A Survey of Sugar Maple Nutrition in Vermont and its Implications for the Fertilization of Sugar Maple Stands.

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Can fertilization of sugar maple stands lead to increased diameter growth, better crown conditions, and/or added sugar production? We have wrestled questions like these for over a decade at research sites in northwest Vermont. Recently we have begun to expand our understanding of maple nutrition by examining stands in a wider geographic area.

The effectiveness of fertilization depends in large part on soil nutrition. Where nutrients are limiting, and tree vigor is not otherwise affected by conditions such as poor drainage or shallow soils, careful fertilization has, in some cases, improved crown health and radial (diameter) growth. In the early 90's, we compared several sugarbushes in our area with contrasting health, and found that poor stands, those that showed significant crown dieback, had much lower soil and foliar calcium. Three years after addition of lime (about 1.5 tons/acre) and smaller amounts of potassium and magnesium to the deficient sugarbushes, mature trees in these stands had improved crown health and radial growth rates had doubled compared to untreated controls (Wilmot et al., 1996). We have yet to demonstrate improved sugar production with fertilization, although some of our data suggested that sap volume was positively correlated with crown health (Wilmot et al. 1995). The influence of fertilization on the sugar production of mature trees is the subject of a current study at the Proctor Center.

We undertook the current survey to characterize soil conditions in Vermont maple stands, to determine to what extent calcium or other nutrients might be limiting. Sampling was carried out during the summers of 1998 and 1999. We collected soils, foliage, and wood cores from 29 stands, both sugarbushes and non-sugarbushes. Because these stands were monitored by the North American Maple Project (NAMP) we also obtained detailed information about the health of these stands over the past decade. At each site we took ten increment cores from trees <11" dbh, five composite foliar samples, each made by pooling leaves from several sun-exposed mid-canopy branches, and five soil samples from each of two depths. NAMP stands are not randomly located, therefore, although this survey covered most of the state, we were not attempting to generalize about the health of sugar maple across Vermont, but rather to characterize tree condition on these various soils.

FIGURE 1

Figure 1: Location of high calcium bedrock in Vermont (black). Vermont, like many states that lie within the range of sugar maple, is an area of diverse geologic resources. The Champlain Valley, Taconic Mountains, and parts of the Eastern Piedmont are underlain by dolomite and limestone, which are high in calcium, while the main belt of the Green Mountains is underlain by schist that is low in calcium. Although soils do not have an exact correspondence to the bedrock over which they are formed, they have the same general characteristics as the bedrock. This is particularly true where soils are thin and outcrops are plentiful. Where glacial till is deep and the soil surface is far above bedrock there can be much local variability in soil nutrients.

Growth rates, height of mature trees, and crown health varied considerably according to location. Growth rates were determined by analyzing cores over the past 25 years. Average diameter growth per tree was 17 cm^2/year for all stands and ranged from a low of 6 cm^2/year to over 35 cm^2/year among the 29 stands. In most cases, growth rates of each individual stand relative to the others was consistent for the past 25 years; i.e.; stands were not changing from fast to slow growing as tree density increased over time, but some sites simply were much better than others for sugar maple growth. The huge differences in growth rate were often accompanied by large differences in levels of crown dieback and foliar density. Fast and slow-growing stands were not randomly located throughout the state, but tended to be grouped. Slow growing stands were often located in the heart of the Green Mountains, where bedrock is low in calcium. When we sampled foliar nutrients, we found a strong association between growth rate and calcium, and a somewhat lesser association between growth and nitrogen. Differences in other foliar nutrients, such as P, K, and micro-nutrients, were not associated with differences in tree growth or health.

In most stands there was little change in the average growth rate over the study period, although most NAMP stands have not been cut since the late 80's, or earlier, and some slowing of growth due to increased stand density should be expected. Pear Thrips, and to a lesser extent Forest Tent Caterpillar, defoliated trees and caused notable declines in tree growth during their infestations, but stands recovered from these outbreaks. Growing season rainfall varied greatly from year to year, particularly in the 1990's, but most of these Vermont stands have not been significantly impacted by drought. NAMP surveys have indicated that there is little if any difference in crown health between sugarbushes and stands with untapped trees (Allen et al. 1992); we saw no significant difference between these two groups.

