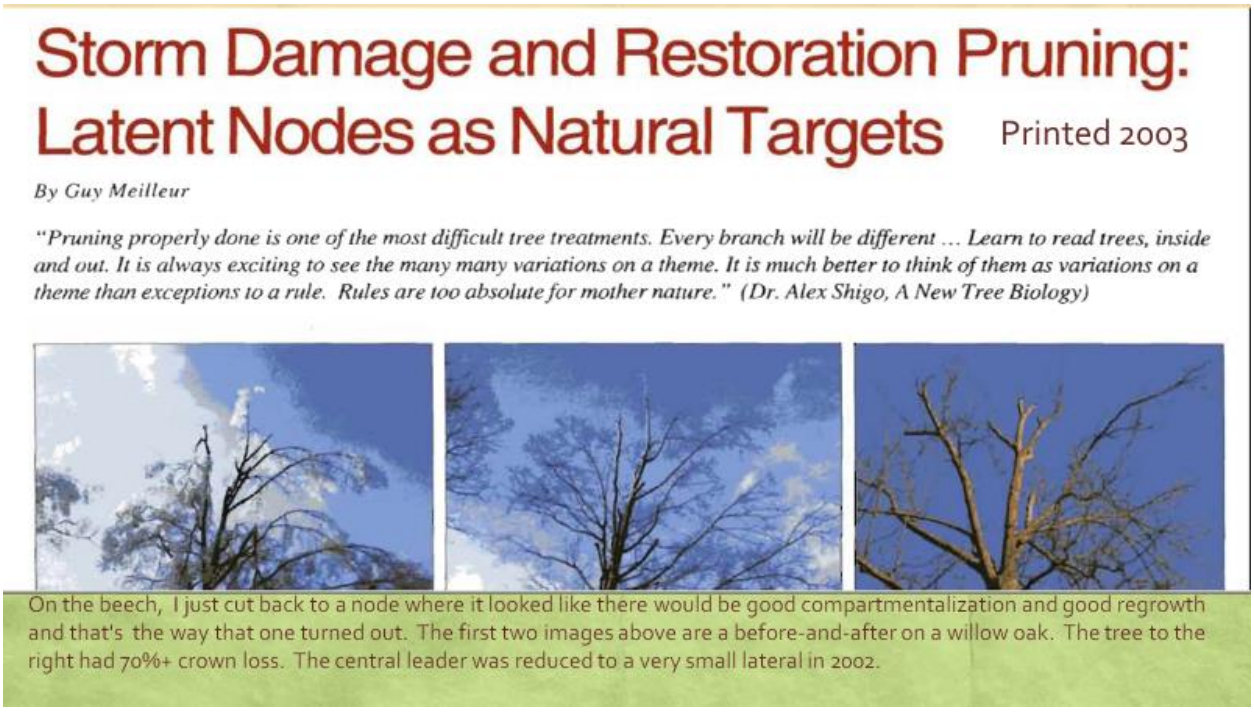
PROLOGUE

December 5, 2002, was a day that will live forever in tree infamy in Raleigh, North Carolina. An inch and a quarter of ice put a crushing load on the canopy of willow oaks, *Quercus phellos*. Huge limbs dangled like grotesque ornaments greeting their owners that morning. Contractors bidding work for the City were told they had to cut all the broken branches back to a "suitable" lateral, at least 1/3 the diameter of the parent, or remove it back to the origin. They were also told, following FEMA guidelines, to remove trees with 50 percent or greater crown loss. It was a Catch-22: by obeying the first rule, contractors would remove much more living crown, meaning that many trees would have to be removed because of City-mandated crown loss.



Storm Damage and Restoration Pruning: Latent Nodes as Natural Targets Printed 2003

