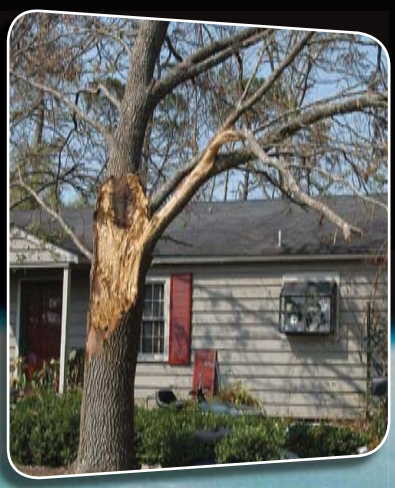
ENH1036

Assessing Damage and Restoring Trees After a Hurricane

Urban Forest Hurricane Recovery Program

UF UNIVERSITY of FLORIDA
IFAS Extension



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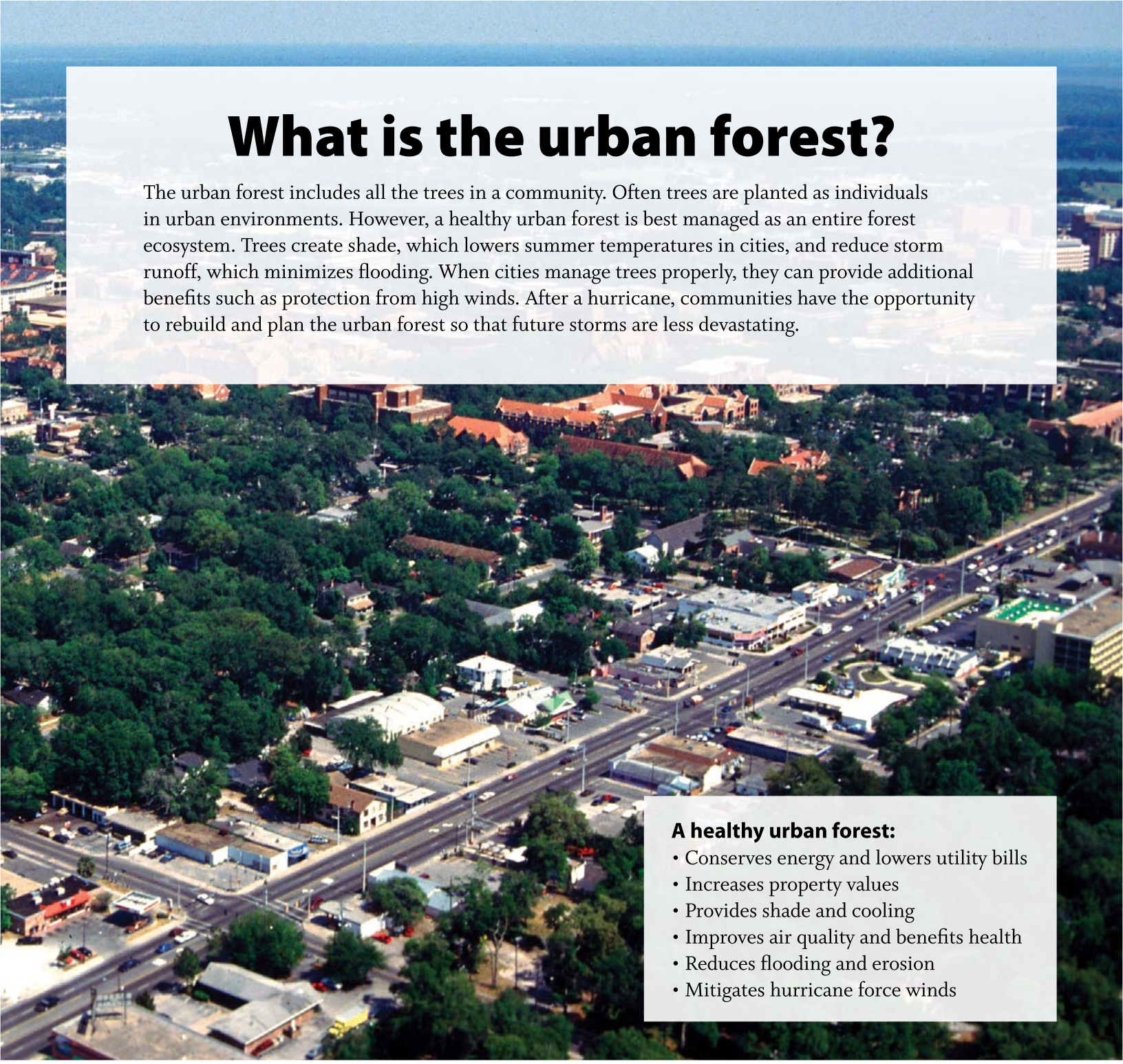
Funded by the Florida Division of Forestry
and the USDA Forest Service, Southern Region

What is the urban forest?

The urban forest includes all the trees in a community. Often trees are planted as individuals in urban environments. However, a healthy urban forest is best managed as an entire forest ecosystem. Trees create shade, which lowers summer temperatures in cities, and reduce storm runoff, which minimizes flooding. When cities manage trees properly, they can provide additional benefits such as protection from high winds. After a hurricane, communities have the opportunity to rebuild and plan the urban forest so that future storms are less devastating.



A healthy urban forest:

- Conserves energy and lowers utility bills
- Increases property values
- Provides shade and cooling
- Improves air quality and benefits health
- Reduces flooding and erosion
- Mitigates hurricane force winds

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Assessing Damage and Restoring Trees After a Hurricane

Urban Forest Hurricane Recovery Program

After the devastation of the 2004 and 2005 hurricane seasons, the USDA Forest Service provided grant funds to help communities recover. Urban forest recovery projects have taken several forms, including new tree plantings, inventory and damage assessment, pruning programs, and replacing invasive plants with more wind resistant species.

