Soil Water and Xylem Chemistry in Declining Sugar Maple Stands in Pennsylvania

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Abstract

Evidence is accumulating that decline of sugar maple, *Acer saccharum* Marsh., in northern Pennsylvania may be related to overall site fertility as reflected in the chemistry of soil water and bolewood xylem. In this paper we discuss factors related to varying site fertility, including effects of soil liming, past glaciation, topographic position and soil acidification. Soil liming experiments at Cherry Springs and Black Diamond sites in northcentral PA have shown a dramatic growth response of sugar maple to improved soil Ca and Mg supplies (Long et al. 1997). Soil water chemistry at 30-cm depth at Cherry Springs and Black Diamond showed significantly higher Ca and Mg and significantly lower Al and Mn concentrations on treated than control plots in 1995-96, over ten years after liming. Ca/Al molar ratios < 1 in soil water on unlimed plots at Cherry Springs suggest that growth stress may be occurring due to nutritional disorders. Sugar maple xylem chemistry at Cherry Springs also showed significantly higher Ca and Mg and significantly lower Mn concentrations on limed than on unlimed plots. Although Al concentrations were undetectable in sugar maple bolewood, Mg/Mn or Ca/Mn molar ratios in xylem were signficantly higher on limed than unlimed plots at Cherry Springs. Similar soil water and bolewood xylem chemistry differences were generally, but not always, found between stands on glaciated and unglaciated sugar maple sites in northern Pennsylvania. Generally, forest stands on glaciated sites showed higher soil water Ca/Al ratios and bolewood xylem Mg/Mn ratios than unglaciated sites. Topographic position (upper, mid, lower slopes) did not consistently correlate with occurrence of high or low Ca/Al and Mg/Mn ratios in soil water and bolewood xylem, respectively, due to the effects of underlying geology and subsurface drainage patterns. Further sampling in 15 sugar maple stands in northern Pennsylvania also showed a positive relationship between radial growth rates and the Mg/Mn ratios in bolewood xylem, suggesting a link between site fertility and growth[2]. Soil acidification experiments at Fernow Experimental Forest in West Virginia and Bear Brook in Maine, which were conducted to test effects of accelerated rates of atmospheric deposition simulated with additions of N and S as ammonium sulfate, have shown rapid leaching of base cations from the soil leading to reduced bolewood xylem Mg/Mn molar ratios (DeWalle et al. in press).

Overall, these studies suggest that wide variations exist in forest site fertility, as reflected by soil water and xylem chemistry, due to complex interactions of glaciation history, topography, and possible accelerated leaching of soil base cations due to atmospheric deposition. Understanding the factors causing such variations in site fertility and their effects on health of sugar maple may provide better management methods for declining sugar maple stands.

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References

DeWalle, D. R., J. S. Tepp, B. R. Swistock, W. E. Sharpe, and P. J. Edwards. In press. **Tree-ring cation response to experimental watershed acidification in West Virginia and Maine, USA.** Journal of Environmental Quality.

Long, R. P., Horsley, S. B., and P. R. Lilja. 1997. **Impact of forest liming on growth and crown vigor of sugar maple and associated hardwoods.** Can. J. For. Res. 27:1560-1573.