By Guy Meilleur

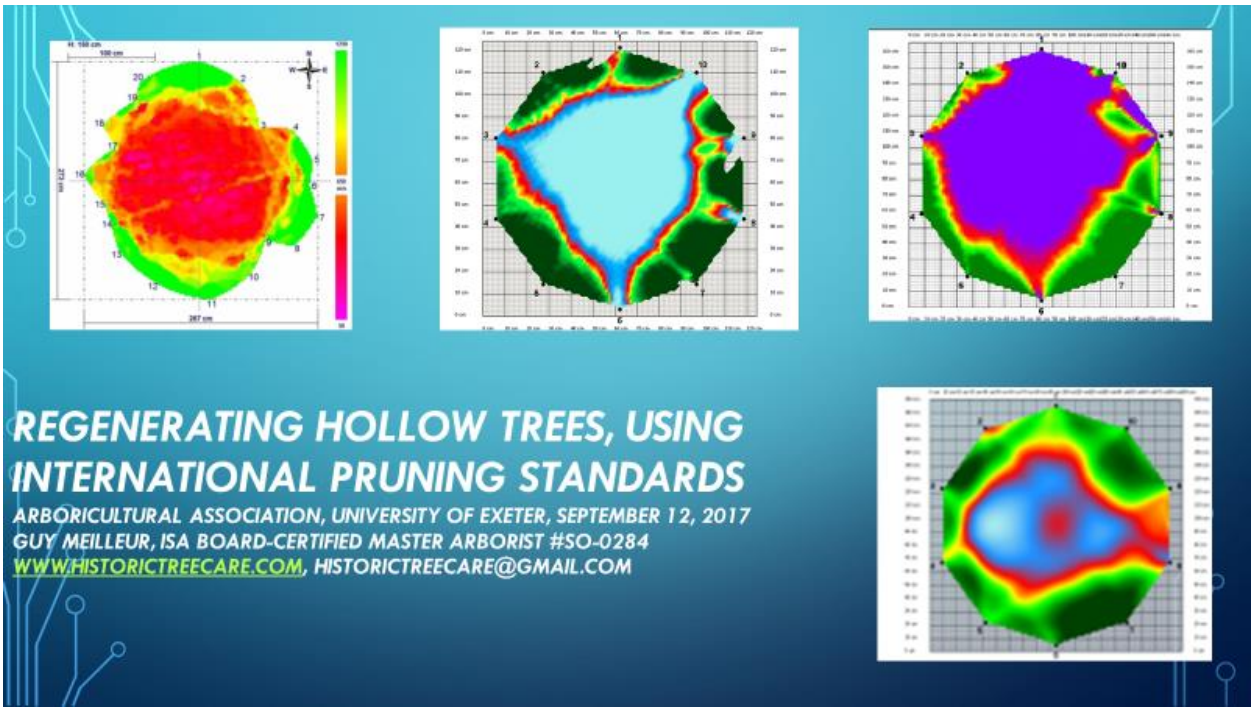
"Pruning properly done is one of the most difficult tree treatments. Every branch will be different … Learn to read trees, inside and out. It is always exciting to see the many many variations on a theme. It is much better to think of them as variations on a theme than exceptions to a rule. Rules are too absolute for mother nature." (Dr. Alex Shigo, A New Tree Biology)

On the beech, I just cut back to a node where it looked like there would be good compartmentalization and good regrowth and that's the way that one turned out. The first two images above are a before-and-after on a willow oak. The tree to the right had 70%+ crown loss. The central leader was reduced to a very small lateral in 2002.

How could that be right? We believed in the ISA motto: "Science, Research, Preservation". Tree preservation was our goal. Branch preservation was the only way to reach that goal. So our pruning was limited to crown cleaning—cutting broken branches only back to growth points, "nodes", conserving as much crown as possible. This exceptional storm overturned the beginner's "1/3 Rule", which was based on a misinterpretation of the literature. As Alex Shigo writes in ***A New Tree Biology***, "Topping is done internodal; proper crown reduction is done at nodes, or at crotches. So the first separation must be nodes—good, internodes—bad."

This storm presented a golden opportunity for researching this question, comparing mature willow oaks treated with minimal crown cleaning to mature willow oaks that were cut back to large laterals, or their origin. We tried to partner on this study with a local tree research laboratory, but were denied. "There is no such thing as a proper heading cut on a mature tree", they insisted. (This dogmatic belief may have led to a mistaken conclusion that I have seen on many tree risk assessment reports: "No amount of pruning can reduce this tree's risk to an acceptable level.")

How could that be right? A “heading cut” is defined as either an internodal cut, a cut to a bud, or a cut to a small lateral. Negative effects from “heading cuts” apply primarily to pruning younger trees. Observing 60” dbh trees in Sweden with 3-4” shell walls, Dr. Ed Gilman noted that “We remove too many trees, and prune too few.” While managing both hollow and storm-damaged trees, we have found that the size of the remaining lateral is far less important than size of wound, light exposure, and other factors.



