

Tree-level Evaluation of Red and Sugar Maple Sap Production Characteristics in Kentucky

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Maple syrup producers judge the quality of a sugarbush tree based on two characteristics: total volume and sugar content of the sap yielded by the tree during the tapping season. Larger sap volumes and sugar contents are directly correlated with higher syrup production. In 1946, C.H. Jones, a researcher at the University of Vermont, developed an equation for estimating the volume of sap required to produce one gallon of maple syrup. Known as "Jones Rule," this equation has been revised over the years to accommodate changing maple syrup standards and is presented below in its current formulation.

$$\text{Sap Volume (in gallons)} = \frac{87.1}{\text{Sugar Content (in } ^\circ\text{Brix)}} - 0.32$$

Figure 1 (right) is a graph of this equation for the typically encountered range of sap sugar contents (1–5 °Brix). From this figure, we see that the sap volume required to produce one gallon of syrup decreases sharply with higher sap sugar contents. Therefore, to make a maple syrup operation most economical, it is the goal of producers to tap maple trees that yield the greatest sap volumes with the highest sugar content.

However, how can producers know which are the highest-quality trees without tapping them? Research studies—some dating to the 1800s—have related tree and forest characteristics with sap production. For example, it is well-known that sap sugar content is usually much higher from sugar maple (*Acer saccharum*) than from red maple (*Acer rubrum*). However, much of this research has occurred in areas with a thriving commercial maple syrup industry, such as the northern United States and Canada. Studies of sap production in more southerly latitudes, including Kentucky, are relatively sparse due to suboptimal conditions for syrup production created by shorter winters and a higher prevalence of red maple than sugar maple in these forests. In fact, no studies evaluating climate, site, or tree influence on maple sap production have been conducted in Kentucky.

To aid the state's growing guild of syrup producers in production planning, we initiated a study of red and sugar maple sap production, with the goal of estimating seasonal sap volume and sugar content yield per tap and assessing the relationship of tree characteristics with these characteristics. We identified 75 red maples and 75 sugar maples, ranging from 6 inches to 36 inches in diameter at breast-height (dbh), in four stands on Berea College Forest near Berea, Kentucky. The four study sites represented an array of forest conditions, comprising different aspects, slope positions, and site productivities (for example, areas near perennial streams and dry ridgetops). For each

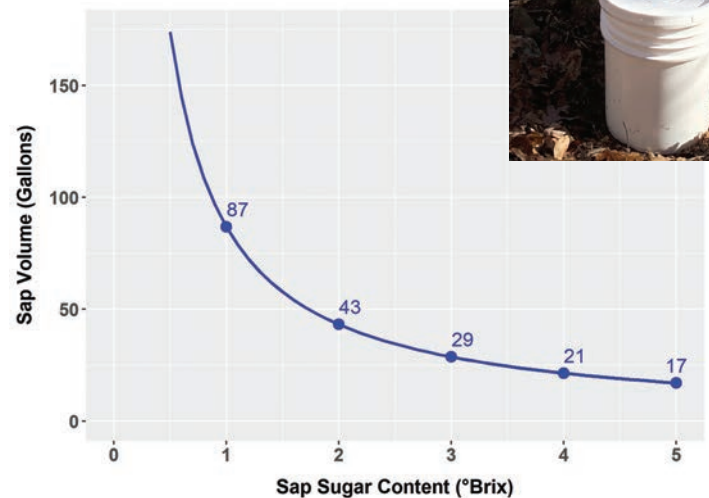


Figure 1. Jones Rule—the sap volume required to produce one gallon of maple syrup at 66 °Brix across the range of maple sap sugar content typical in Kentucky.

sample tree, we installed a single-tap, gravity-driven collection system: one 5/16-inch spile was inserted into a tap hole of equal diameter drilled with a cordless drill, and tubing was used to connect the tap to a lidded bucket. We collected and measured sap volume for each sample tree weekly between the first week of January and the second week of March in 2020 and 2021. To compare sap production with tree characteristics, we were interested in evaluating the relationship of sap volume and sugar content to a tree's crown class. Crown class identifies the position of a tree's canopy relative to the height of the main forest canopy and is a measure of both tree size and competitiveness.



There are four crown class categories described below based on crown position.

Dominant: A large tree in the main forest canopy whose tree crown can receive abundant sunlight from the top and sides. A Dominant tree has a large dbh and tree crown size and is among the tallest and largest trees in the forest canopy.

