Correction of Hazardous Defects in Trees

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Introduction

Every tree in the urban landscape will eventually fail regardless of care. While many trees in an urban environment remain sound and present low risks to public safety until they die from other causes, some trees break apart from accumulated defects and diseases while they are still alive (Fig 5.1). If a target is present near where a tree is growing, there is always a risk that falling limbs or a catastrophic failure of the stem or roots may result in harm to people or damage to property. When any tree in a community accumulates defects that exceed a certain level, the tree becomes an unacceptable risk, and must be corrected or removed. Of course, dead trees and branches present an especially imminent hazard, and should be removed as soon as practical after they are discovered. Pruning or cabling and bracing can correct many defects that make a tree a hazard. This chapter outlines the strategies that communities can adopt to correct trees that develop hazardous defects, along with some ideas for converting dead or dying trees into desirable wildlife habitat.

Figure 5.1. *This tree was previously topped, and extensive wood decay has developed as a result. Two major branches have already failed. This tree will continue to decline at a rapid rate and should be removed.*

While the bulk of this manual deals with the recognition of hazard trees and the development of a community tree risk management program, one of the most important aspects of such a program is the implementation of effective corrective actions in a timely manner. Although the goal of risk management is preventing injury and damage, avoiding litigation is also important to communities, because of the potential costs involved. Evidence that a community has exercised "reasonable care" in regard to maintaining its trees lies in its ability to produce documentation that proves that not only are trees inspected, but that hazardous trees are corrected in a timely manner.

Strategies for Corrective Action

Procedures to correct hazardous defects in trees range from simply pruning out defective branches, to applying simple or complex cabling and bracing systems, to taking the ultimate step of removal and replacement of the tree. The use of cabling and bracing to correct

There are many ways to reduce the risk to the public posed by a hazardous tree, and many times more than one solution is possible.

Corrective action strategies to manage hazardous trees include :

- Moving the target
- Correcting the tree
  - Pruning
  - Cabling and bracing
- Converting the tree to a wildlife tree
- Closing the area to the public
- Removing the tree

Figure 5.2. *Hazard Tree: Structurally defective tree with a target within striking range.*

defective trees is such an important, controversial, and technical subject that it was decided to devote a major portion of this chapter to this subject alone. See the cabling and bracing section below. The rest of this chapter focuses on the other means of correcting hazardous trees: pruning, conversion to non-hazardous wildlife habitat, or removal. Strive for the treatment that results in the least impact on the site while eliminating the immediate hazard.

Moving the Target

As defined in Chapter 1, a "hazard tree" is a structurally defective tree that has a target within range (Fig 5.2). If the target is moved out of range of the defective tree, then the tree is no longer a hazard, but is still a defective tree. Because it is difficult to predict the direction of fall of a defective tree or tree part, and because most people are poor judges of the actual heights of trees, it is recommended that a "target" be defined as any object within a specified distance (1.5 times the estimated tree height) of the defective tree.

Moving the target away from a defective tree can also be an important way of "buying time." If a hazardous tree is identified but corrective action cannot be taken immediately, consider moving the target first. For example, if a picnic table or bench is the target beneath a highly defective tree, but corrective actions cannot be taken for several days or more, move the table or bench away from the tree. Moving the target in most urban situations is probably a temporary measure; in most cases it reduces risk, but does not eliminate it entirely.

Wherever people congregate or spend significant amounts of time in one place, the potential for a hazardous situation exists. For example, one of the categories of users of urban parks is the homeless. Many homeless people will seek shelter for the night under a tree in a park, even if the tree is dangerously defective. Other users of urban parks seek solitude, and go to great lengths to get away from their fellow visitors. For this reason, it should be assumed that if a tree within an urban park is surrounded by mown grass it should be considered as having potential targets. An area of mown grass without nearby picnic tables, benches, or paved paths (i.e., "targets") can probably be considered a low-risk area, but the trees in such an area should still receive periodic inspections, even if the intensity and frequency is less rigorous than that afforded other, more intensively used areas. However, if it is known that people regularly sleep or congregate under a tree or group of trees in a park, even if such use is technically illegal, increased vigilance is required.

