# Mother Nature's Irrigators*
# Plants Share Water With Their Neighbors

*Adapted from an article written by Betty S. Wong, '94*

SURVIVAL of the fittest has often meant beating out the competition. But sharing has been found to be a preferred alternative for some plants. They do not simply take in water through their roots and evaporate it via their leaves. In fact, ecologists have found that some plants draw deep groundwater up through their long roots during the day, and at night annually lose large amounts of the water through their shallow roots to surrounding soil, rather than saving the water to pass through their leaves the next day. This phenomenon is termed hydraulic lift.

Todd E. Dawson, formerly an associate professor at Cornell, discovered not only that hydraulic lift occurs in sugar maples (Acer saccharum) but that neighboring plants take advantage of the "free" water supply during drought periods. These plants are actually healthier than their counterparts found growing further away from the sugar maple trees. According to Dr. Dawson, "This discovery may toss the theory of competition on its ear, because we have always thought that growing next to something that uses the same resources was bad. Instead, we've found that herbaceous plants growing near a tree really benefit."

**Prof. Todd Dawson studies patterns of water use in sugar maples. He keeps a collection of sugar maple samples in the greenhouse of Mudd Hall.**

Dawson and his colleague, Jim Ehleringer, a professor at the University of Utah in Salt Lake City, became interested in hydraulic lift and patterns of water use by trees while studying streamside plants. Water molecules, which are composed of two hydrogen atoms and one of oxygen, can have different masses due to the existence of two forms, or isotopes, of hydrogen. Dawson and Ehleringer were able to identify water from different sources by determining the distinct ratios of these two forms at a source.

By comparing variations in isotopic concentrations taken from different sources, they were able to show that mature streamside trees did not use stream water but used deep groundwater. When Dawson came to Cornell in 1990, he looked for ways to combine his research in water, isotopes, and tree water use with his interest in woody plants and their distribution and physiology. During the summers of 1991 and 1992, Dawson observed water use in sugar maples.

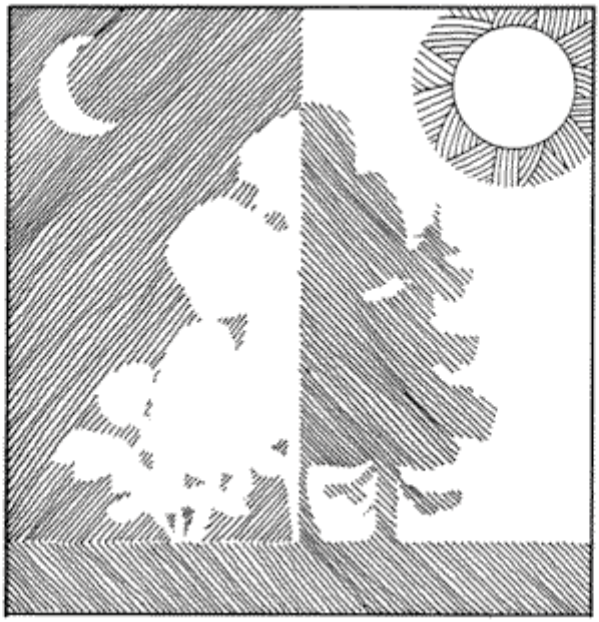
"We had a drought in New York during the summer of 1991," said Dawson. "As we began looking at sugar maples, we noticed a strong gradient in the degree of wilting of herbaceous plants, the further we got from the trees." Why should plants growing closer to trees be looking better than those further away? According to Dawson, a common explanation has been that plants growing under trees receive more shade, live in a cooler environment, and therefore, experience less evaporation and overall stress.

"This may be true," Dawson said, "but it ignores what goes on underground. Probably the biggest problem for plant biologists in studying and understanding plants in response to resource stress is tracking their below ground activity." This is where his experience with stable isotopes proved instrumental.