A team of scientists at the University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) has been tracking and studying major hurricanes since Hurricane Andrew in 1992 to determine their effects on the urban forest.

The information in this publication was gained from these studies and is part of the Urban Forest Hurricane Recovery Program. The main goal of this program is to foster a healthy urban forest that is more wind resistant. It is aimed at citizens and communities who seek to rebuild and set better management practices so that future storms are less devastating.

Acknowledgments:

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Wind Resistant Species 12

Find out which tree species can survive hurricanes better.

Cleaning Up After a Hurricane

Safety Comes First!

Most injuries and deaths in a natural disaster occur during cleanup. Safety must be the first concern.

General safety tips

- Do not work alone.
- Keep a well stocked first-aid kit nearby and learn how to use it.
- Avoid overexertion – this is the most common cause for injury. Avoid lifting over 50 pounds. Remember to lift with the legs and not the back.

Appoint a flagger or use barricades and warning signs to control traffic or onlookers.

Create a safe work zone

- Survey the site to identify potential hazards and discuss where there is potential for injuries. Agree on communication signals before you start to work.
- Set a perimeter around the work area that is two times the height of the tree. More distance is required when felling trees or dropping limbs.
- Mark the area with tape or cones and keep non-workers safely outside this area.

Chain saw safety

Chain saws are considered the most dangerous hand tool available. The risk of injury increases during hurricane cleanup when chain saws are widely used to remove trees and branches. Use these guidelines to avoid injuries:

Photo courtesy of Kevin Eckert

Cut at waist level or below.

- **Follow manual instructions** carefully to ensure safe operation and proper equipment maintenance.
- **Wear the appropriate personal protective equipment.**
- **Keep both hands on the handles.** Many chain saw injuries affect the hands and are the result of using the saw with just one hand.
- **Cut at waist level or below.** Chain saw injuries to the head often result from making overhead cuts.
- **Take extra care when cutting limbs that are bent, twisted, or caught under another object.** They may snap back and hit you or pinch the saw.
- **Take the time to do the job right.** Most injuries affect the legs and feet and are the result of aggressive or careless cutting. Take breaks when needed, because most injuries occur when workers are fatigued.
- **Shut off equipment** when fueling the saw or carrying it a distance of more than 100 feet, or through slippery areas or heavy brush.
- **Be sure the chain saw operator is aware of your presence before you approach.** Chain saw operators often cannot see or hear the approach of other people.
- **Do not cut with the upper tip of the chain saw to avoid kickback.**

Personal Protective Equipment: reduces the likelihood of injury by covering key areas of the body.

Photo courtesy of Kevin Eckert

Photo courtesy of Kevin Eckert

Do not cut with the upper tip!

Kickback occurs when the upper tip of the guide bar contacts an object and causes the saw to come straight back at the operator. Kickback happens so fast that there is no time for reaction.

How to prevent: Cut with the part of the bar closest to the engine. Watch where the tip is at all times – do not let it contact the ground or other branches.

Storm damage cleanup is extremely dangerous, even for professionals!

More safety information is available at the Florida AgSafe web site www.flagsafe.ufl.edu

Get the Right Tree Care Professional

What Situations Require a Professional?

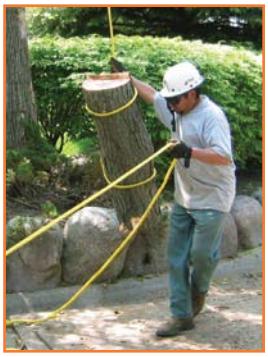
Homeowner: If you use a chain saw, work only on the ground. Get a professional for all other situations. Do not use ladders or ropes.

Professional: Tree care professionals with adequate equipment and insurance can handle these situations.

- Taking trees down in open areas.
- Removing dead or hazardous limbs.

Certified arborist: These situations require advanced training and are best handled by ISA certified arborists.

- Removing a leaning tree or broken limb that is near a house or other potential target.
- Reaching limbs that require climbing.
- Restoring a damaged tree that could be saved.
- Pruning to promote good structure.



Electrical hazards

Trees can uproot underground utilities and tear down power lines during hurricanes. The combination of electrical wires and flooding creates a hazardous environment that requires extreme caution. Only qualified line-clearance arborists should work near electrical utilities.

- Call the power company to report tree limbs that have fallen on a power line.
- Assume all power lines are energized and do not touch. Improper use of generators may energize lines without warning.
- Beware! Electrocution may occur if any part of your body touches a conductor (water, tool, tree branch, metal fence, etc.) in contact with an energized power line.

Hiring an Arborist

Hiring an arborist is a worthwhile investment. Trees increase property value when they are well maintained but can be a liability if poorly pruned or unhealthy.

Beware of scams! Unqualified individuals wanting to make a quick dollar may bring chain saws and equipment to help clean up after the storm. However, qualified arborists from around the country also come to help. Learn to identify the qualified arborists because unqualified workers may get hurt or cause irreparable damage to trees.

To find an ISA certified arborist in your area, contact:

International Society of Arboriculture (ISA)
http://www.isa-arbor.com
(217) 355-9411 or (888) 472-8733
Florida Chapter - ISA
http://www.floridaisa.org
(941) 342-0153

Florida Cooperative Extension Service County Office
Florida Division of Forestry County Office

Use these questions to help you find a qualified arborist:

Insurance:

Are you insured for property damage, personal liability, and worker's compensation?

If you hire an uninsured company, you may be held responsible for medical bills and lost wages for injured workers.

Professionalism:

Are you certified by the International Society of Arboriculture (ISA)?

