Biology, Mechanics and Tree Care

Davey Tree Research Farm is tucked away between corn and soybean fields in northeast Ohio. One every three years, researchers and technicians combine at Biomechanics Research Week to cut, pull, and learn from trees that Davey planted for research purposes over 50 years ago. The TREE Fund, The Davey Tree Expert Company, ISA, and Busy Bee Services provided funding this year. Mark Hoenigman ("honey man" in German) of Busy Bee was one of several small businesses providing the machinery and energy to keep operations running sweetly. TCIA Accredited Limbwalker Tree Service contributed five days of climbing work by BCMA Ryan Lewis, who said "The work was difficult, but I expect the results will improve our understanding of trees."

Biomechanics is "the study of the structure and function of biological systems...by means of the methods of mechanics (the details about how something works or is done)" (Wikipedia). Tree function can only be studied over time--one view does not tell us enough to understand a system as complex, dynamic, and interrelated as a mature tree. Over time, this triennial event makes understanding possible. Researchers from several states, and as far away as Mexico, sought answers to persistent questions about tree health and safety. "Things we cannot do in people's backyards we can do here, to test the limits of trees' ability to withstand the environment and what we do to them," said organizer Alan Siewert, urban forester with the sponsoring Ohio Department of Natural Resources.


Severed roots grew back over this two-foot trench. The results await documentation. (crop pic?)

In 2010, a long row of red maple trees was trenched, just a foot from their trunks. The experiment was designed so any loss of stability could be calculated by pulling on the trees. However, the regrowth of the roots restored stability so rapidly, that experiment was abandoned. Smaller-scale root cutting experiments yielded numbers that could be codified as mechanical engineering formulas, or "rules of thumb" for failure, like "Three times the trunk diameter is the minimum distance for trenching", and "The average decrease in stability for each root cut is 15%". But engineering formulas are based not on living wood but on uniform, unresponsive materials. Research is required to test their reliability. Directly measuring response growth,

decay, and compartmentalization over time, we can see the tree restore mechanical stability in spite of formulas.

The wood around the cavity did not fail, causing formulas to be reconsidered.

In 2013, pull testing trees and branches in one direction, "pure static loading" was the primary activity, culminating with "The Wager Tree". This 10" dbh red maple had a gruesome looking open cavity over 6' long. 40 researchers and technicians stuck pins at the points where they thought the tree would fail. Not surprisingly, most of these guesses landed at the center of the "obvious defect". Technicial Will Koomjian cranked the winch up to 9.4 kilonewtons of pull--over a ton of force--before the trunk first failed, above the cavity! Every guess was low, recalling Carl Sagan's observation that "Science is an attitude, of skeptically interrogating the universe, with a fine understanding of human fallibility."

The next point to break was a lawn mower wound on a buttress root. When the trunk was near horizontal, the tissue around the cavity twisted apart. We cut off the brush and pushed the trunk back to vertical, amazed at the reconnection of those trunk fibers. Similarly surprising strength

around cavities in plane trees led Dr. Ed Gilman to speak for everyone in 2010: “We know next to nothing about tree biomechanics.” In 2014, an understanding of human fallibility was *added* to the ISA Dictionary. “defect: A feature, condition, or deformity of a tree that *may* weaken structure or stability and could contribute to tree failure.” In 2016 we hoped to see the Wager Tree regenerating, but its only response was to die.

In 2016, Adolfo Sanchez of Guadalajara, Mexico teamed with Davey’s Eduardo Medina to carry pull testing to the next level. By winching branches in two directions simultaneously, they were able to document the effects of combined static and torsional loading. “For the first time ever, we combined bending moment and torsion (twisting) in a pull test.” Sanchez enthused. “The results were incredible, to see the visual criteria of failure works in a 6" branch! The 45-degree angle of failure indicates both forces at work. Before that moment we only had results from a 2" branch. The other interesting result was, **we reproduced a similar failure as a natural break**, and a total failure, as the branch tore off completely. In the past pull testing the only stress we measured was bending moment, and the result was a partial failure and a hanging branch. The next step is to measurement the magnitude of stress in different species.”

Caption: Ward Peterson of Davey, the host with the most, holds up a 6" pin oak branch torn off in a pull test. The stub was left alone to respond on its own, so the results of this "natural fracturing" can be studied. 2. The break stopped near a node, which had no laterals, but a lot of strength.

Tearing off that pin oak limb was part of a study on European-style crown regeneration using structural pruning techniques outlined by Henry Davis (TCI, April 2003). Some trees were reduced by 20' or more, using cuts under the 4" maximum set in the German and English tree care standards. Each climber measured their index fingers before ascending, so they could quickly know where to make the right cuts. The bigger, subordinating cuts were made first. We did not try to estimate the relative size of the remaining laterals, or guess at their ability to take

on the terminal role, which encourages outward growth. Mature trees have overextended limbs--terminal roles gone wild!--so the objective is the very opposite--downward growth.