Codominant: A tree in the main forest canopy whose tree crown can receive abundant sunlight, predominantly from the top of its crown. A Codominant tree is a “typical” tree growing in the main forest canopy.

Intermediate: A tree whose crown is growing near the bottom of the main forest canopy and receives very little sunlight, only at the top of its crown. An Intermediate tree has a smaller dbh and crown and is shorter than Dominant and Codominant trees.

Overtopped: A tree whose crown is growing entirely below the main forest canopy and receives no direct sunlight. An overtopped tree has a smaller dbh and crown size and is shorter than other crown classes.

Results... On average across 2020 and 2021, we collected 8.9 gallons of sap per tap from sugar maple and 5.7 gallons per tap from red maple. The maximum sap volume collected per tap was approximately 30 gallons for both species. Average sap sugar content for red maple was 1.4 °Brix across both years, ranging from 0.8 to 2.4 °Brix. Sugar content for sugar maple averaged 1.8 °Brix across both years and ranged from 0.7 to 4.2 °Brix. Both sugar content and sap volume yield were significantly higher for sugar maple than red maple.

Sap volume and sugar content were significantly different not only between tree species but also between crown classes. Dominant and Codominant trees produced the largest sap volumes, averaging 10.6 and 9.4 gallons per tap respectively across both maple species (Figure 2). Intermediate trees produced significantly lower volumes at an average of 5.2 gallons, and Overtopped trees yielded the lowest volumes at 3.8 gallons. Similarly, the sap from Dominant and Codominant trees had higher sugar contents, with an average of 1.8 °Brix across both species, while sap from Intermediate and Overtopped trees was significantly lower at 1.5–1.6 °Brix.

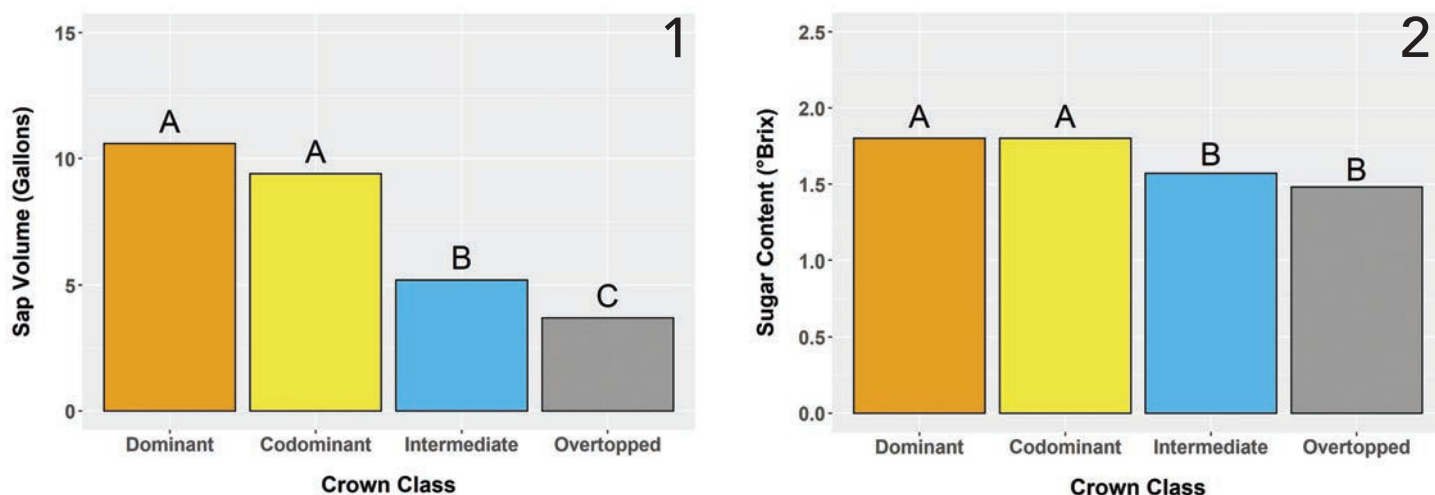


Figure 2. Comparison of average red and sugar maple 1) sap volume and 2) sugar content among tree crown classes. Letters on the graphs represent significant differences between crown classes.

Individual-tree sap production characteristics in Kentucky are much different than in the northern United States and Canada. The results of this study provide current and aspiring syrup producers with Kentucky-specific estimates of expected sap volume and sugar content per tap and a new tool in crown class with which to evaluate potential new sugarbush trees. To maximize productivity, producers should tap the largest available maples, as trees in taller crown classes displayed higher sap volume and sugar content.

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