Being certified requires professional experience and knowledge of the best techniques in the industry. Arborists attend training courses and continuing education classes to learn the latest research.

What are the ANSI Z133.1 and ANSI A300 guidelines?

The American National Standards Institute (ANSI) prints these two guidelines, with which all tree care professionals should be familiar. ANSI Z133.1 represents safety standards for tree care operations in the United States. ANSI A300 represents the best management practices in the industry for pruning and other tree care operations.

Estimates:

What are the procedures involved, equipment used, price, and time frame?

Get more than one written estimate. Keep in mind that specialized equipment, qualified skills, and insurance will cost more. Good tree work is worth the additional investment; poor work may cost more in the long run.

Assessing Damage and...

Right after a wind storm or hurricane, communities and homeowners need to decide what to do with their storm damaged trees. Although damage to trees may seem devastating, some trees can be treated and saved while others need to be removed. Some trees may not require any special treatment and can be left alone. These two possible approaches – removing or restoring – will be discussed in detail to help you make an informed decision about trees in your yard.

When to Remove a Tree

The lower trunk is cracked or broken

- This tree has a large broken branch and the crack extends well into the trunk. The crack will not close and the tree poses a risk.
- The remaining trunk is likely to fail.

Photo courtesy of Norm Easey

The tree is leaning towards a target

- If a leaning tree is likely to fall on a person, building, power line, roadway or other high value target, it should be removed.
- Leaning trees usually have major roots broken, and are unsafe.

A large stem has split from the tree

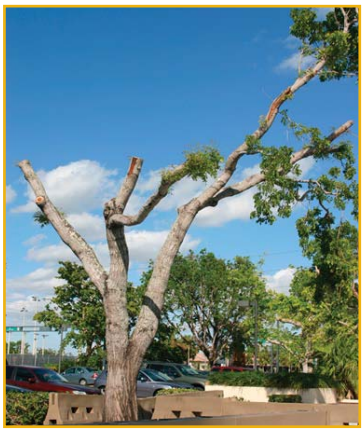
- Notice the dark area at the top of the split – it is a bark inclusion.
- Bark inclusions (see arrow) are weak unions between branches and are very susceptible to breakage.

The remaining tree structure is highly susceptible to breakage

- Restoration is difficult for this large tree because of its poor initial structure (with multiple trunks, codominant stems and bark inclusions).

The major roots are severed or broken

- Medium-aged and mature trees should not be righted because major roots are usually severed, making the tree unstable and unsafe.
- Large trees need large roots for structural support.



Large limbs are broken

- Trees with most of the canopy damaged due to large diameter (greater than 8 inches) branch breakage are more difficult to restore.

Remember!
If you remove a tree, plant another one in its place!
For a list of wind resistant tree species, see page 12.

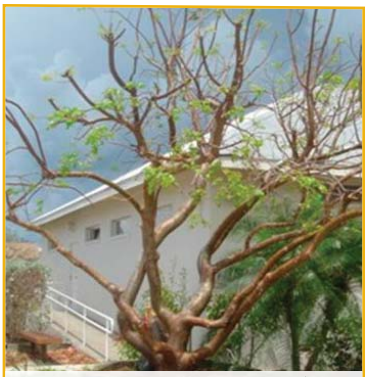
...Deciding What to Do

Even after experiencing high winds, many trees can be restored. However, restore only trees that have major limbs, trunk, and roots intact. To be a good candidate for restoration a tree should not have cracks in major limbs or the trunk, decayed wood, or bark inclusions. Roots should not be exposed or lifted out of the soil. Also, make sure the branch and trunk structure were good prior to the storm. See *Preventive Pruning* (page 10) for more on tree structure.

When to Restore a Tree

The canopy is defoliated

- Trees that lose their leaves in a hurricane usually are not dead.
- Wait. New foliage may be produced by the following spring.
- Trees and palms flooded with salt water often lose leaves. Irrigate to wash salts through the soil.



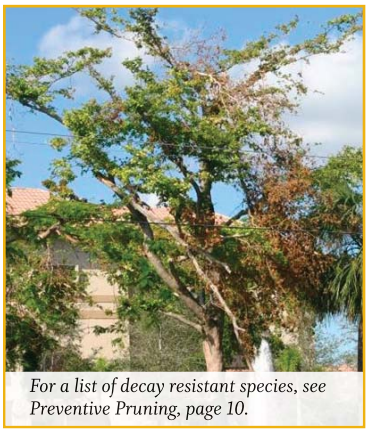
Note: some species may not recover (see Assessing and Restoring Pines, page 9).

Small branches are broken or dead

- Trees with small broken branches (less than 4 inches diameter) can easily be pruned and have a good chance of recovering.

Some major limbs are broken in decay resistant species

- Live oak is one of the many species that are good at resisting decay. Such species can be restored even if there is some major branch breakage.
- Keep in mind that younger trees less than 10 inches in diameter are easier to restore than older trees.



For a list of decay resistant species, see Preventive Pruning, page 10.

Most of the canopy is damaged in decay resistant species

- Trees that resist decay well can lose much of their canopy and still recover after a storm.
- Even with ¾ of their small branches (less than 4 inches diameter) broken or removed by a hurricane, many decay resistant trees can be restored.

Leaning or fallen trees are small

- Only trees that were recently planted or have a trunk diameter smaller than 4 inches should be stood back up or replanted.
- If you are considering standing up large trees, seek professional advice.

How to re-establish a small tree

1. Keep roots moist.
2. Excavate the hole to accommodate roots.
3. Cut jagged or torn roots.
4. Pull tree up as straight as possible.
5. Back fill with site soil.
6. Water as if the tree were recently planted: 3 gallons per inch of trunk diameter, 3 times a week.
7. Stake the tree. Adjust stakes regularly and remove when tree is stable.

