NC Trees & Storms:
Readiness, Response & Recovery

Taking Care of Your Clients before and after the Storm

Thunder/lightning storms, hail, tornadoes, snow/ice storms, and straight-line winds are relatively common occurrences in the southeast United States. Getting your clients prepared well before these storms hit can help prevent and minimize damage to their landscape trees. You can help them assess tree health, provide preventative pruning for young and more mature trees, help them select the right trees for their landscape, and help them mitigate potential hazards. After the storm passes, arboricultural professionals can help manage risk to people and property by removing trees that pose an immediate threat, remove damaged branches that could fail, clean up debris, perform crown restoration, and plan for replacement of any trees lost. The bottom-line is that we know that healthy, well-maintained trees are better able to withstand storm damage and professional tree management after the storm helps protect people and their property.

Readiness

After hurricane Matthew hit in 2016, urban forest managers found that trees with dead branches, those with poor architecture (such as vertically oriented branches and narrow branch unions with bark inclusions), and those planted too deeply, had severe trunk-girdling roots, as well as previously wounded trees were more likely to have severe damage or failed after the storm passed. You can help your client avoid such losses with sound arboricultural practices ahead of the impending storms.

There are many parts to any tree preparation plan. In this section, we provide you with some possible steps to consider when you are helping your clients get their landscape trees ready before the storm hits.

Before you begin doing any type of serious tree evaluations, if you have not already received training to be a Certified Arborist and TRAQ (Tree Risk Assessment Qualification) explore these educational opportunities as they will provide critical insight into the process of risk assessment. The International Society of Arboriculture (ISA) offers both certification training the TRAQ program. TRAQ trains tree care professionals to use a standardized, systematic process for assessing tree risk. Understanding risk is key to protecting your client's safety and their investment in their trees.

Assessment

When you arrive on a site, you should engage in a systemic assessment of the client's trees. Inspect the entire site. Speak with the property owner to determine if there has been any recent construction activities. Are there any drainage issues on the property? Have there been changes to the property that may have affected their trees? You may find it helpful to create zones in their landscape that group trees based on proximity to the home and other structures. These should take priority in your assessment. You should definitely assess older, larger trees differently than younger, smaller trees as the impact of their potential damage and loss will be much greater. Creating a checklist may be beneficial. We offer a few suggestions here.

As you go about your tree assessment, remember that nearly every tree has one or more defects. All trees have a potential to fail, fortunately most do not. Evaluating risk is a science. Educating yourself, attending training events and practicing your art regularly are critical to master the science. Yearly inspections, both on the ground and in the tree canopy are also advised to keep your client's trees ready for the storm. Additionally, after you assess their trees provide them with a comprehensive plan detailing how you will address any issues you find. If you determine a tree needs canopy work, which means climbing is necessary, it is critical to assess for defects that could affect the safety of working aloft. Part of any assessment outlines all of the necessary tree work to prepare for any storm.

Checklist for a Systematic Approach to Tree Evaluation

- Create zones of trees based on their proximity to the home and other structures
- Evaluate medium-sized and larger trees (those over the height of or in close proximity to the structures) for potential defects that could pose a risk
  - *This is not only a visual assessment, but may also involve sounding for suspected decay and sampling for sound wood with a hand drill or a resistance drilling device*
- If necessary, remove any trees for which you cannot mitigate potential risk
- Create a plan to address any defects that can reduce potential risk; this may be through pruning, cabling/bracing, installation of lightning protection, root invigoration and soil decompaction
- If you need to get into a tree to inspect it, be sure it is safe enough to climb

Trees are incredibly resilient. They have the ability to repair defects by "responsive" growth. Responsive growth means that a tree will add wood to areas that are overloaded and less to those that are underloaded. Your assessment should determine how ice, snow, rain and wind will load the canopy. How will the load affect the crown? Will it alter its shape, the density or its symmetry? Trees with a full crown and additional defects are at greater risk of failure.

Root and Soil System

1. Inspect root flare and surrounding soil.

Use a soil probe not only to sample soil, but also to assess compaction. Has there been any disturbance in and around the root system? Is there any damage to the roots? Trees with more than 33% of the roots missing or decayed are at a high risk of failure. Trees with a constricted lower trunk (stem) and/or girdling roots around 40% or more of the root collar are also at high risk.