Correcting the Tree

Pruning

Pruning out the defective parts of a tree is by far the most common means of correcting defects and minimizing the chance of tree failure. Pruning is described fully in Chapter 4 (Prevention of Hazardous Tree Defects). Always follow industry standards for pruning (ANSI 300 – 1995 and ANSI Z1331.1 – 2000) as described in Chapter 4. Guidelines are also provided in Appendix 2: How to Prune Trees.

Examples of tree defects that often can be corrected using proper pruning techniques include:

Figure 5.3. *Remove the entire branch back to its junction for large branches that are cracked.*

Figure 5.4. *Remove large branches that are broken or lodged in the crown.*

Cracks: For a large branch with a major crack, removal of the entire branch back to its junction with the main stem is usually the most effective remedy (Fig 5.3). However, cabling and bracing is an option that should be considered in some circumstances.

Dead Branches: Remove large branches (> 4 inches) that are broken or lodged in the crown. At the same time, remove the remaining stub, using good pruning techniques (Fig 5.4).

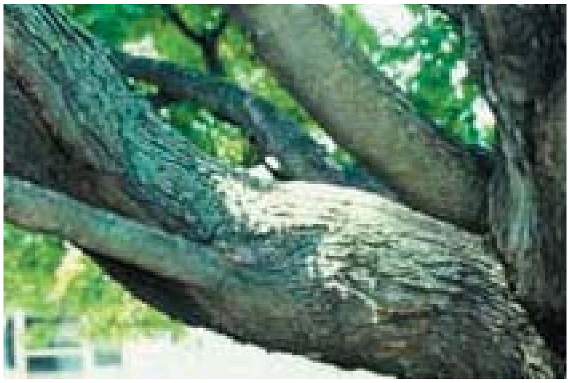

Figure 5.5. *Remove branches with weak branch unions and included bark.*

Weak Branch Unions with included bark: Where a tree has a weak branch union with included bark, remove the affected branch (Fig 5.5). As with most corrective actions, they are more likely to be

Figure 5.6. *Remove all large branches that are decayed (A) or dead (B).*

effective if implemented while the tree is young. See the cabling and bracing section for other options.

Decayed branches: Remove all large branches (> 4 inches) with evidence of decay, and all large dead branches (Fig 5.6 A and B). The pruning procedure must remove the branch back to live, sound wood, but should not necessarily cut into live wood. Proper pruning cuts, even for large branches, are made just outside the branch-bark ridge, without injuring the branch collar.

Figure 5.7. *Remove all branches that have highly abnormal branching habits such as sharp bends or twists.*

Unsound Architecture: Prune branches that have a sharp angle, bend, or twist (unless such growth is characteristic of the tree species) (Fig 5.7). These are "architecturally unsound trees." As with weak unions early intervention is always better than removing large branches later in the tree's life.

Figure 5.8. *Remove all branches that obstruct street signs, signals, street or security lighting or that limit visibility of approaching traffic.*

Visual Obstructions: Remove branches that obstruct street signs, signals, street or security lighting, or branches that limit visibility of approaching traffic (Fig 5.8).

Physical Obstructions: Remove branches that impair pedestrian or vehicular traffic.

Interference with Utility Lines: Prune trees that interfere with overhead utility lines to eliminate the interference. Topping trees for utility clearance is no longer considered an acceptable pruning practice (Fig 5.9). Maintenance of such trees is usually the responsibility of the utility company that owns the lines. Special training and certification for maintenance workers who do this work is mandated by the federal Occupational Safety and Health Act (OSHA), and should be required by all communities.

Figure 5.9. *Trees that interfere with overhead utility lines should be pruned. But not this way! Tree topping is not an acceptable pruning practice.*

Cabling and Bracing

We do not recommend cabling and bracing as a treatment for hazardous trees unless the tree has significant historic or landscape value. The decision to apply cabling and bracing procedures to trees should not be made lightly. Because it is critically important that such procedures be done correctly, the following section provides information that communities can use to make informed decisions regarding when and how to use these tools in their tree risk management programs.