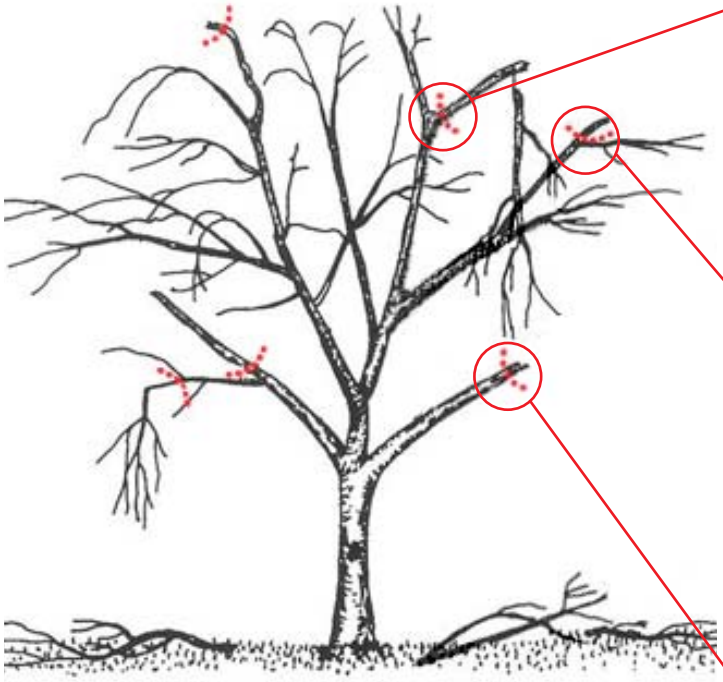
Restoration Pruning: After the Storm

Clean the Canopy

When hiring a certified arborist to restore your trees after a hurricane, know what to expect. A good restoration program begins with cleaning and takes more than one visit to the tree. Immediately after the storm, the canopy should be cleaned by removing hazards such as large dead branches and broken limbs. Cleaning also includes making smooth pruning cuts behind jagged branch tips to allow healthy development of new growth. Very little live wood should be removed because the tree is stressed, and needs to use energy stored in the limbs to recover.

Pruning plan

- Before pruning, make sure the tree is restorable.
- Determine whether the tree is personal or municipal property to avoid unnecessary expenses.
- Look up! Use binoculars to check for broken branches in the upper canopy, and look for cracks along limbs.
- Remove broken, hanging limbs first.
- Make clean cuts behind jagged tips of broken branches.
- Do not remove live wood unless the limb is cracked and may hit a person or property.
- Use a reduction cut as a first choice; if there is not a lateral branch, use a heading cut.



Cleaning the canopy: *The red lines indicate where to make pruning cuts on this tree.*

During restoration, water the tree in dry periods to alleviate stress. In most cases, fertilization is not necessary.

Make good pruning cuts

Pruning a limb is a three-step process.

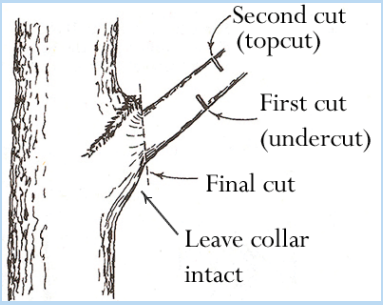
Step 1: Make an undercut about 12 inches from the trunk.

Step 2: Make a topcut farther out on the limb.

Step 3: Remove the stub with the final cut, being careful not to cut flush against the trunk or branch. Leave the collar intact.

What is the collar?

The collar, labeled in the diagram, is the swollen area at the base of the branch where it joins the trunk. The tissue is rich in energy reserves and chemicals that hinder the spread of decay. Good pruning cuts avoid cutting into the collar.



Removal cut

After a hurricane this type of cut is used to remove broken, cracked, and hanging limbs. A removal cut prunes a branch back to the trunk or parent branch. Remove hanging limbs first so that branches do not fall and cause injury. Use caution when removing broken limbs to avoid injuring other branches or the trunk.

Reduction cut

This type of cut is used for making clean cuts behind jagged tips of broken branches. A reduction cut shortens the length of a stem by pruning back to a smaller limb, called a *lateral branch*. The lateral should be at least $^{1}/_{3}$ the diameter of the pruned branch, as shown in the picture. Reduction cuts are a better option than heading cuts.

Heading cut

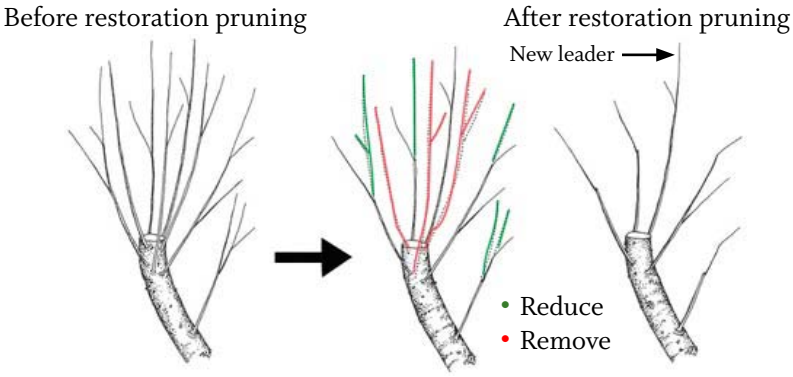
Although not usually recommended for routine pruning, heading cuts are sometimes appropriate on damaged trees if removing the entire limb would remove too much live wood. The food stored in live limbs helps the tree to sprout and produce new leaves. A heading cut is made at a node along the stem, leaving a stub.