Trees impose a normal stress on soil simply due to their weight. The shape of the root plate plays an important role in how and if a tree is prone to windthrow. Flooded soils, such as after a storm, do not support tree roots well. These saturated, weakened soils lose aggregation, clay particles are dispersed and "cementing" particles, such as organic matter, are destroyed. Therefore, the less strength from wind or water it will take to blow over a tree.

a. Action – *Implement root invigoration to de-compact soil and improve root vigor. Protect the critical root zone from any construction activities. Maintain plant health through proper mulching, fertilization, and watering. Inspect trees with root issues twice a year, and make the call to remove the tree when necessary before the storm does!*

Remove trunk-girdling roots where possible. You should do this before they get too big in diameter. While it depends on the size of the tree, once trunk-girdling roots get over about 2 inches in diameter (or over about 10% of the size of the trunk) it may be too late.

b. Action – *Inspect root plate, make sure there is no flat area along the root plate where the tree meets the soil. If this is the case, it may be due to a trunk-girdling root below the surface or the tree was improperly planted. You could employ root excavation to look for trunk-girdling roots, which you may be able to remove. Otherwise, you can strive to minimize stress on the tree- properly mulch, protect root plate from any mechanical damage, irrigate and fertilize as needed.*

This tree has significant trunk girdling roots that will not only negatively affect its future health, but can lead to tree failure.

2. Evaluate root and lower trunk decay.

Construction can weaken the root system making it more susceptible to decay-causing organisms. Trees of advanced age often have root decay. What are signs and symptoms of decay? Loose and dead bark, cracks or holes, excessive sap flow, abnormal root growth or damaged root plates, and fungal conks or fruiting structures. After severe rainstorms, saturated soil displaces trees and can dump loads of sediment over the root plate and lower trunk, which can lead to stress or tree failure.

Be sure to perform an extensive root collar inspection. This may mean removing any ivy, ground cover plants, or shrubs that may obscure your view of the root plate. Such plants can hide serious issues such as root rot, fungal conks and damaged/severed roots that could cause tree failure if you do not notice and address these problems.

a. Action – *Use an air excavation tool to expose the root plate to inspect for damage or decay. If you believe decay is present, you may need to drill to*

This root rot fungus is Pseudoinonotus dryadeus, or weeping conk. It is frequently found on mature willow oak and will definitely lead to tree failure.

establish extent of decay versus sound wood. Monitor cracks or holes for expansion. Open cracks can indicate that the tree or branch is already failing, so removal may be required. Before the storm, ensure that the root plate is stable and roots are well situated in the soil without uplifting or gaps. Reduction pruning to lighten the crown load may help, but you will need to monitor the tree regularly for any movement or further loss of root integrity.

Note: Wood rot fungi have often been growing inside of a tree for many years before it matures and produces the fruiting body we see as a conk. Keeping planting trees properly, preventing compaction, and keeping trees healthy can help prevent infection.

There is no evident root plate on this large oak. This may be because the tree was planted too deeply years ago, there is one or more trunk-girdling roots below the soil surface, and/or the mulch is piled too deeply.

Trunk and Large Branches

1. Dead trees and branches.

Stability of dead trees and branches vary based on the species, size, defects and length of time since death. Smaller diameter (< 10 inches in diameter) branches and stems are more prone to failure.

a. Action – *Remove any dead trees and branches!*

2. Inspect trunk for lean.

Trees at a higher risk for failure are those that have a full canopy and a lean over 30° and are located near a structure. A leaning tree with a portion of the root system newly uplifted, or that has soil cracks or movement is also at a higher risk for failure. Leaning trees with cracks need very close inspection. Trees with any of these conditions are more prone to failure during or not long after a storm event.

a. Action – *Monitor leaning trees regularly. Removal is likely the only option if there is also significant cracking, and/or the soil is displaced or saturated for long periods.*

3. Codominant stems, weak branch unions and branch strength.

Larger trees with codominant stems and a bark inclusion or cracking are at a higher risk of failure. This is true even without the high winds and loading from a storm. Look for strength in the branch unions.

