Ask Proctor: Why Isn't Sap Yield from a Tree the Same Every Year?

Timothy D. Perkins, Research Professor

University of Vermont, Proctor Maple Research Center,

Underhill, Vermont

We occasionally hear the question: "Even if the season is late or short, shouldn't there be the same amount of sap produced during the time that does run than there would have been if it were longerseason or happened at 'the usual' time?"

To state this question in other terms, "Isn't a maple tree just a reservoir with a certain amount of sap init that will run out of the taphole in the spring until all the sap in the tree is fully drained?"

The short answer is no. While sap yield is related to tree size to some extent, the amount of sap produced each season varies depending upon several factors. This line of thinking stems from themistaken assumption that trees are a simple vessel that is full of sap, and that tapping drains all of the sap out of the tree over the course of the spring season until it is empty. In reality, maple trees and springtime sap flow are considerably more complicated than that.

To keep things as simple as possible we will ignore the differences in the amount of sap we collect due to the various methods used (gravity, vacuum, bags, buckets, tubing, spout size and taphole depth,sanitation of spouts/ drops) and focus just on what happens in the tree.

It is important to recognize that sap moves in trees in response to gradients in pressure. These gradients form due to gravity (head pressure), osmotic pressure (due to sugars in the sap), and gas expansion (bubbles in the wood expanding and contracting due to temperature changes). Because of maple wood anatomy, most liquid flow occurs primarily in a vertical (up and down) direction. While side-to-side movement can and does occur, it happens at a rate about 10X more slowly than it does vertically.

Sap flows out from the tree during periods in the spring (or fall) when the wood temperature rises above freezing. During any one flow period, sap will continue to flow from tapholes until either: there is a freeze, the pressures within the tree fall to the same level as atmospheric pressure (or to the pressure within the tubing system if under vacuum), or there is no available moisture in the soil to be taken up.

During a short thaw, or if the tree only partially thaws (this is more common early in the season), not all the avail-

able sap will exit the tree. One side of the tree can be producing sap while the other side or deeper within the tree remains frozen.

During extended thaws which are more common later in theseason, sap flow may eventually cease if collecting by gravity, but continue on tubing with high vacuum.

A simple way to think about it is as a paper cup that starts out completely filled with ice. If you poke a pinhole near the bottom, no liquid runs out – it is all frozen. If you put the cup of ice on your counter, it will start to melt from the outside in and liquid will begin to flow out of the pinhole akin to sap exudingfrom a taphole. The rate and amount of liquid that flows out depends upon how long the thawing-happens. A short thaw produces only a little puddle (small amount of sap) near the cup. A long thaw produces a bigger puddle (a lot of sap produced). But to confuse things more, thawing doesn't always happen at the same rate. Sometimes it can be quite cold in the house and the ice will melt slowly (slow sap flow). At other times you're sitting out by your pool and the sun is shining on the cup and the ice melts quickly (rapid sap flow).

Next, we add yet another complication. The glass might be occasionally put back into the freezer and the liquid refreezes, but at the same time, imagine that water is added to the container as that freezing happens. This refilling several times over the season in trees as well. When the temperature falls toright around freezing, the gas bubbles in the wood contract, creating pressure in the tree which falls below atmospheric pressure (vacuum or suction) and water is pulled into the tree through the roots.

There is yet another factor – sometimes we're able to add just a little water to the glass (as in a fast freeze with just modest uptake of soil water into the tree) and at other times we are able to fill the glass completely (a slow freeze and complete uptake of soil water into the tree).

Taken together, the number, intensity, and duration of thaws produce several sap variable flow events that occur in a season. This is combined with the number and rate of transitions from above-to-below freezing temperatures affecting water uptake dynamics and the amount of sap available for subsequentexudation events from tree stems. Thus, the amount of sap that is produced by any one tree in a season varies considerably depending upon the way the spring plays out. In other words, Mother Nature has a big influence on the amount of sap maple producers collect during a season.