Restoration Pruning: A Few Years Later

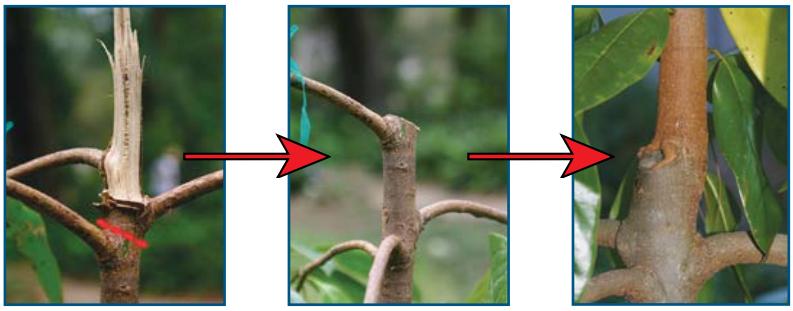
Reduce Some, Remove Some, Leave Some

A management strategy for sprouts on recovering trees

The next step in restoration is managing sprouts to build structure back into the tree. Sprouts should be allowed to grow for a few years before any major pruning is performed. Remember: sprouts are a sign of recovery! Sprouts work to restore the tree's ability to make food, taking the place of the leaves lost in the hurricane. As sprouts get larger and start to compete with each other for light and space, their growth rate will slow. At this point, 1/3 of the sprouts can be removed, 1/3 reduced (or cut shorter), and the rest left to become the new branches. Keep in mind that this process will need to be repeated over a period of years, and the length of time needed for restoration will depend on factors like damage severity and size of the tree.



The goal of sprout management is for the new leader to close over the pruning cut.



Broken stem *Reduced back to lateral* *Sprout closing over cut*

Here is a young tree broken in the storm. The stem on the left received a reduction cut (dotted line). Several sprouts emerged from the cut. Competing sprouts were shortened, then removed. The picture on the right shows the tree one year later, and the remaining sprout is closing over the cut. Branches larger than 4 inches in diameter are less likely to close over.

After Restoration

Build strong structure

Begin structural pruning by either reducing or removing codominant stems. See *Preventive Pruning* (page 10) to learn more.

How long does restoration take?

Listed below are factors to consider that affect the amount of time trees will need for recovery.

- **Age:** young trees recover faster because they are more vigorous.
- **Size:** large trees may require more pruning visits to correct structural problems.
- **Amount of damage:** severely damaged trees need more time for restoration.
- **Species:** decay resistant trees are more likely to have a strong recovery.
- **Health:** trees in poor health before the hurricane are less likely to recover.

Is a heading cut the same as topping?

Topping – the entire canopy has been reduced with heading cuts; very harmful to the tree.

No! Topping is a harmful practice where the entire canopy of a tree is severely reduced with many large heading cuts. Topping (also called hat-racking) can lead to decay and reduce tree vigor. Heading cuts should not be used as a standard practice on healthy trees.

When are heading cuts acceptable?

Heading cut – this small branch of a storm damaged tree can be restored through sprout management.

Storm damaged trees may not have a lateral branch present for making a good reduction cut. In that case, a heading cut may be preferred over removing the limb. Removing an entire limb could reduce energy reserves in the tree, create a large trunk wound, and lead to decay.

Assessing and Restoring Palms

Remove or Restore?

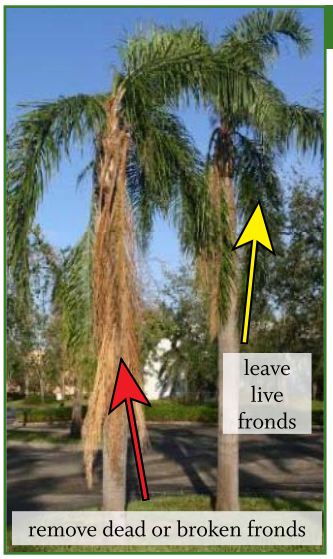
Is my palm dead or alive? Will it recover? These are commonly asked questions after hurricanes. Palms grow differently from other trees. The growing point of a palm is located at the top of each trunk, surrounded by leaves (called fronds). All fronds originate from this one point (called the bud). If the bud is severely damaged or killed, new leaves fail to develop and single-stemmed palms will die. On multi-stemmed palms, the undamaged trunks could recover as long as their buds are not damaged. If the trunk is snapped in half, the palm is dead. However, for palms left standing, the bud is often not visible or accessible, making it difficult to determine whether it is damaged. For these palms, follow these guidelines:

- **Allow at least 6 months or longer for palms to put out new growth.** New leaves may be stunted, discolored or abnormally shaped.
- **It may take 1 to 2 years or more before palms appear normal with a full canopy.**
- **Irrigate 3 times a week for 6 weeks if there is not sufficient rainfall; longer if drought persists.**

Canopy Cleaning

Step 1: Remove hanging or dead fronds that could fall and hit a person or damage property.
Step 2: Remove fronds that cover the bud so that new fronds can emerge.
Step 3: Leave bent fronds attached to the palm until new fronds fully emerge; green fronds help recovery.
Step 4: Leave fronds with any green color, even if they are yellowing or have brown tips. Establish a fertilization program to correct nutrient deficiencies (refer to publication ENH 858, Fertilizer Recommendations for Landscape Plants, http://edis.ifas.ufl.edu/EP114)

Recovery from storms is not a quick process, so have patience with your palms!



Step 1

Dead or broken fronds should be removed because they pose a hazard. Notice the bent, green fronds along the trunk in the background that are still attached. These should be kept until new foliage fully emerges because they help the palm regain energy reserves.

Step 2

Remove fronds that could impede new growth. When broken fronds cross over the top of the palm, they may suppress new growth from the bud.

Step 3

Leave bent fronds such as these for now. They are still green and providing energy to the palm.