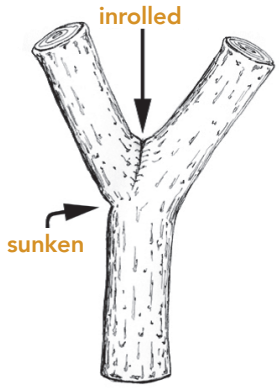
Trees with excurrent form (single, dominant leader and smaller branches oriented approximately horizontal) may have greater resistance to damage in windstorms. Branch or stem unions with an in-rolled bark ridge or a bark inclusion indicate a weak union; whereas, a strong branch union has an upturned branch bark ridge or no bark inclusions.

Vertically oriented branches are more prone to damage than horizontal branches. Research indicates that unions with a small branch to trunk diameter (aspect ratio of less than 1/2) are stronger than unions with an aspect ratio closer to one. Additionally, wide branch angles had less damage during ice and windstorms.

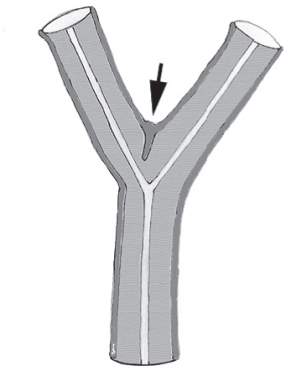
a. Action – *The best course of action is to prevent the formation of codominant stems. This will help prevent weak branch unions. Young tree training is critical to encourage sound future structure. Remove the weaker leader(s) to encourage the growth of the strongest, straightest. Cabling and bracing may be an option for highly valued trees.*

b. Action – *Reduce upright branches back to laterals to develop a more horizontal branching pattern. Be thoughtful about this, as reduction pruning cuts can lead to decay on weak compartmentalizers.*

Weak Branch Unions

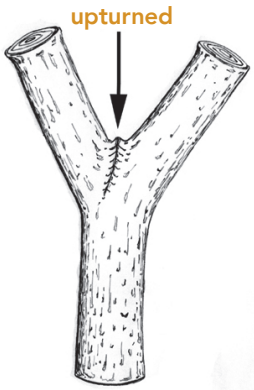


Branch bark ridges are inrolled. Sunken area below branch often found.

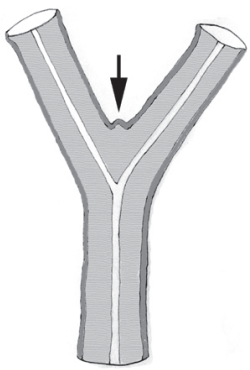


Bark is growing inside the union; termed included bark. There are poor connections between wood in branch and wood in stem.

Strong Branch Unions



Branch bark ridges are upturned.



Bark not growing inside the union. Wood from branch has solid connections with wood from stem.

4. Cavities, cankers and abnormal growth.

A tree with 40 percent or more of the stem cross-section affected by a canker or cavity is at a high risk of failure. In these cases, you will likely need to evaluate the thickness of sound wood in relation to the cavity. We will not address this complex process here, but there are diagnostic tools you can use to perform this task. Additonally, inspect the trunk for any potential issues or defects such as cracks, abnormal growths, decay causing organisms. Know the species of pathogen you are dealing with, as some may not cause decay but can lead to infection by wood-rotting fungi later on. There are many great resources out there to help you identify various fungal organisms, e.g. Wood Decay Fungi by Chris Luley. For example, Phytophthora bleeding canker GET PICTURE kills outer bark and produces a dark-colored sap that oozes from the wound. These cankers consume sugars in the cambium and outer sapwood, and while they do not cause wood decay, they can open the tree up for issues later. You can successfully treat this canker with phosphorous acids.

a. Action – *Prevent any injury to the trunk and large branches when possible. Keep trees healthy by properly pruning when branches are small in diameter, watering and fertilizing. Engage in regular Integrated Pest Management (IPM) activities to identify and treat any disease or insect issues that may be an issue now or may become a problem.*

5. Cracks.

Cracks are often an indication that the tree is already failing. Vertical or radial cracks typically occur from loading stress on a particular plant part and may be susceptible to substantial decay. These cracks may or may not be open. A crack or seam that is closed by wound (callus) tissue may be a minor defect or could be associated with substantial decay. Horizontal cracks indicate buckling of wood tissue and are very unstable, with a high risk of failure.

Along with gloomy scale, this red maple has a horizontal crack. You should remove this tree or the storm is likely to do so for you!