Industry Standards. Industry standards for installing support systems in trees are published by the National Standards Institute in *The American National Standard for Tree Care Operations- Tree, Shrub, and Other Woody Plant Maintenance-Standard Practices - Part 3 - Tree Support Systems* (ANSI 2000). This publication includes sections on hardware selection and requirements, installation practices, cabling and bracing requirements, and guying techniques. The ISA has published a companion publication, *Best Management Practices: Tree Support Systems,"* to serve as a "how to" guide for defining cabling, bracing, and guying procedures and methods (Smiley et al. 2001). Community tree care managers who write contracts and bidding specifications for tree maintenance work projects should be familiar with these standards and best management practices. Communities should hire arborists who are experienced and will agree in writing to perform all cabling and bracing operations in accordance the ANSI A300 - Part 3 - Standards.

History of Cabling and Bracing. Cabling and bracing of trees has been practiced for many years. There are obscure references to bracing done in the early 1800s, but bracing trees, as we know the practice today, can be traced back to the early twentieth century. Some of the first bracing systems used chains and other rigid materials such as rods, flat straps, and tubing. Cable and eyebolts came into use after 1910 and have been widely accepted, with some modifications, as new materials were developed. During the 1930's the National Park Service published guidelines for material sizes and strengths that have been followed since that time. Modern materials used in cabling and bracing systems include rigid material such as threaded rod or bolts or flexible material such as metal or synthetic fiber cable.

Cabling and bracing systems are very similar to the standing rigging on sailing ships. The use of flexible and rigid braces between masts and spars onboard sailing ships to support huge loads is very similar to the goals of bracing trees to themselves (Fig 5.10). Proper selection, sizing, and placing of support materials can be expected to add to the life expectancy of trees.

Figure 5.10. *H.M.S. Victory, the flag ship of Vice-Admiral Lord Nelson at the Battle of Trafalgar, illustrating the use of flexible and rigid braces between masts and spars.*

Cabling and bracing has extended the life of many trees and reduced the risk from failure to an acceptable level. But the design and installation of a proper system of cabling and bracing requires professional judgment and experience. When hiring an arborist to install a cabling and bracing system, look for an experienced arborist who has observed tree failures and worked in trees that have been saved by proper cabling and bracing systems.

Cabling and Bracing Defined

Cabling and bracing is the practice of adding a support system to a tree to reduce the stress on weak branch unions. Many trees have acute, V-shaped branch unions that form included bark. Included bark acts as a wedge that weakens and separates branch unions that join at too sharp an angle. A similar situation occurs when two equal-sized stems form off the main bole of a tree after the loss of the main leader. The bark of the two stems push against each other and the two leaders do not have a strong connection to the main bole (Fig 5.11). As the tree grows, these structural defects can lead to failure of one of the two stems. Adding properly installed cabling and bracing will reduce the strain on the branch union, and extend the life of the tree.

Figure 5.11. *The through bolt was installed to add support to a weakened codominant branch.*

Cabling and bracing can also be used to correct trees with poor architecture. Typically, as trees grow, the trunks and limbs taper toward the ends. This tapering reduces the strain on the higher and outer limbs in the tree. If limbs and trunks do not taper, a large amount of leverage acts on the point of attachment where the branch meets the stem, which can lead to failure. Improper pruning can also place strain on branch unions. The inner branches of some trees have been removed because of the mistaken belief that such hyper-thinning eliminates the possibility of wind failure. Actually, by removing these inner branches, the tree will put on more length and less bulk in its limbs. This leads to the condition referred to as "lion's tailing." Because the limbs are long and thin, but still maintain a full complement of foliage, the limbs will whip severely and possibly fail, instead of swaying naturally.

