There are some things in life you can’t do anything about and the weather is one of them. When storms strike – and inevitably they do – trees suffer and can harm people and property. But much of the trouble can be avoided with some preemptive intervention.

Although we cannot prevent storms, there are ways to reduce the destruction they cause. In this bulletin, we look at some basic principles that can make trees more storm resistant. These guidelines can be applied to trees in the home landscape or to the entire urban forest. Importantly, they can save lives, reduce property damage, and increase services provided by healthy green canopies in our communities. Inaction is a poor option. Making our community trees more storm resistant should be a priority for all tree boards, community foresters, and residents with an interest in the future of our urban forests.

One of the more subtle results from storms is that trees are lost and not replaced. As once observed by Charlotte Glen, a horticulture agent for North Carolina Cooperative Extension, “Property owners who have experienced (storm) damage in the past are tempted not to replace fallen trees due to fear that the same thing will happen again in future storms. As a result, tree populations in our coastal communities are dwindling, and we are losing the significant economic and environmental benefits trees bring to these communities.” This is undoubtedly true even beyond the coast and the trend needs to be reversed. If you are reading this bulletin, you can make the difference by planting trees and providing proper care.

Although storms cannot be prevented, steps can be taken in advance to reduce the chances of damage like this and to keep our community forests safe and productive.
Trees and the Wind

There is nothing to be done when catastrophic tornados come to town. But for lesser wind storms, including hurricanes, some preventative practices can pay huge dividends.

THE BASIC ELEMENTS OF GOOD TREE CARE

At the heart of storm-resistant trees in a community is simply the kind of tree care that should be provided regardless of storm potential. Post-storm inspection of trees by experts verify that many tree failures can be prevented with proper management and some planting design considerations.

HEALTHY ROOTS

Roots with room to grow are an important key to tree stability. Just the opposite is an invitation to disaster — roots that are cut, smothered by change in soil level, or killed by chemicals or compaction. Minimum soil volume requirements and other factors affecting roots have been the topic of numerous Tree City USA Bulletins that are listed on the order form on page 8.

Avoid root cutting, especially within a distance 5 times the diameter of the trunk.

Plant properly. Avoid planting too deep, and straighten or cut circling roots in the planting ball or after removing from a pot.

Proper planting and roots with room to grow and receive proper aeration will result in greater support during storms.

If staking young trees, tie loosely enough to allow sway. This helps stimulate root growth and trunk taper, both important in tree stabilization.

- Use sidewalk design techniques to allow adequate space.
- Utilize structural soil or Silva Cells beneath pavements.
- Consider planting on the lawn side of a sidewalk.
- Soil volume requirements vary by city. For trees with soil depths of at least 3 feet, the University of Florida (Gilman and Partin) recommends:

<table>
<thead>
<tr>
<th>TREE SIZE AT MATURITY</th>
<th>MINIMUM OPEN SOIL AREA AROUND TRUNK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (under 30 ft.)</td>
<td>10 ft. x 10 ft.</td>
</tr>
<tr>
<td>Medium (under 50 ft.)</td>
<td>20 ft. x 20 ft.</td>
</tr>
<tr>
<td>Large (over 50 ft.)</td>
<td>30 ft. x 30 ft.</td>
</tr>
</tbody>
</table>

SYSTEMATIC PRUNING

The Greater Milwaukee area is often cited as a model for urban forestry. Among its examples of systematic tree care is routine pruning of all street trees. Consultants that prepared a management plan for South Milwaukee wrote, “One of the most beneficial and noticeable activities performed in the urban forest is routine pruning. Routine pruning is the cycle of pruning all trees on a rotating basis.” Industry guidelines suggest that the cycle for trees over 6 inches in diameter should be once every 5 – 8 years.

Routine pruning reduces co-dominant stems that break easily and eliminates dead wood that is prone to be broken off and fall or become airborne during wind events. Correct pruning can also reduce wind resistance that is usually responsible for tree failure. In recent years, considerable attention has been given to what is termed ‘tree biomechanics.’ Links to some of this work are found at arborday.org/bulletins.