Step 4

This palm is showing severe yellowing on the lower fronds because it lacks nutrients such as potassium and magnesium. Yellowing or browning fronds still provide energy for growth, and removing too much of this foliage reduces palm vigor. Begin an appropriate fertilization program to correct nutrient deficiencies.

Prune Palms Correctly

Correctly pruned palms

Often palms are over-pruned to look like the photo on the right. Arborists report that palms with too many fronds removed suffered more damage in hurricanes than palms that were not pruned. Removing too many fronds exposes the delicate bud to more wind and more potential damage. Palms need fronds to protect the bud and provide nutrients for growth.

Over-pruned palms

Over-pruning is harmful for palms

- Takes away food-producing fronds.
- Reduces health.
- Leads to stress and decline.
- Attracts pests.
- Takes a year or more to regrow a full canopy.
- Makes them more susceptible to wind damage.

Assessing and Restoring Pines

Remove or Restore?

Pines are very sensitive to wind damage. They can snap, uproot or lean during storms. A pine still standing after a hurricane may have internal damage that is not visible. Before making a decision, wait and see if the tree lives.

- Pines may die slowly over a period of 6 months to 2 years after wind storms.
- Some may remain green for a year or more, then suddenly turn yellow and quickly progress to brown needles.
- Pines with all brown needles are dead and should be removed.
- Monitor pines carefully for insects. Weakened pines may be more susceptible to beetles and diseases.

Canopy Cleaning

Step 1: Remove hazards, such as dead, broken and hanging branches.

Step 2: Remove branches with no needles or brown needles.

Step 3: Leave branches with yellow needles for now.

Step 4: Wait and see how pines do the following year.

What causes yellowing of the needles and pine death?

The causes are not completely understood, but it is likely due to hidden damage produced by bending and twisting during hurricane force winds. Prolonged winds may also rupture smaller roots without breaking the larger support roots. The injured stems and roots are unable to supply the water and nutrients needed in the crown, resulting in yellow needles and pine decline.

Preventive Pruning

Strong Structure Can Reduce Damage

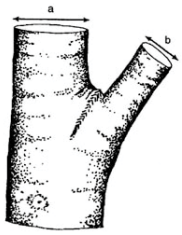
The urban forest is much different from a natural forest. Trees often develop a form that is more susceptible to breakage when growing in urban environments. As a result, trees need preventive pruning to develop strong structure. Research and observation show that well pruned trees can create a more wind resistant urban forest. Listed below are the key components of strong structure.

Codominant stems are weakly attached, and more likely to split from the tree in strong winds.

One dominant trunk

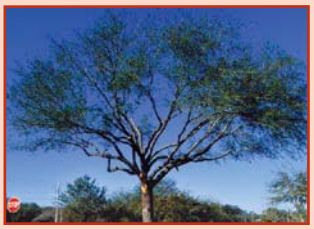
Trees with branches less than ½ the trunk diameter have one dominant trunk. A tree with two or more trunks is said to have codominant stems, or stems of equal size originating from the same point on the tree. This form is weak.

Strong branch unions



Strong attachments form when the union of the trunk and branch is u-shaped.

Weak attachments are indicated by a v-shaped union.



Trees pruned in this manner result in unbalanced canopies that break in storms.

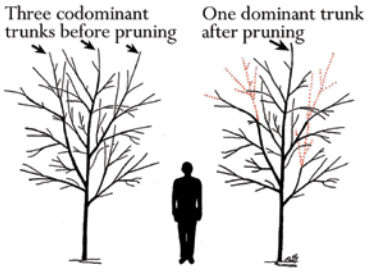
Balanced canopy

The canopy of the tree should be evenly distributed. When only interior branches are removed the tree becomes unbalanced because foliage is concentrated at the tips of branches. This form is more susceptible to breakage and difficult to restore.

How to Build Strong Structure

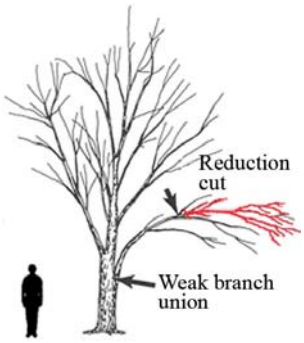
Pruning to create stronger tree structure is an ongoing process known as *structural pruning*. The drawings below show how to achieve each principle of strong structure through making proper reduction and removal cuts. Refer to *Restoration Pruning* (page 6) to learn more about how to make good reduction and removal pruning cuts.

Pruning young trees



Develop one dominant trunk by shortening competing branches with reduction cuts. When performed regularly, this makes trees stronger by allowing the main trunk to grow larger than branches.

Pruning mature trees



To minimize the likelihood of tree damage:

Reduce the length of limbs with a weak attachment to the trunk. Also, *reduce* limbs that are more than ½ the diameter of the main trunk or extended beyond the main canopy.

Before pruning After pruning

Balance the canopy by reducing the length of limbs on the side where weight is concentrated. Do not remove interior branches, as this concentrates foliage at the tips of branches and causes them to break in strong winds.

Decay resistant trees

Trees that resist decay are likely to recover well after a hurricane. Decay-prone trees can become a risk when severely damaged.

Trees that resist decay

Buttonwood, *Conocarpus erectus*
Live oak, *Quercus virginiana*
Mahogany, *Swietenia mahogani*
Tamarind, *Lysiloma latisiliquum*
Winged elm, *Ulmus alata*

Trees prone to decay

African tuliptree, *Spathodea campanulata*
Hong-Kong orchid, *Bauhinia blakeana*
Laurel oak, *Quercus laurifolia*
Redbay, *Persea borbonia*
Red maple, *Acer rubrum*

Design and Manage Communities for Wind Resistance

Design the *Right Place*

Trees growing in groups survive hurricane winds better than trees planted individually.