6. Decay.

Look for any signs of decay on roots, trunk and branches. Fruiting bodies or conks are a good indication that there is internal decay. Often the fungal organism has been growing inside the tree for many years, and only once it is mature will you see the fruiting body, or conk.

a. Action – *Maintain tree health and employ IPM tactics to address issues early on in the life of the tree.*

b. Action – S*ound or drill trees, branches or roots to assess extent of decay. In general, do not climb or rig into decayed stems and branches with large cavity*

openings (more than 30 percent circumference of branch) and those with cracks associated with decay. Where there is no cavity opening or evident cracks, a minimum thickness of sound wood around decay should be 20 – 25 percent of total diameter and 10 -1 5 percent for stems. Stems and branches can generally sustain substantial loss of outer wood tissue without a significant loss in structural strength. If substantial heartwood decay is present, sapwood decay and mechanical damage can contribute to branch failure. Branches with 1/3 or more of the wood surface area affected by decay are unstable. There are formulae to calculate the amount of sound wood to decayed wood needed to determine potential risk.

7. Dead wood, broken or hanging branches.

Look for large (over 2 inches in diameter) dead branches. Are there any broken or hanging branches that need removal?

a. Action – *Properly prune out broken, dead or hanging branches when found. Use a removal or reduction cut where possible. Avoid making heading cuts unless you are trying to encourage new growth.*

8.Canopy.

Look at the canopy overall. Is it symmetric? Are some branches unusually long? Was the tree topped at one time? Research done by Dr. Ed Gilman at the University of Florida, found that crown raising, thinning or reduction pruning reduces the movement of the canopy and main stem significantly. As wind hits the end of a branch, it applies pressure along a "stress pathway" until it hits a weakness or defect. For example, if the stress pathway stops at a lateral branch that has an aspect ratio of close to one, the branch will fail at this point. Old pruning wounds with associated decay can also be a point of failure during wind loading. As we know, codominant leaders with bark inclusions are prime points of tree failure. Additionally, trees and branches with taper are less likely to fail because wind load is distributed along entire length, rather than at the point of attachment. This is why lion's tailing is such a bad practice, as it concentrates the load at the branch base.

a. Action – *Performing reduction pruning to shorten the branch will help remove some of the load from ice, snow and wind on the attachment point. Prune trees to form a symmetrical crown where appropriate. Subordinate (see definition) overly long branches to reduce stress on branch union and/or to reduce weight. Remove weak and heavily shaded branches to open canopy, but do not lion's tail or top trees!*

b. Action – *Create a good site (with healthy, uncompacted soil), properly plant and stake trees can encourage development of taper.*

In this graphic, the "tree" on the left has strong taper and therefore the wind distributes stress across its entire length. The "tree" on the right has very little taper and so the stress is placed at the base, and makes it more prone to failure at this point.

9. Other "stuff".

Look for burls, large branch stubs, carpenter ants, abnormal growth, nesting holes, abrupt bends in branches. Any of these may or may not be indicative of defects that could represent a loss of structural integrity and make a tree or portion of a tree at greater risk from storm damage.

Response & Recovery

Once the storm passes, you will need to assess your client's landscapes for damage and potential risk. Keep in mind that they may be overwhelmed with the damage around their homes. Part of your job will be to ease their mind that you can make their landscape safe now and in the future without giving up on trees all together.

Look for these common hazards of storm damaged trees:

- wires hidden by leaves and branches
- trees may become energized when it contact with electrical wires, or other wires such as cable or communication that are in contact with electric lines
- cracked stems, branches and/or branch unions
- broken branches or hangers
- broken branches hanging by support cables
- points of pressure or tension on downed trees or branches
- ice, snow, and wet conditions that may exist when working in storm emergencies

Once you have inspected your client's trees for these issues, make a plan to address your findings. This plan should detail immediate hazard removals and long-term restoration.

Step One: Determine which trees pose an immediate risk.

Did the storm compromise the primary structure of the trunk and main stems? Is over 50 percent of the tree's canopy gone? Has the main trunk been cracked or twisted? Have large limbs broken off, leaving behind big wounds? Are there sound remaining branches left to help form a new canopy? Are there any new cracks present in the branches? Is the tree newly leaning? Have the roots been displaced or visibly broken? By answering these questions, you can determine the next steps.

Step Two: Tree Restoration Process.

Some trees may have experienced serious damage, but do not pose a safety concern. For these, you will need to implement a restoration-pruning program. There are, however key factors to consider that affect a tree's ability to recover. These are tree health prior to the storm, species, age, size, and extent of damage.

