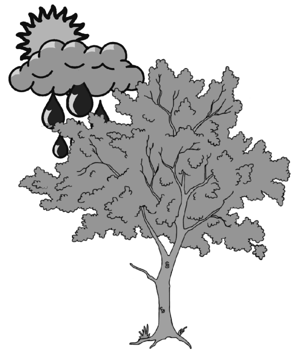
Storm Damaged Trees: Prevention and Treatment



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Thousands of shade and street trees are lost every year to wind, ice and lightning. Estimates of property value loss in Georgia from this type of tree damage can exceed $10 million annually. This value does not include future liability problems. Georgia has 50 to 70 thunderstorm days each year. Each storm can cause extensive damage to trees along its path.

Historic, rare and specimen trees, especially when landscapes are designed around them, are valuable. These trees can become major aesthetic, financial and social losses in storms. This publication summarizes information to help you understand and prevent storm damage to trees. It also lists resistant species of trees to plant, types of tree storm damage and treatments, and lightning protection systems information.

Definitions

Trees are biologically engineered to adjust to *wind loading.* Wind loading is a straight wind from one direction applied evenly over the stem, branches and tree leaves. *Wind release* is the removal of wind loading when the crown and stem snap back into a normal position. In any wind, there are gusts and calms. These alternately load and release the tree. Under normal weather conditions, trees sway in the wind. Movements in the wind initiate changes in the woody material developing the stem.

If a wind continues to come from one general direction all the time, hardwood trees develop extra strength on the side of the tree toward the wind. In conifers, like pine, extra strength is built up on the side of the tree opposite the wind. If the winds are not strong enough to blow the tree over, the tree will develop a trait known as *wind firmness* over several growing seasons.

Wind firmness is directional. Trees growing under a constant strong north wind are easily damaged by a strong east wind. Fortunately, most open-growth trees develop good wind firmness in all directions over the years. Wind firmness develops over time in response to wind.

Storm Damage

There are six main types of storm damage to trees: (1) blow-over, (2) stem failure, (3) crown twist, (4) root failure, (5) branch failure and (6) lightning. Each type is the result of a complex and interactive mix of tree problems and climate.

Blow-Over

With blow-over, the tree is physically pushed over by high winds. Little biological adjustment is available for a tree (or for people) to make to hurricanes, down-drafts or tornado winds. The wind force on the aerial tree portions is too great for the wood structure. Past tree abuse, poor maintenance, pest problems (like fusiform cankers on pine or root rots on hardwoods) predispose the tree to storm damage by weakening the wood architecture.

Stem Failure

Trees do not heal wounds. Trees can only grow over old wounds and seal them off. This results in a tree carrying in its wood every injury it has ever had. These old injury sites – and the old and new wood around them – are structurally weaker than normal solid wood. These damaged areas can quickly fail under a constant wind loading and release. Pest damage, weak wood around old wounds, new wounds and failure of the tree to adjust to wind conditions can lead to stem failure under heavy wind loading and release.

For trees with heavy crowns, abrupt wind gusts and calm periods can lead to stem breakage from release. As the wind load is quickly released, the tree moves back into an upright position. If the mass of the crown moves too quickly when released, the inertia of the moving crown may move too far in the opposite direction leading to stem damage and breakage.

Crown Twist

Tree crowns are the leaves and supporting twigs and branches. Trees are never perfectly symmetrical in every direction. Many trees, through past abuse and poor management, have lopsided crowns. More wind loading on one side of the crown than on another produces a twist (torque) on major branches and the main stem. Over time, the twisting effect can be biologically adjusted from within the new wood. Stem twisting will magnify weaknesses around old injuries and the stem will split or branches collapse.

Root Failure

There are two types of tree roots: fine, absorbing roots and woody, structural roots. As their names imply, absorbing roots have a massive surface area but are weak. Structural roots are woody, have a relatively small surface area, but are strong. Both types provide anchorage for a tree. The primary roots growing from the bottom of the stem (root collar) play dominant roles in holding the tree upright while conducting water, essential elements and nutrients. If roots are constrained, diseased or damaged by construction or – as the top of the tree becomes larger – greater stress is put on the roots. Pulled or snapped roots cause trees to fall or lean.