Section 4.20 of the ANSI A300 pruning standard sanctions heading as "cutting an older branch or stem back to a stub in order to meet a defined structural objective." Section 5.5.6 states that "heading should be considered an acceptable practice in shrub or specialty pruning to reach a defined objective." Because restoration pruning is a type of specialty pruning, the US standard allows "stubs" in trees for the defined objective of preserving those trees. 14 years later, we finally found a place where open-minded research on pruning mature trees was possible.

BIOMECHANICS RESEARCH WEEK

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)". But do we know how trees work? Mature tree systems are complex, dynamic, and interrelated. "Being a generating system, the tree grows new parts in new positions." (Shigo) Trees can only be understood with long-term observation. One view does not show us enough to judge the fate of these vital assets.

Fortunately, there is a triennial event known as Biomechanics Research Week (BRW) that makes understanding trees possible, over time.

Researchers and technicians have combined their talents to cut, pull, and learn from trees planted over 50 years ago at Davey Tree Research Farm in northeast Ohio. Scientists from Guadalajara to Croatia gather every three years to seek answers to persistent questions about tree structure, health, and safety.

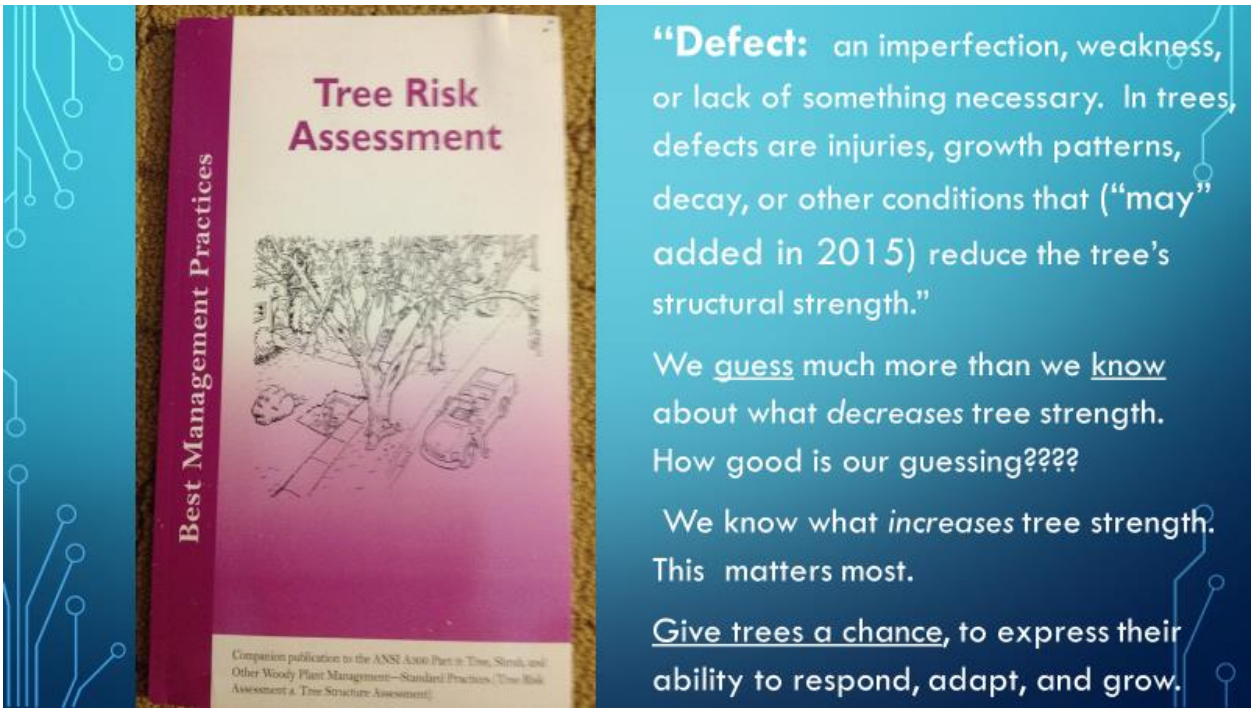
In 2010, I saw that breaking trees apart with carefully calibrated winches was a popular research activity, but analyzing the results is full of problems. Engineering formulas are based on uniform, unresponsive materials—not variable, adaptive tissue. Statistical analysis is removed from real conditions, so testing is repeated, in efforts to find reliability in those formulas. But those efforts are frustrated by the tremendous variability in living trees.