Dawson used an isotope mass spectrometer to detect differences in the isotopic values of different water sources (rainwater, deep groundwater and hydraulically-lifted water) used by sugar maples and herbaceous plants collected from various distances from the tree. By comparing the ratios of heavy to light isotopes, such as deuterium to hydrogen, which vary depending on the water source, he traced where plants got their water.

Says Dawson, "Stable isotopes are an excellent non-radioactive tracer of water. By comparing the 'signatures' of the water samples, we were able to see how much of a plant's water came from isotopically lighter hydraulically-lifted groundwater rather than from heavier rainwater." He found that many small plants, such as wild strawberries, velvet-grass, goldenrod, spice bushes, and lilies, growing near the sugar maples made good use of their location, "stealing" the tree's hydraulically lifted water that it lost each night through its shallow roots. Some plants, like meadow rue and wild strawberries growing within half a yard from the tree derived close to 60 percent of their water from the sugar maple. "The tree acts almost like a below ground irrigation system for many species of surrounding plants."

**Nighttime hydraulic lift: The sugar maple's long roots are able to pull up deep ground water. At night, when water does not evaporate through leaves, water flows into the shallow roots and out into dry soil where it can be used by neighboring plants.**



**Daytime water use: During the day, through the process of transpiration, the tree loses much of the water it draws from its roots out through its leaves.**

Associate Professor Kenneth Mudge, who teaches both horticulture and agroforestry courses, is excited about the potential impact Dawson's finding could have on agriculture. "Usually, ecologists think that the competition introduced by inter-cropping will be harmful. Agroforesters frequently take for granted that inter-cropping is good for crops, but we haven't seen a lot of evidence. The hydraulic lift mechanism now suggests beneficial interactions." Nuria Hernandez-Mora, a graduate student pursuing a masters degree in natural resource policy and management comes from Spain, where the plants grow in arid lands. Plants in areas like these could greatly benefit from hydraulic lift. She said that traditional agricultural methods extract scarce resources from the land without giving any nutrients back. "By combining crops and trees, you can return something back to the land rather than simply taking away."

According to Dawson, hydraulic lift by the deep-rooted sugar maples may not only irrigate surrounding plants but also facilitate enhanced nutrient status of the soil. He said, "I'm not ruling out that growing in a cooler environment under a tree's canopy has its benefits. I'm only adding the notion that plants are also getting more water; both are beneficial. Furthermore, nutrient balance can depend on how wet the soil is. More water dissolves and mobilizes more nutrients. So hydraulic lift could make the nutrient status under the tree better than in soil further away from the tree."

"I think Professor Dawson's research has amazing potential for agriculture," Hernandez-Mora said. "We know some trees are beneficial because they provide nutrients from their leaves that fall to the ground. Now we know they are also recycling water. I see hydraulic lift as a recycling system. The rainwater that eventually ends up deep within the ground comes back up through the tree's roots and can be used in the shallow soil by surrounding crops." She feels that the system can be used to regenerate dry lands and improve farming in developing countries that do not have access to fertilizers and advanced irrigation pumps.

However, Mudge said that unfortunately, alley-cropping, the inter-planting of trees with crops, is only successful under limited conditions. He said, "The benefits of alley-cropping do not work in acidic, low-fertile areas, like those found in many parts of the tropics. The trees never develop deep root systems and, therefore, wind up competing with crops for the same surface water."

Although neighboring plants clearly thrive from the tree's hydraulic lift of water, scientists are still unsure of how giving up precious water benefits the tree itself, if at all. According to Dawson, "This process could be a way for the tree to enhance its own water resources by releasing excess groundwater into shallow soil to be used later. The tree could also be improving its own supply of nutrients in the soil. We just don't know yet."

Only six species of plants, four of those being trees, are presently known to conduct hydraulic lift, but Dawson feels that the phenomenon is probably much more widespread. Dawson said, "I'm excited about the potential implications of hydraulic lift. And it's all based on something neat that a plant can do and that can be applied not