MAPLE SAP FLOW: HOW IT HAPPENS

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For many years it has been known that freezing nights and thawing days will cause maple sap to flow. Research at the University of Glasgow (Scotland) and the University of Toronto give us the following explanation.

Freezing of water normally occurs at 0^o C, or 32^o F, but will often "super cool" by dropping slightly below this temperature before starting to freeze. When it does freeze, heat is released which raises the temperature of the wood to 0^oC. This heat is called the **latent heat of freezing** and the rise in temperature is called the **exotherm**. As the temperature approaches and drops below freezing, some sap is slowly sucked upward by the stem. At the precise moment of the **exotherm**, when ice just begins to form, sap is rapidly and vigorously sucked up. Sap uptake continues during the full period of the **exotherm** as long as water remains to be frozen. As the temperature drops, trees freeze from the outside in and the smallest branches freeze first. The sap that is sucked up through the portions of the **sapwood** not yet frozen adds to the ice crystals growing in colder parts of the tree.

But, this should not occur. Water expands as it freezes, and sap should be pushed out as it freezes. The reason the opposite happens in maple has to do with the composition of the wood. Hardwood trees transport water by conduits called **vessels**. These cells are surrounded by **wood fibre** cells that, in maple, are filled with air. When maple wood begins to freeze, frost forms inside the gas filled spaces of the **wood fibres.** Water contributing to the frost comes from the water conduits and is replaced by the same kind of **capillary forces** that cause water to be drawn into a sponge.

When the maple tree thaws out the next day the excess sap, accumulated as frost, falls down the tree by gravity. As a result, sap flow is downward into the **tap hole** and into the **spile**. This sap is also pushed by the pressure of the gas bubbles in the fibre cells. The gas filled spaces are under pressure because as frost forms inside the gas spaces the frozen water displaces and compresses the gas bubbles.

When maple trees freeze rapidly, the amount of sap sucked up is reduced. But when maple trees freeze slowly, the volume of sap is much enhanced and the yield of sap the next day, if the temperature rises above freezing, is much greater than if the freezing the night before had been fast. The reason is that when the water in the vessels freezes too fast it does not allow frost buildup in the wood fibres.

Knowledge of how sap flow works may be able to suggest management techniques for sugar bush operators, or allow us to predict sap yields.