Two *Platanus x acerifolia* planetrees were pull-tested. One had a cavity on the trunk, one did not. The assumption was that the tree with the "obvious defect" would fail first. However, the trunk of the "normal" tree broke, while the hollow tree stood up to much more force, and finally uprooted! The response growth around the cavity never failed. The assumption and the t/r <.3 formula, not the hollow tree, were proven to be defective. These results led Dr. Ed Gilman to observe: "We know next to nothing about tree biomechanics."

In 2013, pull testing trees and branches in one direction, "pure static loading" culminated with "The Wager Tree". A 10" dbh *Acer rubrum* 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. True to our training, most of the guesses were centered around the deepest part of the cavity. The winch was

cranked up to 9.4 kilonewtons, over a ton of force, before the tree failed--well above the cavity! Every single guess was low.

In 2014, based on this research, a confession of our collective ignorance was voiced in an *addition* 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." Response growth is the other side of the 'defect' coin. When the tree's fate is in question, its response deserves equal attention and weight, in tree time.



In 2016, Adolfo Sanchez of Guadalajara, Mexico carried pull testing to the next level. Winching branches in two directions simultaneously, he documented the effects of torsional loading. "The 45-degree angle of failure indicates both forces at work. 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 measure the magnitude of stress in different species.”

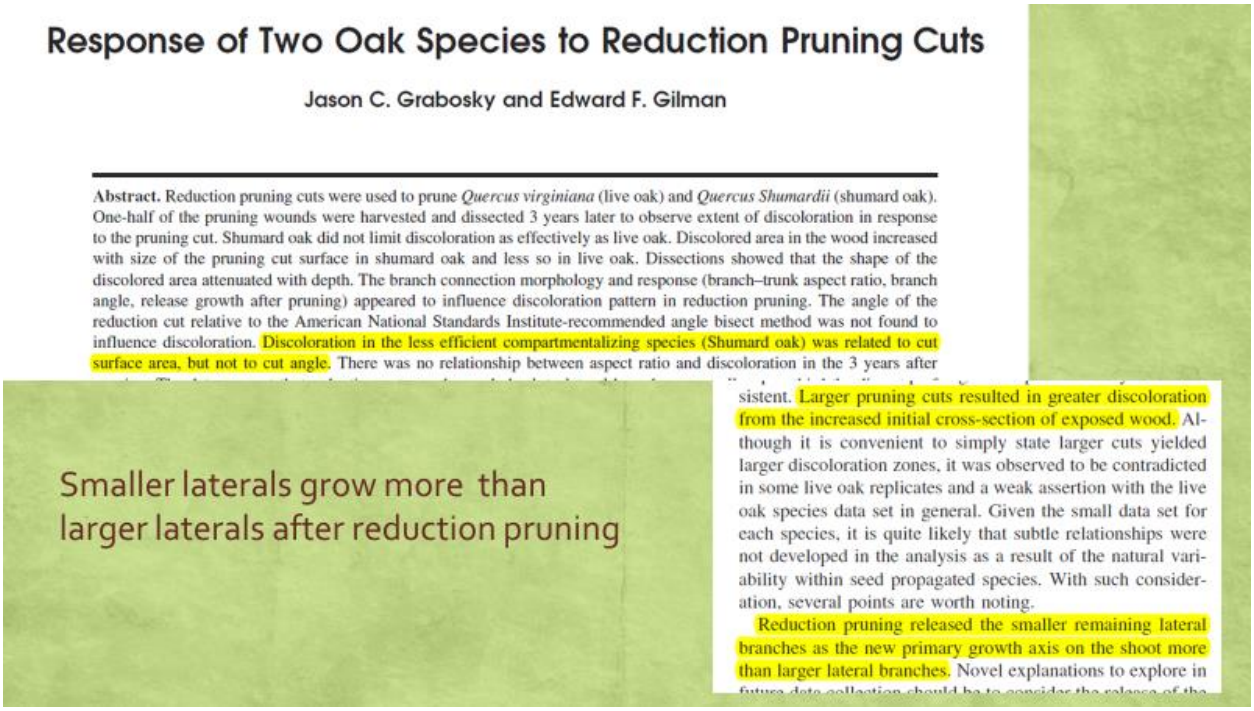
A 6” *Quercus palustris* pin oak branch (above) was torn off in Sanchez’s pull test. The break first stopped near bulges at a node, which had no laterals, but a lot of strength in its Protection Zone. The break finally stopped 33 cm below that at the next ‘terminal node’, where the apical bud was set after the previous growing season. The stub was left to respond on its own, so the results of this “natural fracturing” could be studied. The break was on the north side of the crown, where shade limited the response measured in 2019 to a few short sprouts.