Analysis of Tree Condition. There are many considerations that must be addressed before a cabling and bracing system is installed in a tree. The tree may have a high value in a particular landscape, or it might be a historic or unique specimen. Before investing in a cabling and bracing system, the cost of installation and future maintenance must be balanced against the risk of failure and possible loss of aesthetic value during the tree's extended life.

Carefully assess the tree to determine if it is a reasonable candidate for the investment in cabling and bracing. Consider the whole tree during this assessment. The roots must be strong enough to support the tree. If there is decay in the main trunk or branches, factor that information into the decision to remove or save the tree. If the tree has cracked already, the arborist must know how well the tree species in question is able to compartmentalize decay. Some trees can isolate decay better than others. The outcome of a decision to apply a cabling and bracing procedure to a white oak (*Quercus alba*) may be completely different than if the tree in question is a basswood. Remember that cabling and bracing does not repair a tree. Cabling will add a level of security and risk reduction, and can help to affect the direction of failure if a branch should fail. When designed properly and installed by a trained arborist, proper use of cabling and bracing will extend the life of a tree and reduce the risk to an acceptable level.

If the decision is made to use cabling and bracing to extend the life of a tree, it must be understood that such treatments are temporary. Give consideration to planting a younger tree or trees to be used as replacements if the cabled and braced tree is removed.

Some trees will benefit from having weight removed from the branches before the installation of cabling and bracing hardware. Therefore, do all necessary pruning before the tree is cabled. Remember, removing major lateral limbs creates large wounds that can lead to extensive decay on the main bole of the tree. If weight reduction is determined to be necessary, a slight crown reduction by using proper thinning cuts in the crown is the safest course of action. The possible harm from over-pruning a tree to remove a significant amount of weight must also be recognized. Most trees will need only routine pruning to remove dead limbs and other material in accordance with accepted pruning standards as discussed in Chapter 4.

Inspection Schedule. Once a tree has been cabled and braced it is necessary to inspect the tree on a routine schedule. The size, age, site, and risk potential of the tree will determine the inspection schedule. However, no cabling or bracing installation should ever go more than two years without inspection, and annual inspections are a good idea. Some inspections can be done from the ground. Binoculars can be used to make a more thorough inspection of the tree without having to climb it, or use an aerial lift to inspect the crown. As time passes, it will be necessary to have an arborist inspect the anchor points and any changes in the tree's growth from within the tree. There may come a time when a new cabling and bracing system will be necessary. Again, this assessment will need to be done by an experienced arborist following the same procedures as in the first installation.

As the tree grows taller, the time will come when a new system should be added, higher in the tree. Do not remove the old, lower system before the new system is completed. Do not attempt to remove old hardware imbedded in the tree. That will unacceptably damage the tree. Cut such hardware flush and leave it in place.

The Wye Oak:

A case study of corrective actions including cabling and bracing

The Wye Oak was recognized as America's largest white oak for more than 60 years. Located in the village of Wye Mills on the Eastern Shore of Maryland, the Wye Oak was 96 feet tall with a crown spread of 119 feet and a bole circumference, at 4.5 feet above ground, of more than 31 feet (Fig 5.12). It has been estimated that the acorn that gave rise to this tree germinated around the year 1540. The Wye Oak was one of only two National Champion trees that remained on the American Forestry Association's list of champions since the list's inception in 1940. What enabled this tree to survive for more than 460 years, despite injuries and defects, was a conscientious effort on the part of managers to preserve the tree with corrective treatments, including application of fertilizer and insecticides, pruning, and cabling and bracing.