Differences in soil pH and soil calcium, as well as other soil nutrients, were not as well associated with tree condition as were foliar nutrients. Soil surface horizons averaged pH 4.75; at a depth of 6" they averaged pH 5.2. There was a striking relationship between soil calcium, particularly at the 6" depth, and the presence or absence of maple regeneration. Many stands had regeneration that was mostly beech and striped maple despite a canopy of sugar maple; soil calcium at these stands was always low. Where sugar maple regeneration was abundant, soil calcium in the deeper horizons was usually much higher.

Landowners often ask whether soil or foliar samples are more useful for determining possible deficiencies in stands of mature sugar maples. Soils are notoriously variable, and samples taken a few feet from each other may vary widely in nutrient content; for this reason many samples are needed to accurately portray stand nutrition. Paradoxically, foliar nutrient sampling can be an accurate way to characterize soil nutrition; although samples are more difficult to obtain, results are less variable and show nutrients obtained by the tree's wide rooting zone. Another substitute for soil sampling is observation of key indicator plants. Certain herbs and ferns, such as maidenhair fern, wild ginger and leeks, Herb Robert, and trees such as basswood, hickory and white cedar are much more prevalent in areas with higher soil pH and soil calcium. As the graph below demonstrates, stands where these indicators are present often have ideal conditions for sugar maple growth.

Implications of this study:

Because there is so much variation in the availability of soil nutrients in Vermont, and in other regions where sugar maple grows, it is not possible to make blanket recommendations about diagnosing and treating nutrient deficiencies. Calcium is a key nutrient in this region, although deficiencies of other nutrients are believed to be responsible for poor sugar maple vigor in other areas of North America. We have seen short term benefits from liming stands of mature trees growing on nutrient poor soils. Where calcium containing bedrock is present, liming of maple stands is not likely to be cost effective, because calcium, and probably other nutrients are not limiting. We have yet to determine the long-term effects of fertilization, such as the length of the period of improved growth, which is an important factor in a cost-benefit equation.

The association of poor or absent sugar maple regeneration with soils that are low in calcium suggests that these soils may have become nutrient depleted since the canopy was formed. It is not clear yet whether calcium additions to these soils

Figure 2: Growth of trees differed according to plant indicators for the calcium content of the soil. The graph shows average yearly wood growth between 1973 and 1997 for 3 groups of stands on 3 soil types. Instead of soil tests, here we used the presence or absence of key indicator plants, such as maidenhair fern, to reveal soil calcium levels. Note the sharp drop in the average growth rate at all sites in 1988. This was the year that Pear Thrips defoliated trees in much of the state.

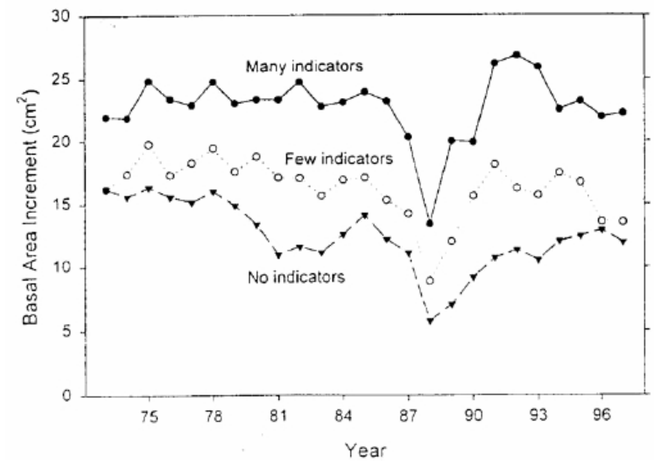

Figure 2

can stimulate regeneration. It is notable that the level of calcium from deeper soil horizons was important to the amount of sugar maple regeneration. This may imply that for liming to be effective it needs to penetrate well below the soil surface, suggesting a heavy or repeated dose of finely ground limestone that can make its way through the soil before it is leached away.

The author is interested in hearing from people who have fertilized maple stands in the past. Please contact him at the above address.

References:

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