Tearing off that pin oak limb was part of a study on crown regeneration using structural pruning techniques outlined by Henry Davis in 2002. Pin oaks were reduced by 20’ or more, keeping cuts under the 4” maximum recommended in the German and British tree care standards. The bigger, subordinating cuts were made first. Arborists 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 often have overextended limbs--terminal roles gone wild!--so the objective is the very opposite—inward and downward growth.

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.

"I hope that the results of this project can affect the daily decisions we make while pruning, and how we train new arborists.", BCMA Ryan 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.



Crown reduction pruning can be the best thing to do for a tree or the worst thing. Excessive crown reduction is known as topping, "large internodal cuts without regard to tree health or structure." This study uses specified nodal cuts (made at growth points) that do not exceed four inches in diameter. "Smaller cuts shall be preferred", is the mild wording in ANSI A300 Part 1, Pruning. "Limbs (>10 cm)

should not be removed." is the German Standard.

All A300 Parts state that "The arborist shall establish the objective." The "shall" makes this a requirement; "should" means recommendation. The arborist considers the owner's goals in light of potential arboricultural treatments and plans the work to achieve the owner's goals to the fullest extent possible. We adapted the default objective in the German standard, which applies to most of our work: "Maximize health, safety, and value." Like all the informational, supporting language in the British and German standards, the words are italicized. The ANSI A300 does not include informational guidance in the body of the document.

In 2016, Silver Maples, Pin Oaks, Red Maples, and sweetgum trees were cut back with 2-4 inch maximum cuts, depending on tree size. The specification called for a dose up to 40% of the leaves removed. One inexperienced arborist with simple specifications and a bucket truck was able to prune seven mature silver maple trees in 2.5 hours. In 2018 and 2019, we measured the response in both the callus growth closing the wounds and the sprouting response below the wounds. Callus was fairly uniform. Where the "donut" of tissue was uneven, that was related more to vascular flow than the location of the cuts.

New branch extension growth averaged close to 16" in 2017 and 10" in 2018. With cut size limited to the maximum in the European standards, in pin oaks there was no sprouting at the cut surfaces. That means the regrowth should be better attached and conforming to the trees' natural growth habit. Overall, sprouting after specified reduction pruning is typically located at interior nodes, and gradual.

The maples and sweetgums responded differently. There were more sprouts at the cut surface. Some of the regrowth was wild and unnatural in appearance, unlike the oaks. Ryan Redvers of Ontario, a soft maple specialist, initiated a study in 2019 on silver maples using cuts smaller than 2". Redvers' system of regular pruning at the same areas could be considered a variation of pollarding. Based on his experience, natural growth response follows smaller cuts. Redvers pruned 3 trees with a lighter dose, 3 with a heavier dose, and left 3 as controls. In 2022, we will see whether silver maples respond more favorably to his lighter touch than to the larger wounds I inflicted in 2016. Live and learn!

After studying Redvers' method in 2014, above, I knew he was the man for the silver maple job!

EPILOGUE

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.” Integrating fresh viewpoints from practitioners will keep Biomechanics Research Week energized in 2022, and beyond!

We had hoped to measure the sprouting response in the spring of 2020, but this data collection trip was delayed due to travel restrictions. We plan to return late in 2020, to see if the sprouting continues to slow down for a fourth straight year. So far, the rate and pattern of sprouting indicates that after a specified hard reduction, no followup pruning is needed for at least five years. Following international pruning standards, Grabosky and Gilman’s research, and Henry Davis’s 20th-century work on structural pruning of mature trees, regenerative pruning makes trees sustainably smaller and safer. After our next measurements are recorded, we will submit this work to the journal *Arboriculture & Urban Forestry.*

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

1. Pruning is which Part of the A300 Tree Care Standard?

1

2

3

4

2. The objective is formed when

The owner or manager tells the arborist what to do

The arborist plans the work to achieve the owner's goals

The purchase order is signed

The check is in the mail

3. The universal principle of pruning mature trees is

Reduce to laterals at least 1/3 the diameter of the parent branch

Remove large limbs with perfect collar cuts

90-3-90: the less cuts the better

The smaller the wound, the better

4. A heading cut is defined as

an internodal cut

a cut to a bud

a cut to a small lateral

any of the above

5. Observing 60” dbh trees in Sweden with 3-4” shell walls, Dr. Ed Gilman said

“They have ticking time bombs all over the place.”

