ROOT PRESSURE IN TREES: A SPRING PHENOMENON *Reprinted from Farming, the Journal of Northeast Agriculture. May, 2011*

Just about anyone who has felled trees in the spring has seen a stump that bleeds sap. From this observation, it is easy to conclude that here is the explanation for sap flow in maple, sap rising to the top of tall trees, and sap movement in general—somehow it all comes from a "pump" in the roots. This isn't the case; instead, sap bleeding from stumps and other wounds in some tree species is the result of root pressure, a phenomenon that occurs only under limited circumstances at certain times of the year. While root pressure isn't responsible for our maple industry, it does make another syrup industry possible.

Root pressure does not cause sap flow in maple during our sugaring season, as can be demonstrated by cutting down a maple tree on a warm winter day. If the trunk is thawed, sap will flow continually from the cut surface of the trunk, but not from the stump. The flow is downward from the crown, not upward from the roots. The maple sap flow mechanism comes from the branches which are exposed to freezing and thawing temperatures; almost all other tree species lack this mechanism and do not have early spring sap flow.

Root pressure occurs when the soil begins to warm, and when snow has melted, and icy water from snow melt has largely drained from the soil, forest soils warm quickly. This happens in part because the trees are still leafless and do not shade the forest floor. For root pressure to be generated at this time, moist but well-aerated (not water-logged) soil conditions are generally required. As the weather and soil conditions become favorable, the root accumulates minerals in its sap at high concentrations. These minerals are present in the soil water, but in a lower concentration. Water passes through the root tissues freely, but the minerals do not (the root is a semi-permeable barrier). By the laws of physics, the water naturally flows from the area of low mineral concentration to the area of high mineral concentration, and this flow of water into the root pressurizes it. This is the phenomenon of osmosis, which is very common in plant and animal cells; for example, in non woody plants, osmosis allows plant cells to accumulate water and be plump enough to keep the plant upright.

When a tree with a pressurized root system is felled, the pressure is relieved by sap flowing from the cut surface. The pressure generated by this system is normally less than 1 atmosphere (14.7 lbs per square inch), which is about half the pressure commonly recorded at the start of a maple sap run. One atmosphere is enough force to lift water about 34 feet, so this mechanism is obviously not powerful enough to supply leaves in the crowns of mature trees. In fact, once leaves emerge, root pressure disappears, and another, stronger force lifts water dozens and even hundreds of feet in the air. The evaporation of water from leaves during the growing season, which is called transpiration, causes a suction to be transmitted throughout the whole tree, and this suction draws water from the soil into the roots. Thus, root pressure is a short-lived phenomenon, perhaps useful in some species to refill parts of the sap transport system that have become dried and gas-filled during the winter.

Root pressure has been noted in many tree species, but is most prominent in birch, and it is responsible for the birch syrup industry. Some of the highest root pressures measured have been recorded in birch, and additionally, birch has sweet sap, albeit much less sweet than most sugar maples. The birch sugaring season is described as beginning when producers are "seeing the first butterfly" and generally lasts for about 3 weeks, ending when the leaves emerge. This is a good description of the time when the soil is warming. Buckets are hung on the trunk, as root pressure is strong enough to push sap well beyond

ground level. Collection occurs from tapholes during the hours when wood is thawed enough to allow sap to flow. A great deal of boiling is necessary to produce birch syrup at a sugar concentration that matches the concentration of maple syrup. There is little scientific information available about this interesting industry, which in many ways parallels our own.