Tree health and age prior to storm. Keeping your client's trees healthy before the storm hits is one of the most important steps in being ready. Healthy trees have more energy reserves than unhealthy trees, and this allows them to recover from extensive damage. Unhealthy trees or those with preexisting conditions such as insect/disease problems, decline, nutrient deficiencies, root rot and decay are less likely to cope well in a storm. These trees may lose foliage and limbs, blow-over or quickly decline once the storm passes due to low energy reserves. Selecting the right tree for the landscape is critical to encouraging healthy trees. Along with this, is properly installing them. If your client wants to install their own trees, make sure they know the correct method. Additionally, implementing a root invigoration program, conducting IPM regularly, ensuring you have a comprehensive watering and fertility program are all key in maintaining healthier trees. Young trees typically have lots of stored energy and can begin the recuperation process very quickly. Their recovery may only take a couple of years, whereas older trees may need many more years to begin forming a new canopy, no matter the amount of storm damage.

Tree species. Tree species respond differently to storms. Some are decay resistant and some are wind resistant. Decay resistant trees can experience some damage, but the wounds will resist infection and spread of decay-causing organisms. Wind resistant trees may only suffer from some defoliation and a few broken branches but will likely not blow-over during a storm. This is important when deciding which trees you should focus your efforts on during cleanup, as those resistant to decay will respond better to restorative pruning efforts.

Tree size. Larger trees and branches inflict much more damage when they break off during a storm, but also create larger wounds. You will have to determine if the tree is healthy enough to withstand clean up pruning that creates large wounds. Additionally, you will have to determine if the loss of such large branches compromises the tree's structure so significantly that you must remove it.

Table 1:
Trees species with moderate to high ability to resist decay
(arranged alphabetically by botanical name)

Common name	Botanical name
sugar maple	*Acer saccharum**
musclewood (blue beech)	*Carpinus caroliniana**
catalpa	*Catalpa speciosa*
thornless honeylocust	*Gleditsia triacanthos var. inermis*
black walnut	*Juglans nigra*
crape myrtle	*Lagerstroemia spp.**
pines	*Pinus spp.*
white oak	*Quercus alba*
red oak	*Quercus rubra*
live oak	*Quercus virginiana**
black locust	*Robinia pseudoacacia*
yew	*Taxus spp.*
American elm	*Ulmus americana*
lacebark (Chinese elm)	*Ulmus parvifolia*

** Also has moderate to high wind resistance*

Extent of damage. The more damage (large or many wounds and extensive canopy loss), potentially the more time it will take a tree to recover. Significantly damaged will be more susceptible to stress from abiotic and/or biotic agents. You should consider the life span and long-term health of the plant when determining whether removal or restoration is appropriate. You must also consider the client's financial resources for a possibly lengthy restoration process. It may be best for your client to remove significantly damaged trees and planting new ones in their place. Encourage your client to have you inspect their trees yearly to determine if they are sprouting or declining. Vigorous sprouting means the tree is likely on the road to recovery and you can begin restoring the canopy.

Step Three: Encourage patience as recovery takes time.

A comprehensive restoration-pruning program may take from two to five years or longer for large, severely damaged trees.

As you know, some trees may lose all their leaves during the storm but do not die. Of course, the greater the wind speed, the more leaves a tree will lose. Some trees, such as live oak, lose their leaves early on during the storm, which may be to help reduce wind resistance. If, however, there are no new leaves by spring or early summer, your tree (no matter the species) is likely dead and you should remove it. Take note that while a tree can produce an entire new canopy after foliage is lost, it "steals" stored food reserves (sugars and starches) and it takes time to rebuild those stores. This can weaken the tree over time and cause stress, but there are things you can do to help out your trees. These include proper water and fertility management, yearly inspections to manage new growth and remove dead limbs, and watching out for any insect/disease problems.

For the most part, you should use removal and reduction pruning cuts to repair storm-damaged trees. If the tree is in reasonably good health, and the storm severely damaged a branch you may choose to use a heading cut. Do this only if there is no other option because it leads to substandard wound closure. This type of cut encourages sprout growth that you can then choose from to rebuild the long-term structure, and maybe the better choice than removing a large limb to the collar. When it is part of a restoration process, it is not topping. Select the strongest sprouts, reduce some and remove the weakest. Revisit the tree every couple of years to continue to build a new canopy structure.

