biodiversity of above-ground carbid beetles (Martel et al., 1991) and early season lepidopteran fauna is also reduced in declining maple stands (Martel and Maufette, 1997).

Soil Conditions?

Sugar maples grow optimally in well-drained, acid soil that is neither too wet nor too dry. They respond negatively to soil compaction or exposure to salt. Since urban and suburban soil is usually non-acidic, highly compacted from construction, and contaminated with road salts, sugar maples do poorly in these areas. But sugar maple decline also can be seen in more natural environments. Many authors have looked for correlations between areas of decline and the nutritional statuses of the trees and soil. For example, Drohan et al. (2002) found that foliage from declining plots had significantly lower base cations (K, Ca, and Mg) and higher Mn as compared to that from non-declining plots. Soils in declining plots had lower base cations and pH, a Ca:Al ratio of less than or equal to 1, lower percent clay, and higher percent sand and rock fragments than soils on non-declining plots. Declining sugar maple plots in their study occurred at higher elevations on sandstone-dominated geologies. Soils were found to be base poor-sandy soils that contained high percentages of rock fragments. Soils below 50 cm on declining plots had lower soil pH and foliar chemistry indicative lower foliar base cations. Mohamed et al. (1997) found that Al in stem xylem was significantly higher in declining trees relative to the healthy trees from those acidic sites in which Al was freely available in the soil. Horsley et al. (2000) concluded that the most important factors associated with sugar maple health were foliar levels of Mg and Mn and defoliation history (see also Watmough et al., 1999). The vigor of vesicular arbuscular mycorrhizae do not seem to be markedly different in areas of maple decline (Ouimet et al., 1995).

Anthropogenic Causes?

Anthropogenic pollution, especially acid rain, and forest decline are major environmental issues that many scientists have tried to link causally (Bell et al., 1998; Sharpe, 2002). Certainly, maple stands growing in acidic soils are at greater risk for decline (e.g. Liu and Tiree, 1997; Duchesne et al., 2002). However, there are numerous examples of past declines in the condition of individual species within forests or of the entire forests themselves. Many of these declines are natural, being brought about by a variety of factors, including stand dynamics, pests, and diseases. The emphasis that has been placed on air pollution in recent declines may not necessarily be justified, although air pollution has undoubtedly brought about the decline of forests at some locations (Innes, 1992). Bauce and Allen (1991) reported that a steady growth decline of all dominant trees during the last 30 years was significantly correlated with adverse climatic conditions and that high levels of stand density (competition) appeared to predispose sugar maple trees to adverse affects of climatic (winters with periodic thaws and sparse snow cover, summer drought, low autumn soil water recharge) stresses. They concluded that in some cases, sugar maple decline may be part of a natural stand density regulatory process. Based on analyses of tree ring data, Payette et al. (1996) concluded that there had been 3 major growth depressions of sugar maple trees in the last 100 years. In their view, the major growth depression the early 1980s was due to a synergistic combination of natural disturbances affecting stand dynamics, in particular drought and defoliation by insects such as the forest tent caterpillar (*Malacosoma disstri*), and to a lesser extent, severe winters. An apparent rebound

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in the health of sugar maple stands in there area of study after the 1980s suggested to them that the severe maple decline in the 1980s was not due to anthropogenic pollution. Studies that have examined the effects of altering the soil pH on the progress of maple decline have yielded mixed results. Liming (e.g. Moore et al., 2000) and K fertilization (Ouimet and Fortin, 1992) increase the vigor and growth of sugar maple in an acid soil, poor in available Ca and Mg. Four years after the lime application, improvements in foliar concentrations of N, P, Ca, and Mg were noted. Liming also increased the radial growth of sugar maple compared with control trees. Acidifying fertilizer, however, did not produce the visual symptoms of maple decline (Hutchinson et al., 1998). Thus, while acid rain may be contributing to the stress and decline of sugar maple, it may just be one of many factors.

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