SUGARBUSH ROOTS *reprinted from Farming, the Journal of Northeast Agriculture October, 2010*

After a long morning hanging tubing or performing other sugarbush maintenance, a maple producer might relax at the base of one of his or her favorite maples for lunch and a little nap. Far above, the sun is making sugars in the leaves, some of which is destined for next year's sap collection. But beneath the fallen leaves and debris the invisible root system is as essential as anything above ground, for sugaring and for the health of the tree. When a tree tips over, we see a portion of its root architecture, but what is exposed is only a small fraction of the whole, and the pieces that remain over time only hint at their various functions. Without a healthy root system, our forest trees would decline and die.

Tree roots support what is often a massive amount of wood and leaves. They absorb and transport soil water and minerals, store reserve carbohydrates manufactured in the leaves, and synthesize hormones needed for the proper growth and development of the tree. Some forest root systems, including those of American beech, form new shoots from injured roots and are responsible for much of the tree's regeneration.

The shape of a tree's root system is partly determined by genetics and partly by site conditions. Trees more commonly found on dry sites, such as oak, hickory and pine, usually have tap roots to exploit a deep water table. Most maple forests are located in areas that get considerable amounts of rain during the growing season, consequently the various trees in these forests have evolved fairly shallow root systems. In waterlogged soils, many tree species, including sugar maple, develop a system that is often too shallow to support a mature tree and is prone to wind throw. Yellow birch seeds often germinate on dead logs or stumps and once the stump rots away these trees develop characteristic aerial roots that prop the tree well above the forest floor. Sugar maple, as well as fir and spruce, have what is called a flat root system, consisting of long woody lateral roots, which are much branched. The distance of root extension from the trunk can depend in part on how easily the soil is penetrated; for example, roots are usually much longer in sandy soil vs. heavy clay soil. Roots typically cover an area 2 or 3 times the area of the crown, and in lighter soil the roots may extend many times the average height of the trees.

A huge percentage of the total system is made up of fine roots, generally 1/16" in diameter or smaller. These roots, which are responsible for the absorption of water and nutrients from the soil, are more like leaves than stems in terms of longevity—they live for a few weeks or months, often dying during winter or drought, and are replaced at a great rate when conditions are favorable. As much as half of the carbon fixed by the leaves may be used for maintaining existing roots and growing new ones, primarily these fine roots.. In the maple forest, the decomposing leaves supply much of the nutrients needed for growth, and the thick layer of organic matter holds moisture well, thus, most of the fine roots are close to the surface. In one study in a New Hampshire forest, the median depth of beech, yellow birch and sugar maple fine roots was less than 4" below the surface. Their numbers can be enormous—one red oak was estimated to have 500 million root tips. As roots age, fine roots turn from white to brown, and their function may shift from absorption to transport of absorbed materials.

Absorption of soil water and minerals is aided by both root hairs located near the growing root tip, and by mycorrhizal roots. The latter are roots that are invaded by various species of fungi, in a relationship that is beneficial to both the fungus and the tree. The tree supplies sugars for the growth of the fungus, which in

turn modifies the root to increase its ability to absorb water and nutrients. While many mycorrhizal roots are visibly thickened compared to roots not invaded, sugar maple mycorrhizal roots are not outwardly different from uninfected roots.

Roots respire—a process that breaks down sugars made by photosynthesis, resulting in energy for maintenance and growth. To do this, they need oxygen, which filters through the soil. Where the soil is flooded, or the water table is perpetually high, roots cannot get the oxygen they need for respiration; thus a very shallow system develops, which may not fully support the trunk.

Root grafting is a strange and interesting phenomenon that often takes place in forests. As the soil is crowded with roots from various trees of the same species, some that contact each other may fuse so that materials can pass from one tree to another underground. In this way, trees that have been girdled or even stumps may survive for many years as they are supplied from an undamaged tree. Toxic substances and pathogens such as Dutch elm disease can also be passed from tree to tree through these grafts.

The root systems of our trees are rather mysterious, and somewhat fragile. Compaction of the soil by machinery can inhibit gas exchange and water infiltration, making the soil a less hospitable place for root survival and growth. Damage by logging, grazing animals and other means can not only hinder root function; these wounds can also aid the spread of diseases such as sap-streak disease in maple. It pays to take precautions to protect the part of the tree that is not visible, just as we protect the rest of the tree that we can see.