Someone shortened this tree using a reduction cut. As you can see, there is some loss of bark, decay occurring at the rather wound, and no interior branch protection zone. This cut may have been the only option after a storm.

This tree lost much of its canopy in a storm and heading cuts were made on some branches. After many years, you can see where the sprouts form these cuts have grown and taken over the main canopy structure (see red circle)

Step Four: Stand up and stake small fallen trees and plant new trees.

Standing up small trees that blew over should be a priority right after the storm to minimize root drying. Arborists experienced in storm-damage mitigation found that trees larger than 4 inches in diameter often blow over again when the next storm comes along. Therefore, it may be most cost effective to replace these trees rather than trying to stand them up again. This is in part because large severed roots (greater than 1 inch in diameter) are less likely to regenerate to produce new roots. Also, these larger roots may be more likely to have decay and can therefore make the tree unstable in the future. While there are many staking methods out there, with trees blown over in the storm, the best way to stake them is illustrated in Figure 1 (Developed by the University of Florida and the Urban Tree Foundation). For larger trees with an expansive root system, you may consider using 2 inch by 4 inch boards rather than the 2 inch by 2 inch boards indicated in the diagram. This staking method is very successful because the stakes are holding down the portion of the tree that needs held down- the root system! This staking allows the tree to move normally above ground, building a strong trunk taper and greater wind resistance in the future.

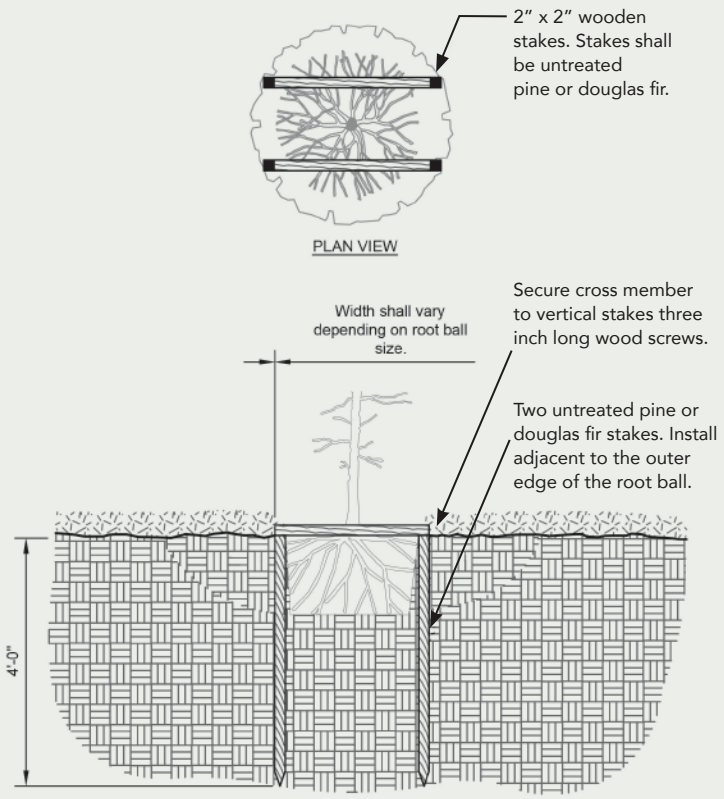


Figure 1. Staking method for newly transplanted or trees blown over in a storm.

If a tree has to come down, plant something new in its place to build a greener future. Trees offer countless environmental, economic, and social benefits. There are many resources available for learning more about properly planting trees and the best species for North Carolina.