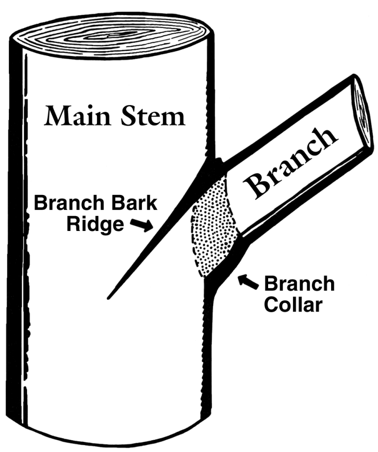


Figure 1. ***Branch collar where stem and branch join.***

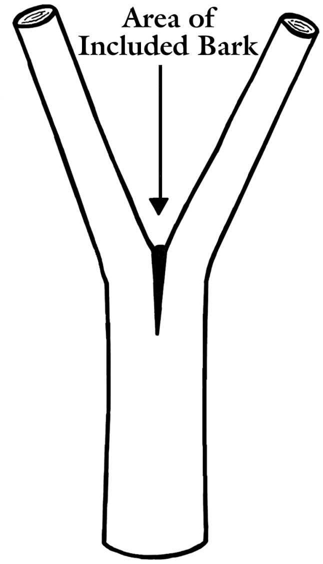


Figure 2. ***Co-dominant branches or forks are bad for tree support. Splitting can easily occur due to a weak crotch area that can contain included bark (bark that has been grown around).***

Branch Failure

Branches are poorly attached to the main stem. A branch is stuck on the side of the stem each year by a small layer of stem wood called the *branch collar*. The branch collar surrounds the branch base. The woody material from the branch enters the stem and turns downward. This structural arrangement allows the branch to be flexible and disposable. The stem can shut off the branch when the branch becomes a biological liability to the tree (Figure 1).

Heavy loading (as during an ice storm) puts great stress on the branch collar area. Over many years, a tree will adjust to this stress, but ice storms or downbursts that occur only rarely will leave the branches unprepared and susceptible to tearing downward along the stem or snapping. The branch collar area can also be weakened by *included bark*. This material is bark from both the expanding stem and branch. Where the branch and stem expand against each other, bark can be surrounded and overgrown inside the branch collar area. Included bark leads to weaker structure and a place for pest attack. This is why forks (called *co-dominant branches*) are structurally weak. These weak areas can easily fail in a storm (Figure 2).

Lightning

Lightning damage is a life-threatening situation. Lightning either moves in a narrow line down the branches, stems and roots or along a wide pathway encompassing the entire tree cylinder. Lightning directly destroys tree tissues by electrical disruption and heat. Steam explosions down the stem in a wide or narrow band show where the electrical current has moved through the tree.

Massive root damage can remain unseen. Damage caused by lightning leads to extensive water loss that is also life-threatening. Pests quickly attack a lightning weakened and damaged tree. For example, the Southern pine beetle quickly destroys a lightning struck pine.

Preventing Storm Damage

There is no way, except for complete enclosure, to protect trees from all storm damage. Trees are not adapted to worst-case storms – only to our average wind climate. Listed are several things to minimize the main types of storm damage:

- Let trees adjust to the wind environment. Tight staking and guying from the time of planting holds a tree in place while preventing internal adjustment to wind loading. Always stake and tie the tree loosely where the stem can move and bend in the wind. Keep ties in place for a few growing seasons to ensure a well-established root system. Continue to loosen and, eventually, release the ties. Leave the support stakes in place to protect the stem from mechanical damage. After five to seven years, remove all tree support. The tree will continue to grow and adjust to its new environment.
- Practice proper pruning techniques by cutting branches before they become larger than 1 inch in diameter. Do **not** damage the branch collar (Figure 1, page 2). The branch collar is part of the stem and, if damaged by poor pruning, provides an avenue of attack into the main stem for pests. Proper pruning minimizes a number of structural problems that occur in association with new wood growth around a pruned branch.
- Eliminate co-dominant branches. Prune forked branches and branches that arise opposite each other on the stem early. Cut one side off now to prevent loving the whole tree later if it splits in a storm. In trees with opposite branching patterns (such as ash or maple), proper branch training is essential for a long-lived, storm resistant tree.
- Keep trees as healthy as possible with timely watering and proper fertilization. Healthy, vigorous trees adjust more quickly to changes in the environment, are more wind firm and react more effectively to damage.
- Do not over-fertilize the tree with nitrogen or over-water the soil. This can increase the crown surface area and/or decrease the rooting area. This type of biological change makes the tree susceptible to storm damage.
- Eliminate lopsided crowns. Prune branches to produce a reasonably symmetrical crown. If more than 70 percent of the crown is on one side of a mature tree, consider tree removal and replacement. Guying and bracing branches are last-ditch efforts when a tree has to be saved in spite of itself.
- Remove or treat pest problems such as branch cankers to minimize potential damage. Do not over-treat tree hollows. Do not remove decayed wood from hollows unless it falls away in your hands. Cleaning hollows can lead to further internal damage. Cover the openings to hollows to allow the tree to grow over the opening; covering also prevent animals from expanding the hollow and keeps water from running in.
- Keep the tree growing upright with one main stem. Prune away branches that compete in height with the main stem. Eliminate branches with tight or narrow crotches.
- Install lightning protection systems on historic, rare, specimen or recreational area trees. Consult a qualified arborist or urban forester to ensure adequate design. Lightning protection systems are covered in detail in the section "Lightning Protection Systems."
- Continue to promote wind firmness by not over-crowding trees and by proper guying and bracing. A tree must always be able to move in the wind. Do not keep a tree tied into position with tight cables. In a stand of trees, slowly remove trees over a number of years to allow wind firmness to develop in the remaining trees.

Table 1 (page 4) lists trees that are most an least resistant to storm damage. Table 2 (page 6) gives a brief list of storm-caused tree damage and suggested treatments for use by communities and homeowners.

Table 1. Tree Species Resistant to Storm Damage from Least Resistant to Most Resistant (after "How to Evaluate and Manage Storm-Damaged Forest Areas." 1982. USDA Forest Service. Forestry Report SA-FR 20.)**

Least Resistant Species	
boxelder	ash
hickory	sycamore
red maple	sugar maple
yellow poplar	magnolia
basswood	beech
dogwood	white oak
silver maple	magnolia
cherry	southern red oak
water oak	sweetgum
red cedar	blackgum
slash pine	baldcypress
loblolly pine	live oak
longleaf pine	**Most Resistant Species**

**Resistance is taken from average growth habits in the tree's native range. Cultural treatments, constrained growth situations, or planting out of native range will change tree resistance to storm damage.

Lightning Protection Systems

Because of the complexity of lightning protection systems, they deserve special mention and review. Protect historic, rare or specimen trees from lightning damage. Also, protect trees that might shelter people or animals during a storm. Trees closer than 25 feet from a building or structure should also be protected and their protection systems interconnected. Parks, golf courses and public buildings should have large, important trees protected to minimize liability problems.

Lightning protection is expensive in labor and materials. **Properly install** lightning protection systems using the **correct materials** to ensure long-term protection. It is **essential** to consult with a trained arborist or urban forester **and** a lightning protection system installer **before** designing a protection system for your tree.

This appendix is only a review of definitions and a summary guide to this complex area of tree protection. **This is not an installation guide!**

You **must** consult the listed standards and literature for precise information.

Lightning protection systems do not attract lightning. A protection system dilutes and slowly releases electrical change potential between ground and cloud. Trees are not good conductors of electricity, but they can act as a better conduit than air. Protection systems dissipate the electrical charge before it can build to high levels.

Down Cables

A main conducting cable should run between the highest accessible part of the tree, along the stem, and into the ground. Run smaller cables along unprotected major branches and splice them securely into the main cable. Secure the top-most ends of each main or branch cable to the tree and to a solid metal conductor (point). This air terminal, or point, should be solid copper or copper-bronze.