“We know a great deal about tree biomechanics.”

“We remove too many trees, and prune too few.”

“Hazard tree removal is the essence of arboriculture.”

6. After the storm, ____ for better form

Make all cuts just outside the collar

Wait and see

Head (Make heading cuts)

Make coronet cuts

7. Reducing branches to a lateral that can assume the terminal role is important for

Young trees

Mature trees

Older trees

All trees

8. Ryan Redvers’ system of regular pruning at the same nodes is a variation of

Topiary

Pollarding

Espalier

Topping

9. Sprouting after specified reduction pruning is typically

Located at the cut surface, and fast

Located at the cut surface, and gradual

Located at interior nodes, and fast

Located at interior nodes, and gradual

10. Informational text in the body of the UK and German standards is signified by

Bolding

Underlining

Italicizing

Standards do not include informational text

11. The first failure point of the Wager Tree was

Above the cavity

Below the cavity

At the most extensive decay

On a tension root

12. A defect is a feature that _____ weaken structure.

Is highly likely to

Is not likely to

may

will

13. 9.4 kiloNewton’s is approximately

500 lb

1000 lb

1500lb

2000lb

14. The largest recommended cut in the German and British tree care standards is

2”

4”

6”

There is no maximum recommended collar cut

15. The break in the pin oak branch stopped

At a lateral branch 1/3 the diameter of the parents branch.

At a node with no lateral branches.

At the branch collar.

Six times its diameter beyond the origin.

16. The sprawling pin oaks were reduced by

5’ and more

10' and more

15' and more

20' and more

17. Henry Davis’ structural pruning technique makes -_____ first.

Inner branch removal cuts

Outer branch removal cuts

Bigger subordinating cuts

Smaller cleaning cuts

18. Stems that are cut into little crowns are

Bayonets

Coronets

Martinets

Silhouettes

19. One person with simple specifications and a bucket truck was able to prune _____ mature Silver maple trees in 2.5 hours

5

6

7

8

20. In 2007, a study on reducing oak trees found that more growth

Sprouted from the cut surface

Died within three years

Was dispersed among interior laterals

Was dispersed among exterior laterals

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

PRUNING

http://www.historictreecare.com/wp-content/uploads/2012/05/restore_2010_06.pdf
http://www.historictreecare.com/wp-content/uploads/2012/05/After-the-Storm-from-TCI-Magazine-April-2003.pdf
http://www.historictreecare.com/wp-content/uploads/2015/02/Pruning-for-Preservation-1106-AN.pdf
http://www.historictreecare.com/wp-content/uploads/2016/09/Mike-ORyza-and-the-Case-of-the-Vexing-View.pdf
http://www.historictreecare.com/wp-content/uploads/2015/02/PolePruning_2008_06-1.pdf
Poster—Pruning Standards and Simple Specifications at work
http://www.historictreecare.com/wp-content/uploads/2017/06/AREA-140801.pdf
http://www.historictreecare.com/wp-content/uploads/2015/11/Response-Growth-after-Pruning-150810.pdf

15% LESS CROWN; 50% MORE STABILITY

WESSOLLY http://www.historictreecare.com/wp-content/uploads/2015/02/Wessolly-How-hollow-may-a-tree-be.pdf
GOODFELLOW Page 56 http://www.historictreecare.com/wp-content/uploads/2015/02/Goodfellow-Branch-Failure.pdf
MUIR Slides 12 et al https://www.trees.org.uk/Trees.org.uk/files/9a/9ab61d8d-843f-4eea-83b9-fe4bdd8d3393.pdf

TREE RISK MANAGEMENT

GIVE TREES MITIGATION
http://www.historictreecare.com/wp-content/uploads/2017/10/ISA-CEU-Risk.pdf
http://www.historictreecare.com/wp-content/uploads/2017/07/AA-JUN-JUL-2017-pg10-17_V2.pdf

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http://www.historictreecare.com/wp-content/uploads/2019/09/Defending-Tree-Value-0808-TCI-.pdf

The first failure was a foot above the open cavity. The fibers separated longitudinally on the tension side.