The Wye Oak was the focal point for the four-acre Wye Oak State Park, established in 1939. At the time the park was established, the tree had marked buttressing at its base (Fig 5.13). The most common theory is that in the past, riders tied their horses to the tree while visiting nearby stores or taverns, and that damage caused by these actions resulted in the malformations. Also, the inner portion of the lower trunk had been severely decayed to a height of eight feet. While today's arborists would never recommend filling a tree cavity with concrete or any other rigid material, filling cavities was an accepted practice in the past, and at some time, the bole cavity in the Wye Oak was partially filled with concrete. The lowermost piece of the concrete filler can be seen in Figure 5.14. Cavity filling treatments like this one do not delay the decay process in the tree, do not make the tree less likely to fail, and can considerably complicate the removal

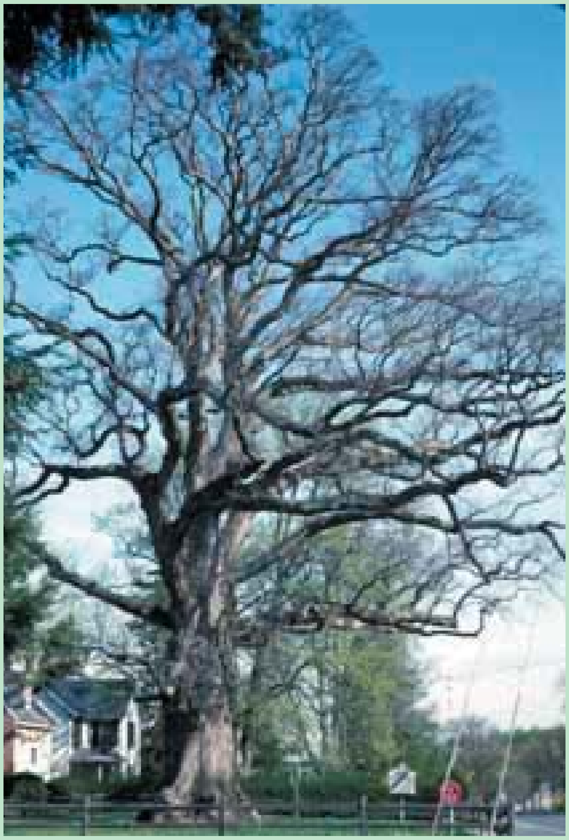

Figure 5.12. *The Wye Oak, formerly known as the largest white oak in the United States. It was located in the village of Wye Mills, MD and was estimated to be 460 years old. Deeded to the state of Maryland on September 20,1939 and made into a State Park. The end for this urban monarch came when a thunderstorm on June 6, 2002 felled the tree.*

Figure 5.13. *Buttressing knees were present on the Wye Oak. The most likely theory of their origin is that horses tied to it while their riders visited a nearby store or tavern, damaged the tree, and initiated the malformations.*

process. The tree has been fertilized annually, and treated with insecticide if gypsy moth or other insect damage was predicted.

By the 1980s, the tree was in the declining phase of its life. In 1984, a large limb, weighing more than 35 tons, fell from the tree. Many more equally massive limbs were losing the mechanical   exibility needed to withstand the stress loading placed upon them by wind. For this reason, the tree received frequent pruning to remove dead limbs and excessive new growth that would produce wind resistance. In the 1950's the State Park began using cabling and bracing to support the old tree. More than 100 load-sharing cables intertwined throughout the crown. The cables had a combined length of more than 3,500 feet (Fig 5.15). As can be seen in Figure 5.16, in a leaf-off setting, the cables had some slack in them. Once the tree came into full leaf, these cables would be taut. Each cable was equipped with an adjustable turnbuckle that was checked every two years.

Figure 5.14. *Cavity treatments do not delay the decay process in the tree, do not make the tree less likely to fail, and can considerably complicate the removal process when it is finally time to take the tree down.*

The addition of this amount of metal cable into the crown of the tree increased the risk of a lightning strike. For this reason, four highly conductive, braided copper leads were grounded on each of four sides of the tree. Every cable in the tree was joined to every other cable by short braided copper jumper cables. Despite being an open grown tree and having a significant amount of metal in its crown the tree was never been damaged by lightning.

Figure 5. 15. *Looking up into the crown of the Wye Oak, some of the over 100 load-sharing cables could be seen. The cables have a combined length of over 3,500 feet.*

In addition to the actions described above, the state of Maryland worked to mitigate the increased liability this large old tree and the addition of hardware in the tree created. A fence was erected around the tree (Fig 5.17). This fence effectively moved the target (the public) away from the tree, eliminating the risk of damage caused by a falling 35-ton (or heavier) limb. While people could not walk under the dripline of the tree, they could still use the area outside the fence for viewing the tree close up. All major limbs had been trimmed back to the fence line.