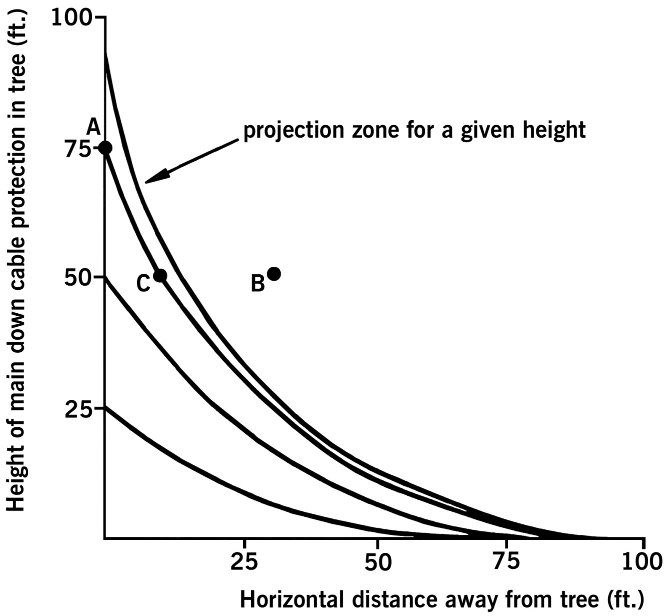
If a tree is forked, both forks need a cable. If a tree is fewer than 3 feet in diameter, use one main down cable. If the tree is 3 feet in diameter or larger, use two or more main down cables along the stem on opposite sides. Interconnect all down cables with each other as well as any metal bracing or support cables.

An alternative to protecting the whole tree is to protect the area from the major branch junction down along the main stem. This can leave the main branches unprotected.

Use woven copper cables (minimum 32-strand, 17-gauge) for the main down cable. Bends in the cable should be minimized and never sharper than 90 degrees (with an 8-inch radius). Smaller woven copper cables (minimum 14-strand, 17-gauge) can be used for protecting major branches. Usually, three to eight branch cables are used, depending on tree size and shape. Be sure major branches are protected. Figure 3 (page 5) shows an example of the protection zone around a protected stem.

Firmly connect cables, metal connectors and other support materials to each other and to the tree. Tree attachment must allow enough slack to support branch swaying in the wind. Extra slack will be needed to allow for moving air terminals farther up the branches as they grow. Attachments to the tree must withstand pressures from radial growth. Inspect lightning protection system components every two years.

Bring the down cable along the stem and out a soil trench 1 to 2 feet deep to a distance at least $1\frac{1}{2}$ to 2 times the crown radius. Place the grounding rods beyond the dropline of the tree to prevent major root damage.



Example: A) 80 feet tall tree with main air terminal at 75 feet.
B) Large branch sticking out horizontally from main stem 30 feet at 50 feet above the ground.
C) Branch is not protected. Branch could only extend 10 feet from stem at this height to be protected by main down cable.

Figure 3. ***Protection area around main stem. Branches spreading beyond the protection zone for a given height will need a branch cable installed.***

Grounding

Lightning protection systems need to be adequately grounded. If the tree lightning protection system is within 25 feet of other lightning protection systems, water pipes, sprinkler systems or well casings, make interconnections. Use screw or bolt clamps to ensure proper electrical connections.

Ground rods should be copper alloy and at least $^{1}/_{2}$-inch in diameter and 10 feet long. Securely fasten ground rods to the down cables. Grounding methods differ in different soils.

- **Clay Soils –** Drive rods 10 feet deep and firmly connect to down cable.
- **Sandy Soils or Limited Soil Space –** Use forked or multiple grounds. Use two or more grounds 10 feet apart driven 10 feet deep or more.
- **Shallow Soils –** Drive two to three ground rods as deep as possible into the soil. Separate each rod by more than 10 feet. Interconnect all grounding rods. For shallow clay soils, long rods can be buried in soil trenches 12 feet long and 2 feet deep. In shallow sandy soils, longer rods can be installed in soil trenches 24 feet long and 2 feet deep.
- **Rocky Soils –** Use rods or metal plates firmly attached to the down cable. Put the rods or metal plates in rock cracks or pockets where moisture accumulates and then cover with soil.

For all grounding, a grounding resistance of less than 50 ohms is acceptable. If you are unsure of grounding effectiveness, install extra grounds and have the resistance of your system measured. The whole system is worthless if not adequately grounded.