The second failure was at mower damage on a tension root.

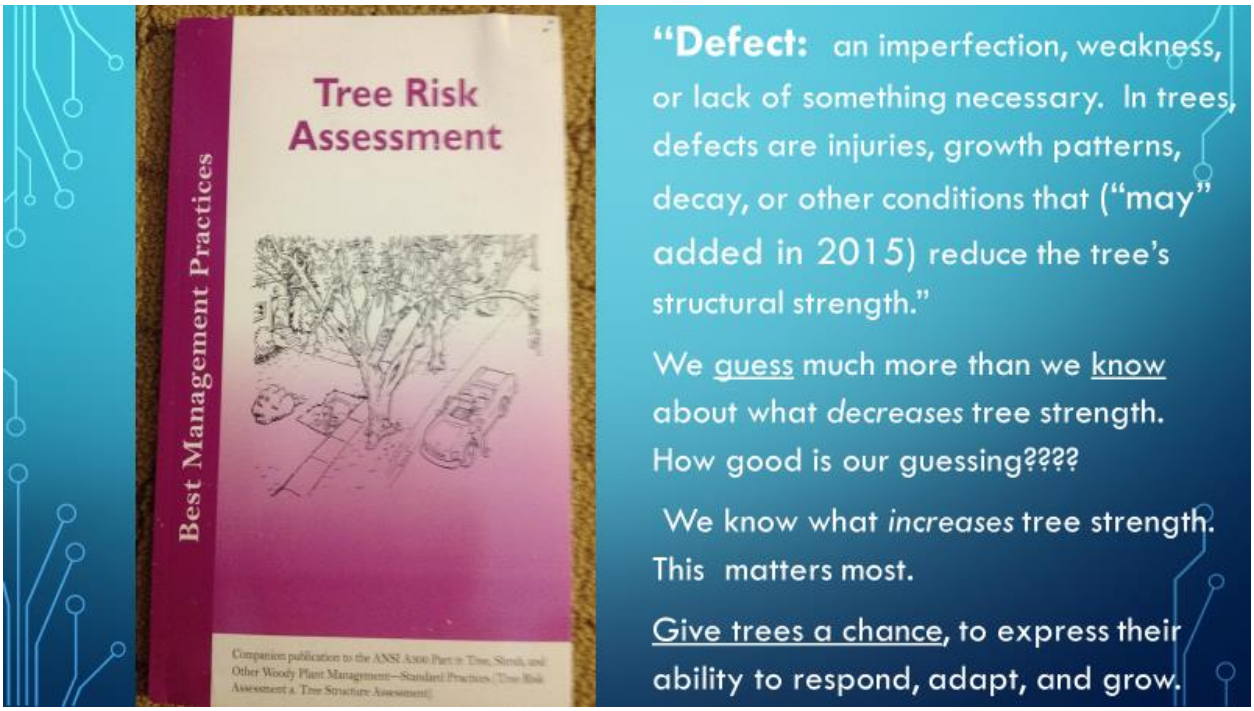
The trunk was bent over 60 degrees when the woundwood around the cavity started failing. But it sprung back into position, with just a little help.

After the brush was cut off, one person with a pole pushed the trunk back up to the angle shown here.

The first failure had been at the height indicated by the man's right hand.

The tree's response growth will be measured and tested at the next Biomechanics Week.

