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Ask Proctor: How does Sap Move Near Tap Wounds

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Because of the vertical orientation of the dominant anatomical feature of wood (vessels and fibers), sap within the stem of maple trees moves primarily in a vertical direction, either upward during as the tree is freezing/uptake phase or downward (mostly) during the thawing/exudation phase. When a tree is tapped, a zone of impermeable wood forms around the wood. This wound zone, referred to variously as "stain", "discoloration", "compartment", or "non-conductive wood" (NCW) is slightly darker in color than normal, unaffected wood (Shigo and Marx 1977). Owing to the anatomy of maple sapwood, the NCW that forms after tapping is normally just slightly wider and deeper than the taphole, but extends both upwards and downwards a considerable distance from the wound (Figure 1). Recent research has shown the NCW occupies an average volume about 50 times that of the precipitating taphole (van denBerg et al. 2023).

The physiological reason behind the formation of NCW is to render the affected area inhospitable to disease-causing organisms. By "walling off" or "compartmentalizing" the wound, infection cannot readily gain a foothold and spread throughout the wood tissues. As a consequence, the wood in the zone of NCW is rendered forever impermeable to liquid. Water and sap cannot flow through and carbohydrates (starches and sugars) cannot be stored in the affected zone. In effect, the stained area is no longer functionally a part of the tree except as structure.

Isselhardt (2022) demonstrated the strong negative relationship between sap yield and the proportion to the amount of stained wood hit during tapping. It is clear that avoiding old tapholes is vital in maintaining good sap yields and is why it is important to not overtap and create a high proportion of stained wood within the tapping band.

So how do trees cope with these internal zones of NCW in their stems, particularly in maple trees that are tapped year-after-year? Isn't it important that their conducting tissues be intact?

As it turns out, the vascular system of maple trees is incredibly redundant. There are billions of tiny vessels within the stem. Some of these vessels stop functioning for one reason or another as they age. In some cases, such as when vessels embolize due to drought in the summer or freezing during thewinter, vessels can be repaired and the conduits refilled with liquid. In other cases, such as that accompanying the formation of NCW, functionality cannot be restored. As vessels get buried deeper into the tree by radial growth, the hydraulic conductivity (the ability

to move liquid of older tissues diminishes. This is the reason why making tapholes really deep doesn't result in increasing sap flows.

However, movement of sap and water in the stem is renewed by the addition of additional functional wood during each growing season. As long as enough new wood grows each year, the loss of functional wood by wounding or aging can be compensated for and the formation of NCW by maple tapping is sustainable.

What happens to the flow of sap around areas of NCW? Is it slowed down? Generally this is not the case. Because there are so many vessels extending from the roots to the crown, but instead are comprised of a series of short (ranging from a fraction of an inch to over a foot long) conduits that are loosely associated with each other at the top and bottom in groups, liquid can readily flow around blocked areas of modest size. In effect, sap moves around the zone of NCW.An analogy to this is a stream. A stream generally flows fairly well and in a relatively straight line. However, if you drop a big stone in the stream the water above the rock doesn't stop – it goes around. In fact, the water immediately adjacent to the rock the water runs slightly faster than it would if the rock eren't there. The same thing happens in a maple stem in the area around NCW – the sap flows around the wound. Extending this analogy further, if you keep dropping stones in the stream, you still don't really impact the flow much – the water will keep running around the stones. However, if you persist in adding stones you will eventually reach a point where there are too many stones piled up in one area and the water can't move around quickly enough, in effect causing a dam. The corollary to this in a maple stem is overtapping or cluster-tapping. Too much NCW builds up to the point where liquid cannot readily find a path around that area, and sap flows will diminish. This effect is exacerbated if annual radial (stem) growth is slow, either because the trees are small and not fully in the canopy, or if trees are very large and the growth rings are very narrow. Avoiding overtapping, cluster tapping, or repeated heavy tapping on just one side (south side of stem, above a large root, or below a large branch) is the best approach to sidestepping this problem because recovering from this problem may require considerable time, energy, and careful monitoring.

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Figure 1 . What's under the bark? A photo of a maple steam along side another stem with the bark removed to show NCW from previous taphole wounds. Note that the zone of NCW is just slightly wider than the taphole, but extends vertically upward and downward from the wound for a considerable distance. Avoiding tapping into these areas ofNCW is critical in maintaining good sap yields. Original display created by David Folio, Hillsboro Sugarworks, Bristol, Vermont. Photo Credit:Mark Isselhardt, UVM Extension Maple