In one carefully controlled study by Gilman, Masters and Grabosky and published in Arboriculture & Urban Forestry, it was found that the effects of all pruning are not equal. In their study of young live oaks that were wired to measuring devices and subjected to generated wind speeds of up to 110 mph, thinning and reduction pruning resulted in less than half the crown movement than nonpruned trees. Raising the crown and “lion tailing” did not offer the same benefits and other studies have shown that these practices raise the mass of the tree and increase the likelihood of failure.

Pruning palm trees requires special care and most people tend to over-prune them. In fact, pruning species such as coconut palms may do more harm than good in preventing storm damage. For more information, follow the links as noted on page 8.
GROUPING

Trees that are isolated in the landscape are more likely to be lost to the brunt of storm winds than those that are in groups. A ‘group’ has been defined as five or more trees sharing the same soil space. This arrangement offers a degree of mutual protection, root stability and reduction of wind velocity. Replanting after storm destruction offers a good opportunity to evaluate design and consider group planting instead of lines of trees.

Species Diversity

The uniform planting of elms in Midwestern cities more than a century ago resulted in a wakeup call that is still not taken seriously in some communities. When Dutch elm disease struck, entire blocks of beloved shade trees succumbed to the attack. By planting diverse species, the unexpected arrival of a new invasive insect or disease will have much less of an impact. This is also true for storm preparation. Since some trees are more susceptible to storm damage than others, species diversity is one more protection against the enormous loss of trees due to bad weather. Recommendations vary, but the National Arboretum’s time-honored formula for species diversity in a community is that there should be no more than 10 percent of any one species, 20 percent in the same genus, and no more than 30 percent belonging to one family. Arborist John Ball suggests that five percent in any one genus is even better. When uniformity is considered a ‘must,’ scattering such blocks or strips of the same trees throughout the city (spacial diversity) is recommended.
Ice storms are defined by the U.S. National Weather Service as the accumulation of at least ¼ inch of ice on exposed surfaces. Unfortunately these weather events are a common problem over large areas of the country and can cause enormous damage to trees. Links as noted on page 8 will take you to some comprehensive treatments of this subject, but the illustration below summarizes the problem and what makes some trees more ice-resistant. Careful species selection, pruning and root care are the keys to reducing vulnerability to ice storms. Illustrations are based on work at the University of Wisconsin – Stevens Point and the University of New Hampshire.

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Consider Storm-Resistant Trees When Planting

Prevention is the best cure for storm damage. Whether planting new areas of the community or planting for restoration following a storm event, here are some common species recommended by a variety of experts. In some cases, storm resistant cultivars may be available but native species that have developed with local weather conditions are almost invariably recommended as a first choice.

### RECOMMENDED

#### WIND RESISTANT
- American Holly
- Baldcypress
- Black Tupelo
- Buttonwood
- Carolina or Mountain Silverbell
- Chastetree
- Coconut Palm
- Crepe Myrtle
- Dogwood
- Fiddlewood
- Florida Sugar Maple
- Foxtail Palm
- Geiger Tree
- Gumbo Limbo
- Ironwood
- Live Oak (not in wet soils)
- Long Leaf Pine
- Southern Magnolia
- Paradise Tree
- Pigeon Plum
- Pitch Apple
- Pond Cypress
- Redbud
- Red Oak
- River Birch
- Royal Palm
- Sabel Palm
- Sea Grape
- Solitaire Palm
- Sand Live Oak
- Saucer Magnolia
- Screw Pine
- Schumard Oak
- Slash Pine
- Tulip Tree
- Turkey Oak
- Southern Magnolia
- Swamp Chestnut
- Sweetbay Magnolia
- Sycamore
- Weeping Podocarpus
- Winged Elm
- Yaupon Holly

#### ICE STORM RESISTANT
- Amur Maple
- Baldcypress
- Balsam Fir
- Butternut Hickory
- Black Walnut
- Blackgum
- Blue Beech
- Bur Oak
- Catalpa
- Colorado Blue Spruce
- Crabapples
- Eastern Hemlock
- European Larch
- Ginkgo
- Hemlock
- Hophornbeam
- Horsechestunt
- Kentucky Coffeetree
- Littleleaf Linden
- Mountain Ash
- Northern White Cedar
- Norway Maple (Not legal in some areas)
- Norway Spruce
- Ohio buckeye
- Pignut Hickory
- Redcedar
- Shagbark Hickory
- Swamp White Oak
- Sweetgum
- White Oak
- White spruce
- Witch-hazel
- Yellow Buckeye