Researchers who visited post-hurricane sites found that many tree failures could have been prevented with good design. The most important design element that is often overlooked is having enough soil space for tree roots to grow. To provide anchorage for the tree, roots need to spread beyond the edge of the canopy and grow deep into the soil. Both homeowners and community planners should make sure there is space for tree growth when choosing to plant large maturing trees.

Provide space for growth

- Plant trees in soil spaces according to their mature size:
  - large trees: at least 30 feet x 30 feet.
  - medium trees: at least 20 feet x 20 feet.
  - small trees: at least 10 feet x 10 feet.
- Soil should have plenty of open surface space to allow growth of trunk and main flare roots.
- Ideally, soil should be well drained to allow roots to grow at least 3 feet deep to anchor trees.
- Group trees together in large spaces rather than individually in many small spaces.
- Do not plant right next to a house, wall or any other structure.

Select the *Right Tree*

Small maturing trees are nicely suited for this site because of overhead power lines and small soil space.

Choose trees that resist decay and therefore recover well from wind damage. Small maturing trees (30 feet at maximum height) are often a better choice for areas where there is not enough soil space for large maturing trees. Make sure trees are adapted to local site conditions, such as dry versus wet soils. See *Wind Resistant Tree Species* (page 12) for a list of trees to plant. For more information on selecting trees for Florida and southeast U.S. go to http://orb.at.ufl.edu/FloridaTrees.

Consider small maturing trees

- When planting near power lines.
- When planting within 10 feet of curbing, building or any other obstruction.
- When the space is inadequate for root growth or the soil is shallow, compacted or poorly drained. Large trees can blow over due to shallow roots.

Tree Management: Evaluate Trees for Hazard Potential

Hazard: internal trunk decay.

Large trees are more likely to be damaged in a hurricane. When such trees are located near a home, property damage could be reduced by having a professional arborist evaluate the trees to assess risk and treat problems. Here are some things to look for:

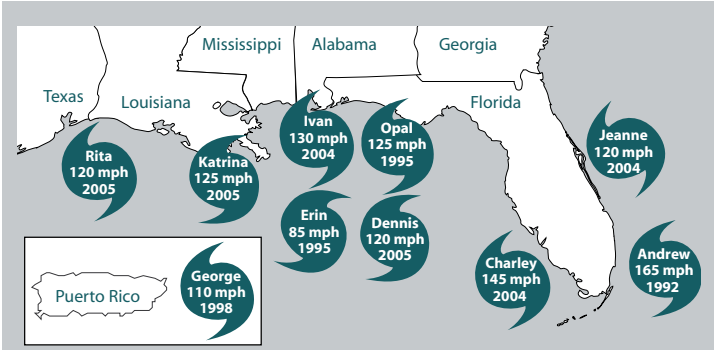
- **Know the species of the tree.** Is it prone to decay? How long is the life span? Trees near the end of their lives are at greater risk of failure.
- **Check the health of the tree.** Look for defects such as root rot and internal trunk decay. A tree can appear perfectly healthy on the outside and have serious flaws that require attention (see photo at left).
- **Is the structure strong or weak?** Become familiar with the components of strong structure to decide (page 10).
- **Evaluate previous cultural practices.** Have the roots been cut during construction? Is the tree located near a paved surface? Has the tree been topped or poorly pruned? These situations can increase likelihood of failure.
- **Is the canopy very dense?** Trees with dense canopies can be made more wind resistant by removing small branches from the outer edge of the canopy. Interior branches should not be removed.

Hazard: major support roots cut.

Do not wait until the last minute to prepare your trees for storm season! Take action now. Hire an ISA certified arborist.

Wind Resistant Tree Species

These wind resistant tree lists were developed from research of ten hurricanes which struck the Southeast U.S. Coastal Plain, South Florida and Puerto Rico between 1992 and 2005. In addition, a survey of arborists, scientists and urban foresters contributed information to rank wind resistance. The recommended tree species are divided into the Southeast U.S. Coastal Plain region (which includes USDA hardiness zones 8 and 9) and Tropical and Subtropical regions (including USDA hardiness zones 10 and 11).



In the University of Florida/IFAS wind resistance study, urban forests were measured after 10 hurricanes. For each hurricane, the maximum sustained wind speed at landfall (mph) and year are listed.

U.S. Southeast Coastal Plain

American hophornbeam, *Ostrya virginiana*
Baldcypress, *Taxodium distichum*
Beech, blue, *Carpinus caroliniana*
Chickasaw plum, *Prunus angustifolia*
Common persimmon, *Diospyros virginiana*
Crape myrtle, *Lagerstroemia indica*
Dogwood, *Cornus florida*
Fringe tree, *Chionanthus virginicus*
Hickory, Florida scrub, *Carya floridana*
Hickory, mockernut, *Carya tomentosa*
Hickory, pignut, *Carya glabra*
Holly, American, *Ilex opaca*
Holly, dahoon, *Ilex cassine*
Holly, yaupon, *Ilex vomitoria*
Inkberry, *Ilex glabra*
Magnolia, saucer, *Magnolia x soulangiana*
Magnolia, southern, *Magnolia grandiflora*
Magnolia, sweetbay, *Magnolia virginiana*
Maple, Florida sugar, *Acer saccharum* subsp. *floridanum*
Maple, Japanese, *Acer palmatum*
Oak, live, *Quercus virginiana*
Oak, myrtle, *Quercus myrtifolia*
Oak, post, *Quercus stellata*
Oak, sand live, *Quercus geminata*
Oak, Shumard, *Quercus shumardii*
Oak, swamp chestnut, *Quercus michauxii*
Oak, turkey, *Quercus laevis*
Podocarpus, *Podocarpus* spp.
Pondcypress, *Taxodium ascendens*
Redbud, *Cercis canadensis*
River birch, *Betula nigra*
Sparkleberry, *Vaccinium arboreum*
Sweetgum, *Liquidambar styraciflua*
Tupelo, black, *Nyssa sylvatica*
Tupelo, water, *Nyssa aquatica*
White ash, *Fraxinus americana*
Winged elm, *Ulmus alata*