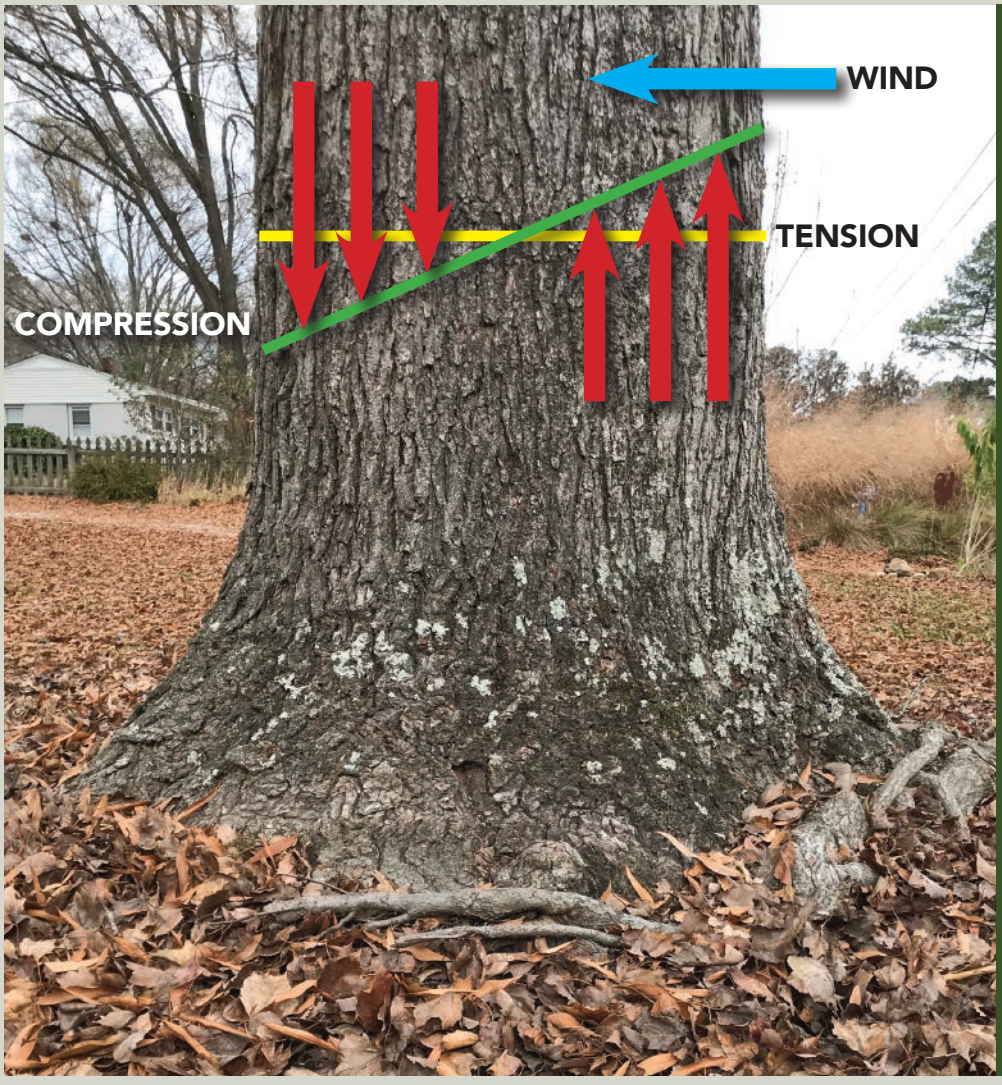
Check out the following websites for more information:
NC State Extension- Proper Tree Planting Techniques
https://plants.ces.ncsu.edu/

For more information on trees and tree care, visit the following websites: www.ncforestservice/gov/Urban/Urban_Forestry.htm
www.ncufc.org

Although this is a newly planted tree, the tie down idea is similar to that in Figure 1. The landscape contractor used 2 inch by 4 inch boards, tied down with nylon strapping attached to metal auger anchors (not visible). This is a great method to use when standing up trees the storm has blown over.

Some Important Notes: **Tree Mechanics**

According to information presented by Claus Mattheck and Helge Breloer (The Body Language of Trees), trees develop wood to "hold themselves together". Wood fibers are oriented to: a) minimize potential for shearing apart; b) lay down wood in a radial direction to minimize splitting; c) wood fibers are stuck together in "lignin chimneys" to prevent longitudinal splitting; and d) lateral wood growth around the ray cells prevent them from separating from wood fibers, which prevents cracks. Trees have the ability to form the strongest wood where it experiences maximum internal stress. As the tree grows, these stresses hold xylem rays and fibers together, especially in locations of higher risk of failure. These growth responses allow trees to better tolerate outside forces.