A note about materials: Aluminum materials are not suggested for tree lightning protections systems. Effective system life will be significantly shortened. Materials specifications are clearly reviewed in the standard references listed in the bibliography and must be strictly followed.

All tree lightning protection systems should **always** carry a name plate with the installer's name and address. Figure 4 shows a simple view of a tree with a lightning protection system installed.

Take care of your trees properly and you can minimize potential storm damage. For specific information on trees and forest care, contact your county extension agent, arborist or urban forester.

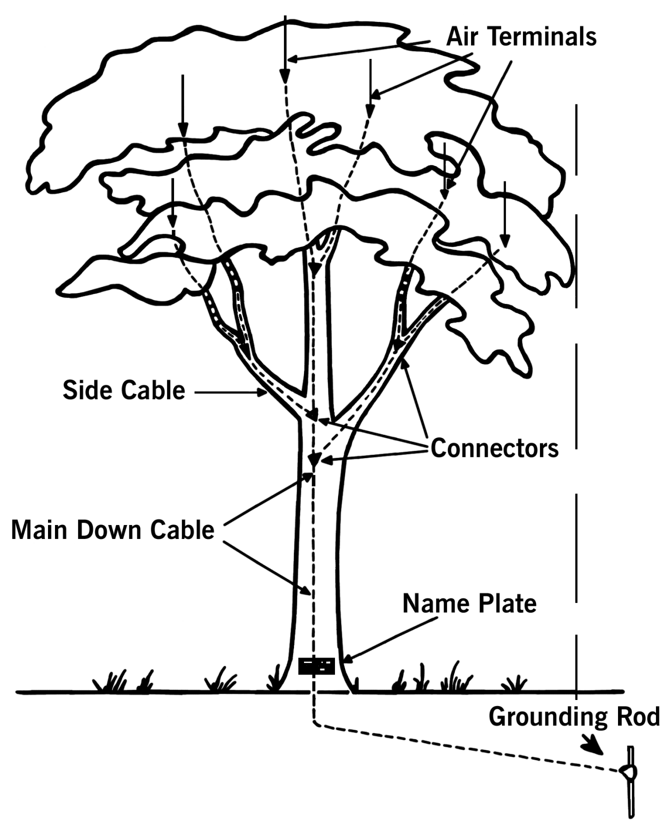


Figure 4. ***Tree with properly installed lightning protection system.***

Table 2. Community Tree Damage Control Based on Future Tree Health Expectations (CAUTION: Damaged tree behavior is, at best, unpredictable and dangerous. Always use proper safety equipment and knowledgeable tree fellers.

Tree Damage

- dead tree
- snapped or twisted stem breaks
- major branch collapse (greater than 50% of live crown affected)
- roots broken – tree pushed over
- roots broken – tree leaning
- leaning or bent pine
- lightning strike – general pines
- lightning strike – hardwoods (greater than 30% of bark circumference affected)
- branch damage leaving severely lopsided crown (70% or more of crown on one side of tree)
- tree left with large stress or twist cracks in main stem
- interfering with utility right-of-way safety and maintenance
- split tree (hazard from remaining stem falling)
- hardwood tree with more than 50% of live branches broken or damaged
- pines with more than 30% of live branches broken or damaged
- top broken (greater than 50% of live crown gone in hardwoods or greater than 30% of live crown gone in pines)
- mechanical damage to mains stem (greater than 30% of bark circumference affected)

Treatment: Remove entire tree to eliminate liability problems, further labor and continued tree problems.

Tree Damage

- lightning strike – hardwoods (less than 30% of bark circumference affected)
- foliage destroyed
- twigs and small branches blown off or broken
- mechanical damage to main stem (less than 30% of bark circumference affected)

Treatment: Minimize stress, water, wait one growing season to fertilize and prune.

Tree Damage

- top broken (less than 50% of live crown gone in hardwoods or less than 30% of live crown gone in pines)
- hardwoods with less than 50% of live branches broken or damaged
- pines with less than 30% of live branches broken or damaged
- stagheading (dead branches)

Treatment: Properly prune dead and dying branches, water, cut back to next major living branch (drop crotch). Wait one growing season to fertilize and prune to shape.

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