### NOT RECOMMENDED

#### NOT WIND RESISTANT
- Avocado
- Banyan/Ficus
- Black Olive
- Camphor Tree
- Carolina Laurelcherry
- Carrotwood
- Chinaberry
- Chinese Elm
- Chinese Tallow Tree
- Clerodendron
- Ear Leaf Acacia
- Eucalyptus
- Goldenraintree
- Hong Kong Orchid Tree
- Laurel Oak
- Mahogany
- Norfolk Pine
- Queen Palm
- Royal Poinciana
- Sand Pine
- Schefflera
- Seaside Mahoe
- Sea Hibiscus
- Silk Floss Tree
- Silk Oak
- Sweetgum
- Washingtonia Palm
- Wind Tree

#### NOT ICE STORM RESISTANT
- American Basswood
- American Elm
- Bigtooth Aspen
- Black Ash
- Black Cherry
- Black Locust
- Black Oak
- Bradford Pear
- Butternut
- Eastern Cottonwood
- Hackberry
- Honeylocust
- Jack Pine
- Pin Cherry
- Pitch Pine
- Quaking Aspen
- Red Elm
- River Birch
- Siberian Elm
- Silver Maple
- Virginia Pine
- Willows

**NOTE:** Not listed are species considered ‘intermediate’ in wind resistance. Always check locally for what survives storms best in your community. Also, many or most of these trees can be made more wind resistant through structural pruning.

Ice storms are defined by the U.S. National Weather Service as the accumulation of at least \( \frac{1}{4} \) inch of ice on exposed surfaces. Unfortunately, these weather events are a common problem over large areas of the country and can cause enormous damage to trees. Links as noted on page 8 will take you to some comprehensive treatments of this subject, but the illustration below summarizes the problem and what makes some trees more ice-resistant. Careful species selection, pruning and root care are the keys to reducing vulnerability to ice storms. Illustrations are based on work at the University of Wisconsin – Stevens Point and the University of New Hampshire.
What About Salt?

In coastal areas, preventing wind damage is hard enough but salt spray and salt saturation of soil adds to the problems.

When Hurricane Ike struck the community of Galveston Island in 2011, hundreds of trees were destroyed by the wind. But after the storm, residents found that even most of the surviving trees were dying – up to 90 percent in some neighborhoods. The culprit was salt saturated soil left after the storm surge. In this case, a silver lining of the cloud was the formation of the Galveston Island Tree Conservancy and the replanting of some 25,000 trees in cooperation with the Texas A&M Forest Service. It also resulted in the creation of an urban forestry plan complete with planting standards, recommendations for species diversity and salt resistant trees, and a means for planting with the help of volunteers.

Salt basically robs a tree’s ability to absorb life-sustaining water. Storms bring excessive salt spray as much as a quarter of a mile inland, and increasingly high sea surges can leave behind deadly amounts of salt water. Scientists at Virginia Tech offer these recommendations for countering salt problems:

• Plant on berms where salt water will not accumulate.

• After salt exposure, leach the soil through irrigation with fresh water. Flush salt by applying 2 inches of water over a 2 – 3 hour period or until runoff occurs. Repeat this treatment 3 days later.

• Plant salt resistant species, and plant salt sensitive species uphill or otherwise away from salt spray or soil saturation.

Storm-driven salt can damage trees with spray and inundation of the land by sea surges can result in saturation of soil with salt-laden water.

Source: U.S. Forest Service and shown in descending order of resistance.