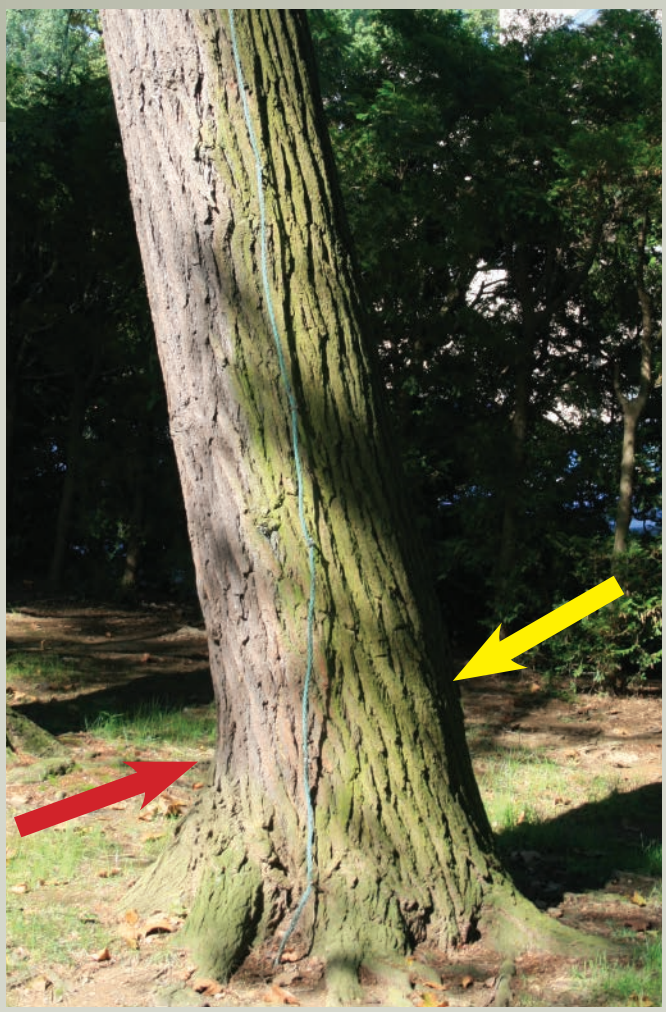
The tree forms reaction wood to accommodate for wind. Compressive stresses are somewhat alleviated by the pre-existing tensile stresses. However, compressive stresses can pose a greater risk than tensile stresses on the windward side because wood fibers may buckle more easily than they tear.

While storms can mean extensive rain, ice or snow, wind is a force trees must handle regularly. Wind is therefore the most dangerous and important load placed on trees. It imposes both bending and shearing stress. Wind forces the tree to form reaction wood as a method of uniformly distributing that stress. This means the tree will increase wood production in areas with heavier loads, and produce less wood in places with a lower load. Reaction wood is formed with or without wind in branches to prevent them from cracking or bending under their own weight. Compression wood is formed on the underside of branches, has a higher lignin content than normal wood, and is stronger when under compressive forces. Trees form tension wood on the upper sides of hardwoods and contains more cellulose than normal wood, which is stronger under tension and resists downward bending. Wood tends to be weaker in compression than in tension.

When you are assessing a tree visually for potential risk factors before or after a storm look not only for biological issues, such as vigor and fungal conks, but also for mechanical issues. For example, look for defects such as bulging, leaning, bark cracks, and potential for wind throw.

Bark can be very useful in locating stress, particularly that of leaning trees. Thick barked trees, like oak, will form puckered or congested bark on the compressed side of the lean, while the bark on the other side may appear loose or stretched. Relaxation of the wood (subsidence) on leaning trees can be due to a loss of vigor or water shortage during a severe drought. If you find any issues of concern, you may need to do a more detailed inspection, such as use of sounding, a resistograph, or a root crown excavation.

Assessing the strength of a tree is a complex issue, requiring a comprehensive process. Under normal conditions, trees can pose a risk but when exposed to ice, snow and wind loading the variables change and require a somewhat different perspective to ensure you are exploring the potential for the unpredictable situations.



This leaning tree has adjusted by forming reaction wood. The bark on the compressed side of the lean is tight and shortened. The bark opposite is longer and appears stretched.

For more information on trees and tree care, visit the following websites:

www.ncforestservice/gov/Urban/Urban_Forestry.htm
www.ncufc.org

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To learn more about what you should do once the storm has moved on, please visit the NC Urban Forest Council, NC Forest Service, and NC Cooperative Extension websites, along with Trees are Good, the National Arbor Day Foundation, and many others for more information and guidance.

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