 **Ends were reduced back to laterals**

 **Cuts shaped like little crowns, “coronets” may prove to increase decay without improving tree response.**

One original thought was to take over 40% off many of the trees, but a lack of easy brush disposal and mercy by the climbers kept the dose lower. Many cuts were made at a fork, some were back to an upright lateral behind the fork. Species including sweetgums, red maples, pin oaks, silver maples, and white pines were selected in a random pattern, with all treatments receiving a range of sunny and shady conditions. We knew from past work in the field that exposure to sunlight is a big factor in crown regeneration. Dr. Jake Miesbauer and technician Don Ropollo discovered this the hard way, from rotten responses to large cuts made in 2013.

Nic Rataiczak ascends one of 7 trees that he reduced in 2.5 hours. The specs were simple, so little training was needed.

In 2019 and 2022 we will take increment cores to document the limits of decay from pruning wounds and measure the lateral branches below the specified cuts, to assess the trees' response

after three and six years. "I hope that the results of this project can affect the daily decisions we make while pruning, and how we train new arborists."Lewis said, "We'll do better work when we pay attention to tree growth, and rely less on arbitrary formulas, like the 1/3 rule." We expect the same results in Ohio that we typically see in the field, in line with Jason Grabosky and Ed Gilman's reduction of Shumard oaks and live oaks in Florida. Sprouting from the cut surface was rare, with regrowth dispersed among interior laterals. The trees may reconfirm that 2007 study, indicating that specified retrenchment by European standards can regenerate smaller, safer, healthy, long-lived, low maintenance crowns.


Pin oak with upper crown reduced hard, and side limbs thinned gently.

Other pruning studies ran concurrently, including graft-inducing surgery on compacted and included bark. Natural grafting (also known "kissing", inosculation or anastomosis) is common with non-vascular plants, but less documented among woody vascular plants. Arborists observing the body language of trees will notice some of those bodies grafting to themselves and each other, but we don't always have time for details. After surgery, one white oak replaced included bark between two 10" codominant stems with a branch bark ridge in just two years,

2011-2013. Self-grafting might seem unusual, but it's a normal process in biological systems. After successfully tracing included bark on Bradford pears in his own yard, Michael Frankhauser "wondered about the introduction of friction savers into tree care. The idea was to reduce damage in this very same area, but I wonder if any research was done to see if that damage even mattered or was actually detrimental. So many things get pushed through on a single case or a very limited case situation."

No room for chisels in this fork! Pruning with a straight handsaw was less precise.

"Tree research is really hard to do." Frankhauser observed. "They're the hardest of all living organisms to study. I honestly believe this is why they are so neglected. Professors like to be able to nail down facts, which is way easier when you're working with fruit flies. So the smartest guys are working on the least complicated systems because they can maintain a high level of accuracy. Coming from a biochemistry background, tree systems are scary because there are so many variables. But I think that this surgery warrants further research, and may prove to be a beneficial treatment." The forks chosen were at least 50% included, as measured in work done by Duncan Slater in England. The general rule is to remove black and dark brown bark, and avoid damaging white tissue.

Another study focused on avoiding included bark at the base of the tree. After girdling roots are removed, we often see black plates of bark that have been compacted by the pressure of girdling. The tissue above the girdle can quickly expand and roll over this black bark, forming the structural defect known as included bark. Scraping off the compacted bark allows the phloem beneath to expand outward, preventing the tissue above from 'including' it. In our experiment, we removed half of the compacted bark in alternating strips, avoiding damage to white tissue. We will see whether bark tracing in August in Ohio will promote the relative expansion of phloem that we have seen in the field. "My short experience with the pruning project was completely educational. I had a great time!" reported Al Kraus of TCIA member Independent Tree. "It vindicated some of my current practices, and gave me new ideas and thought processes. The boys kept it going just fine during my short sabbatical. I'll be back in 2019!"

Thursday afternoon, the researchers presented their work to the technicians and over 50 members of the public in the triennial Biomechanics Field Seminar. Two more studies focused on root

anatomy, which revealed some unexpected grafting, some between different tree species. These connections reminded researchers of how much we do not know about tree ecosystems, and the strands in the web underground that we typically do not see. On the other end of the tree, blocking down a spar creates a lot of strain on the trunk, which has resulted in tragic accidents. How much strain is too much? "We're trying to learn how to measure that", reported Lucas Drews of Woodland Tree Service. "One trend we have seen is: If the lowering rope is perpendicular and secured to the base of the tree, the force is much lower than it is with an anchor point on another tree."

Friday, another large group cycled through a dozen stations set up on site, learning the whys and hows of Pollinator Plot Development. Recognizing the value in the ecosystem in which trees play so many parts, Davey aims to expand their companion planting and maintenance services. At the edges of the tree plantation, areas are left unmown, and plantings are selected for pollinators and other beneficial associates. (Next to our work area, the honey-tasting station sweetened our day, and replenished our resources!) Cross-pollination of ideas was "the original intent of Biomechanics Week, even before the research", recalled Ward Peterson. "Getting researchers and practitioners working together helps them all get a broader view of their potential connections and contributions to the industry. Culturing a climate of creativity and mutual understanding is breeding fresh approaches to the research and practice of tree care."

REFERENCES:

Henry Davis' work: http://www.tcia.org/TCI-publications/tci-magazine/pdfs/09-2002-TCI-Mag.pdf http://www.tcia.org/TCI-publications/tci-magazine/pdfs/05-2003-TCI-Mag.pdf