<table>
<thead>
<tr>
<th>Species</th>
<th>Salt Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live Oak</td>
<td>Sweetgum</td>
</tr>
<tr>
<td>palms</td>
<td>Water Oak</td>
</tr>
<tr>
<td>Slash Pine</td>
<td>Sycamore</td>
</tr>
<tr>
<td>Longleaf Pine</td>
<td>Sweetbay</td>
</tr>
<tr>
<td>Pondcypress</td>
<td>Southern Red Oak</td>
</tr>
<tr>
<td>Loblolly Pine</td>
<td>Hickory</td>
</tr>
<tr>
<td>Redcedar</td>
<td>Mimosa</td>
</tr>
<tr>
<td>Tupelo</td>
<td>Pecan</td>
</tr>
<tr>
<td>Baldcypress</td>
<td>Magnolia</td>
</tr>
<tr>
<td>Red Maple</td>
<td>Dogwood</td>
</tr>
</tbody>
</table>

Source: U.S. Forest Service and shown in descending order of resistance.
After the Storm

Although storms deprive communities of valuable trees each year, even more are lost because of how they are treated after the storm. With some precaution and good judgment, damaged trees can be saved. When this is not possible, prompt replanting will eventually erase the scars of storm damage.

“Experience has shown that with proper care of damaged trees and planting of new trees to replace those toppled or mortally wounded by a storm, once-devastated neighborhoods can come back,” observes Matt Harris, chief executive of Arbor Day Foundation. For information about the Foundation’s efforts to reforest devastated communities, please visit arborday.org and type ‘storms’ in the search box. Aside from replanting, here are some steps that will help save damaged trees:

• Don’t panic. Instead, take the view of what can I do to save this tree?
• If damage is not significant, prune off broken limbs and let the tree grow for 2 – 3 years; and then correct any structural defects.
• Resist any fly-by-night offers to remove a damaged tree. Check the credentials of any arborists who offer to help and make sure they are ISA certified. Talk to them about saving the tree instead of simply the cost of removal.
• Either yourself or with the help of an arborist, assess the damage and decide. Which of the categories shown to the right is it?

PALMS

Palms with broken trunks fall into the “farewell” category. However, if uprooted, the tree should be stood upright as soon as possible, replanted at the original depth, and braced and watered for at least 6 months. If the tree is otherwise okay but the fronds are broken or browned, leave them on the tree. The photosynthesis from any green portion will help the tree recover. In either case, use fresh water to leach salt from the soil if it has been brought in by the storm.

MINOR DAMAGE

Minor but prompt and proper pruning may be all that is needed. Retain as much of the foliage as possible, since this is how the tree manufactures the food it needs. Young conifers that are bent over can often be staked to eventually restore their original shape.

WAIT AND SEE

If less than 30 – 50% of the branches are broken and the tree is otherwise healthy and free of decay, there is a good chance it will survive. Prune broken branches and correct any other hazards, but then give the tree some time.

FAREWELL TO A FRIEND

If the damaged tree has a split trunk, unnatural lean, more than 50% of its crown missing, or was already in poor condition, then it is probably time to say goodbye. Have the tree removed by competent professionals – and be sure to replant with a storm-resistant species or cultivar and establish a young-tree pruning program to develop good branch architecture.
Storm Preparation Can Lead to Growth Award

Here are examples of activities that can help you prepare for adverse weather events while at the same time earning points toward the ten needed to qualify for a Tree City USA for a Growth Award.

**CATEGORY A: EDUCATION & PUBLIC RELATIONS**
- A campaign to promote planting storm-resistant trees
- Publicity about tree care following a storm
- A workshop or mass media ads about proper pruning (including pruning for strong branch architecture and other storm-resistance techniques)

**CATEGORY B: PARTNERSHIPS**
- Creating a tree planting and/or stewardship group
- Establishing a formal working relationship with a utility or nonprofit tree organization
- Initiating or improving a cost-sharing program to encourage the planting of storm-resistant trees on private property

**CATEGORY C: PLANNING & MANAGEMENT**
- Completing a management plan or emergency plan
- Creating or updating a street tree inventory or conducting an ecosystem service analysis.
- Conducting the pre-storm stage for use in i-Tree Storm (a method of rapidly assessing the extent of damage and cleanup needs after a storm)

**CATEGORY D: TREE PLANTING & MAINTENANCE**
- Assessing tree risk and mitigating or removing hazard trees
- Street tree pruning
- Tree planting for restoration after a storm

FOR MORE INFORMATION...

For more information about the Tree City USA Growth Award, please visit arborday.org and enter Growth Awards in the search box. For quick links to more information about topics mentioned in this bulletin, go to arborday.org/bulletins and navigate to Bulletin No. 75.