Palms

Cabbage, *Sabal palmetto*
Date, Canary Island, *Phoenix canariensis*
Date, *Phoenix dactylifera*
Pindo, *Butia capitata*

Tropical and Subtropical

Baldcypress, *Taxodium distichum*
Buttonwood, *Conocarpus erectus*
Cocoplum, *Chrysobalanus icaco*
Crape myrtle, *Lagerstroemia indica*
False tamarind, *Lysiloma latisiliquuum*
Geiger tree, *Cordia sebestena*
Gumbo limbo, *Bursera simaruba*
Hickory, Florida scrub, *Carya floridana*
Holly, dahoon, *Ilex cassine*
Ironwood, *Krugiodendron ferreum*
Lignumvitae, *Guaiacum sanctum*
Lychee, *Litchi chinensis*
Magnolia, southern, *Magnolia grandiflora*
Magnolia, sweetbay, *Magnolia virginiana*
Mahogany, *Swietenia mahagoni*
Mastic tree, *Sideroxylon foetidissimum*
Oak, live, *Quercus virginiana*
Oak, sand live, *Quercus geminata*
Paradise tree, *Simarouba glauca*
Pigeon plum, *Coccoloba diversifolia*
Podocarpus, *Podocarpus* spp.
Pondapple, *Annona glabra*
Pondcypress, *Taxodium ascendens*
Satinleaf, *Chrysophyllum oliviforme*
Sea grape, *Coccoloba uvifera*
Stopper, boxleaf, *Eugenia foetida*
Stopper, redberry, *Eugenia confusa*
Stopper, white, *Eugenia axillaris*
Sweetgum, *Liquidambar styraciflua*
Tupelo, black, *Nyssa sylvatica*

Palms

Alexander, *Ptychosperma elegans*
Areca, *Dypsis lutescens*
Bottle, *Hyophorbe lagenicaulis*
Blue latan, *Latania loddigesii*
Cabbage, *Sabal palmetto*
Chinese fan, *Livistona chinensis**
Coconut, *Cocos nucifera*
Date, Canary Island, *Phoenix canariensis*
Date, *Phoenix dactylifera*
Date, pygmy, *Phoenix roebelenii*
Fishtail, *Caryota mitis*
Florida silver, *Coccothrinax argentata*
Manila, *Adonidia merrillii*
Pindo, *Butia capitata*
Royal, *Roystonea elata*
Spindle, *Hyophorbe verschaffeltii*
Thatch, key, *Thrinax morrisii*
Thatch, Florida, *Thrinax radiata*
Triangle, *Dypsis decaryi*

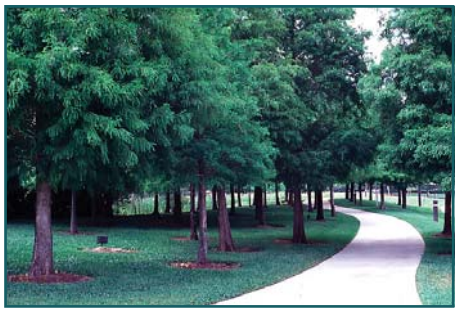
** Caution: manage to prevent escape (as recommended by IFAS http://plants.ifas.ufl.edu/assessment.html)*

We present these lists with the caveat that no tree is perfectly wind-proof and that many other factors contribute to wind resistance including soil conditions, wind intensity, previous cultural practices, tree health and age. These lists do not include all trees that could be wind resistant. They list those species encountered during our studies in large enough numbers to run statistical comparisons.

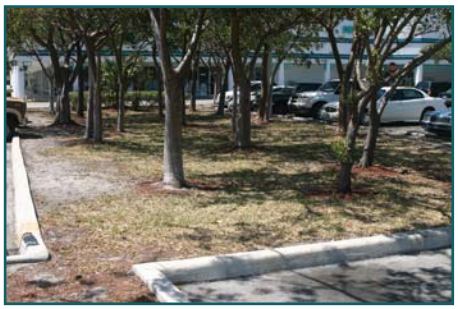
Establishing Trees for a Healthy and Wind Resistant Urban Forest

A healthy and more wind resistant urban forest depends on managing existing trees and establishing new trees properly. When planting new trees, consider these recommendations:

Plant tree species that are more wind resistant, such as cabbage palms.



Match recommended species to the local site conditions.



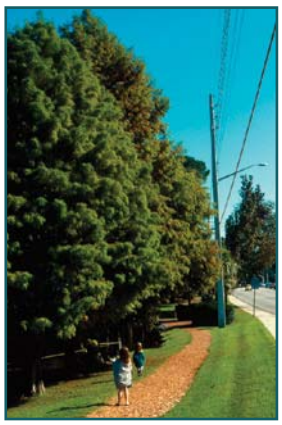
Consider planting trees in groups (at least five trees) as opposed to individually.

Give trees adequate rooting space (with no obstructions).

Plant a variety of species, ages and layers of trees and shrubs to maintain diversity in your community.

Consider soil properties (soil depth, water table and compaction). This porous surface reduces runoff and improves root health.

Plant high quality trees with good structure (Florida #1 or Florida Fancy).



Plant considering the aerial space needed for a mature-sized tree.

Establish a structural pruning program early on. Reduce the length of branches competing with the main trunk.

This publication is also available electronically at http://edis.ifas.ufl.edu/EP291

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