HOW CABLING AFFECTS TREES

By Brian Kane

Figure 1: A side effect of the first experiment, which investigated whether trees grow differently after different types of cable are installed, was that trees grew around two Cobra systems. Images courtesy of the author.

Cabling is a common practice in arboriculture. For many years, arborists have installed cables to support weakly attached and overextended branches. Part 3 of the ANSI A300 Standard and the ISA's Best Management Practices describe the "how-to" of cabling (and other supplemental support systems), but there are very few scientific studies that have tested whether these guidelines are appropriate or have examined how cabling affects trees.

In the 1930's, Thompson measured the force required to extract different diameter lags from a variety of species, but all of his tests occurred immediately after installation. Very little work was done after this, until recently, when two studies took a fresh look at the force required to cause failure of the attachment of the cable to the stem or branch (Kane 2011; Smiley 2011).

These two studies highlighted 1) the difficulty of extracting lags – nearly all of the tests broke the lags rather than pulling them out of the wood (Kane 2011); and 2) that there is a wide range of force required to break different anchoring systems – eyebolts were the strongest and bent-eye lags the weakest (Smiley 2011). Several studies have looked at how much decay occurred with different types and depths of drilling to install hardware in trees, but there aren't really any studies that have examined other possible effects of installing a cable.

Since there didn't appear to be much information on how installing a cable affected a tree, my co-workers and I recently conducted some experiments (and we also have some ongoing experiments). Our goal was to try to understand whether installing a cable – even though it should reduce the likelihood of failure of weakly attached branches – increased the likelihood of failure of the whole tree or other parts of the tree. Two factors that could affect the likelihood of whole-tree failure after installing a cable are 1) changing the way the tree sways in the wind and 2) causing the tree to grow differently.

In the first experiment, we investigated whether trees grow differently after different types of cable are installed. Experiments on forest-grown trees showed that when trees are guyed for support, they grow much taller and trunk diameter above the guy wires is greater than below the wires. We thought that, since steel cables are less flexible than Cobra cables, they would restrict motion of the co-dominant stems and cause them to grow differently.

In the second experiment, we studied how trees sway with and without steel cables between co-dominant stems in red oaks. Since cables are often installed to reduce the likelihood of failure of weakly attached branches, we wanted to see if the sway motion changed with a cable, which might increase the likelihood of failure of the whole tree, even if the weakly attached branches were less likely to fail.

In the first experiment, we installed steel and Cobra cables in red oaks with co-dominant stems, leaving some trees as controls without a cable. Five years later, we removed the trees and cut five discs from each co-dominant stem. On each co-dominant stem, two discs came from just above and just below where the cable was attached to the stem and three discs came from the trunk (about four feet above the ground, halfway up the trunk, and about six to eight feet below the cable itself).

On each of these discs, we measured the thickness of 16 growth rings – five after and 11 before installing the cable. We measured growth rings in line with and perpendicular to the direction of the cable. In total, we measured more than 5,000 growth rings under the microscope, a couple of millimeters at a time!

In the second experiment, we winched trees away from their vertical orientation and then quickly released tension in the winch, which caused trees to sway back and forth. An accelerometer attached to the trunk measured the sway motion. Pulling and releasing trees isn't exactly the same as when they're blown in the wind, but measuring the sway motion allows us to calculate two structural properties – frequency and damping ratio. When trees are blown by the wind, wind speed is important to determine the load on the tree, but it's also important to understand frequency and damping ratio of the tree when trying to estimate the likelihood of failure.

We also tested trees with and without leaves to see if the season, as well as the presence of a cable, affected frequency and damping ratio. Frequency is how fast a tree sways, and damping ratio indicates how quickly a swaying tree stops swaying if no additional forces act on it. At higher sway frequencies, it's harder for the wind to efficiently transfer energy to the tree, so there's a smaller likelihood of failure. There's also a smaller likelihood of failure when trees have a larger damping ratio.

In both studies, we installed cables at two-thirds the distance from the co-dominant union to the top of the tree and tensioned cables so that they were taut when the trees were leafless. In ongoing studies, we are measuring frequency and damping ratio of red oaks with co-dominant stems that have been cabled at different heights and at different tensions, and how different anchoring methods such as eyebolts and dead-end terminations affect the amount of discoloration and decay.

The results of our first experiment showed, with one exception, that installing a cable did not change the pattern of diameter growth of the co-dominant stems five years after installation. The exception was: Diameter growth was greater in the discs cut from just above and just below the eyebolt anchoring steel cables to the co-dominant stems. But it was only greater in line with the eyebolt, rather than perpendicular to it, and by three years after the cable was installed, diameter growth was the same for all trees and discs. We think that the explanation for the greater growth was the formation of woundwood associated with drilling the hole for an eyebolt. Since no holes were drilled for Cobra systems, there was no woundwood formation.

On both systems, we observed some possible side effects of cable installation. Trees grew around two Cobra systems (Figure 1) and there was some bark damage from rubbing thimbles (Figure 2).

In our second experiment, whether trees were in-leaf or not had a bigger effect on frequency and damping ratio than installing a cable. Leafless trees had higher frequency (they swayed more quickly) and smaller damping ratio (it took more time to stop swaying after pulling and releasing them). Installing a cable doubled tree frequency – but only on leafless trees; there was no effect when trees were in-leaf – but did not change the damping ratio.

Figure 2: There was some bark damage from rubbing thimbles.

We believe that the greater frequency of cabled, leafless trees was due to trees being stiffer. It's harder for the wind to move a cabled co-dominant stem because the cabled stems do not move as freely as when they are not cabled, but they are not so restricted that they grow differently. We think that the added mass and drag of leaves negated the effect of the cable on frequency when the trees were in leaf. The increase in frequency with a cable shouldn't increase the likelihood of whole-tree failure because less wind energy can be transferred to the tree and, since damping ratio was not affected by the cable, we can be a little more confident that cabling didn't adversely affect the likelihood of whole-tree failure.

In both of the experiments, we tested trees that were growing in a forest, not in a residential yard, so we can't be sure that the results we found would apply to open-grown trees. Open-grown trees usually have more branches than the trees we tested, and this can affect the frequency and damping ratio. Despite this limitation, we think that our experiments are useful because no other studies have looked into the questions we asked about the effects of installing a cable.

Taken together, results from our studies suggest that installing a cable does not seriously increase the likelihood of tree failure, which is good to know. It was also interesting to see the effect of leaves on tree swaying. Other research has shown that leaves can dramatically affect the load on, and swaying of, trees. Arborists who work in temperate climates (where the leaves drop from deciduous trees in the winter) should consider at what time of year strong winds are most likely to occur, because leaves can have such a great effect on factors that influence the likelihood of failure.

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