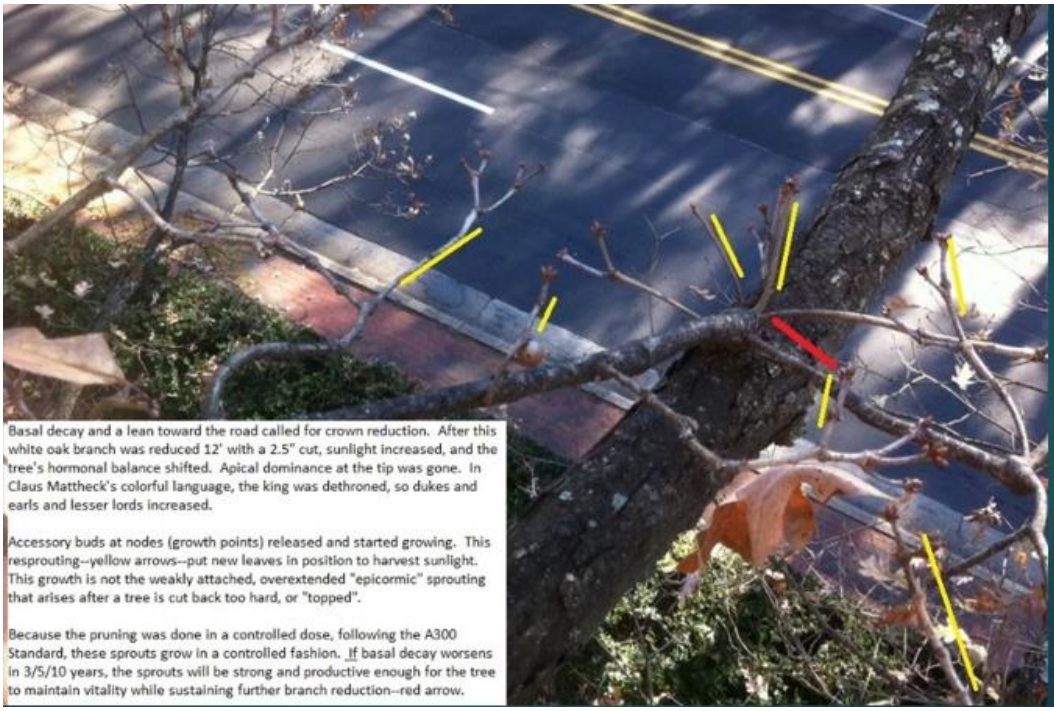
"Science is an attitude, of skeptically interrogating the universe, with a fine understanding of human fallibility."
Carl Sagan



Ryan Redvers ascends a silver maple.

Poor response by a silver maple to hard pruning in 2016.

Rotten response to big cuts on silver maple in the shade.



Basal decay and a lean toward the road called for crown reduction. After this white oak branch was reduced 12' with a 2.5" cut, sunlight increased, and the tree's hormonal balance shifted. Apical dominance at the tip was gone. In Claus Mattheck's colorful language, the king was dethroned, so dukes and earls and lesser lords increased.

Accessory buds at nodes (growth points) released and started growing. This resprouting--yellow arrows--put new leaves in position to harvest sunlight. This growth is not the weakly attached, overextended "epicormic" sprouting that arises after a tree is cut back too hard, or "topped".

Because the pruning was done in a controlled dose, following the A300 Standard, these sprouts grow in a controlled fashion. If basal decay worsens in 3/5/10 years, the sprouts will be strong and productive enough for the tree to maintain vitality while sustaining further branch reduction--red arrow.

Response of Two Oak Species to Reduction Pruning Cuts

Jason C. Grabosky and Edward F. Gilman

Abstract. Reduction pruning cuts were used to prune *Quercus virginiana* (live oak) and *Quercus Shumardii* (shumard oak). One-half of the pruning wounds were harvested and dissected 3 years later to observe extent of discoloration in response to the pruning cut. Shumard oak did not limit discoloration as effectively as live oak. Discolored area in the wood increased with size of the pruning cut surface in shumard oak and less so in live oak. Dissections showed that the shape of the discolored area attenuated with depth. The branch connection morphology and response (branch–trunk aspect ratio, branch angle, release growth after pruning) appeared to influence discoloration pattern in reduction pruning. The angle of the reduction cut relative to the American National Standards Institute-recommended angle bisect method was not found to influence discoloration. Discoloration in the less efficient compartmentalizing species (Shumard oak) was related to cut surface area, but not to cut angle. There was no relationship between aspect ratio and discoloration in the 3 years after

This study reveals the effectiveness of specified reduction pruning.

sistent. Larger pruning cuts resulted in greater discoloration from the increased initial cross-section of exposed wood. Although it is convenient to simply state larger cuts yielded larger discoloration zones, it was observed to be contradicted in some live oak replicates and a weak assertion with the live oak species data set in general. Given the small data set for each species, it is quite likely that subtle relationships were not developed in the analysis as a result of the natural variability within seed propagated species. With such consideration, several points are worth noting.

Reduction pruning released the smaller remaining lateral branches as the new primary growth axis on the shoot more than larger lateral branches. Novel explanations to explore in