While the cables might not have held up a limb if it failed, they would in uence the direction the limb fell in, swinging the failing limb inside the fence line. As an added benefit, the fence protected the roots of the tree from being trampled.

Figure 5. 16. *In this leaf-off view, some slack can be seen in the cables due to the reduced weight of the branches.*

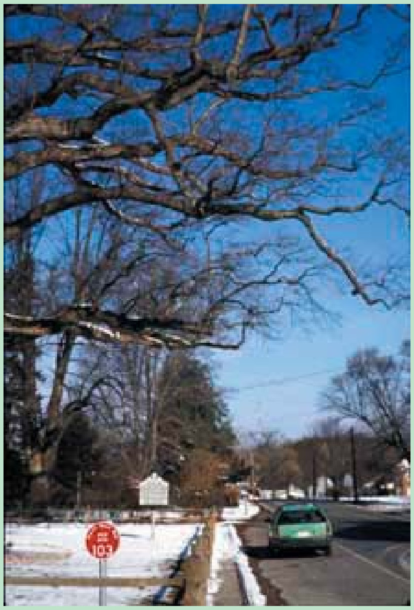

Figure 5.17. *All major limbs of the Wye Oak were trimmed back to the fence line. Should a limb fail, the cables might not hold it up; they would, however, influence the direction of its fall and swing the failing limb inside the fence line.*

What eventually felled this giant tree was fungal decay. For decades, possibly centuries, fungi had been recycling the heartwood of the Wye Oak. For several years, it was known that brown cubical butt rot fungus (Laetiporus sulphureus, previously known as Polyporus sulpureus) was attacking the root crown of the tree. What was not fully appreciated was the extent to which the sapwood had decayed. On June 6, 2002, a thunderstorm felled the giant tree. After the Wye Oak fell, park employees discovered the tree was hollowed to about 10 feet and the cavity was about eight feet across. In addition, there was a shell thickness of only 2 to 4 inches on a radius of more than 15 feet. As described in Chapter 3, the shell thickness guidelines for this tree would have required a 60-inch shell thickness. What is even more amazing than the fact that the tree was standing at all, is the fact that when it died, it was bearing a maturing crop of acorns. Thus, a 2- to 4-inch shell of functional sapwood was sufficient to maintain but not structurally support its crown.

When the thunderstorm of June 6, 2002 felled the tree it imploded upon its butt shell, the main stem falling straight down into the void above the partial concrete filling, and then toppled over into the street. That the tree was standing at all is a testimony to how well it had been cabled and braced. The judicious use of pruning and heavy application of cabling and bracing extended the useable life of this historic and culturally significant urban tree to more than 460 years. However, urban trees are not immortal and even the largest of them eventually succumb to wood decay fungi if not to an accident or to the accumulation of a lifetime of injuries.

Liabilities. Cabling and bracing is a practice that, when properly applied, can extend the life of a tree. In addition, cabling and bracing can reduce the potential for failure to an acceptable level. Once a tree comes under an arborist's care, the arborist is obligated to follow accepted trade practices. During the inspection, the arborist may determine that the removal of part of the tree is a better option than cabling and bracing. Care must be exercised in this case since the removal of large portions of the tree can lead to conditions that could lead to tree failure. If the risk of failure is too high, then removal of the tree may be the best option.

Since cabling and bracing has a long history of use and is an accepted, standard practice, the concern for additional liability should be little different than if the tree were being pruned. However, correction of defects by cabling and bracing requires additional inspection and maintenance that must be performed regularly to ensure the integrity of the procedure. Failure to perform regular inspections, and to correct any problems that may arise, may indicate negligence. Choosing not to install a cabling and bracing system because of a fear of liability is not a good decision. The best procedure is to follow a plan that reduces the risk of failure to an acceptable level.

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