CHAPTER 12

DEVELOPING A PREVENTIVE PRUNING PROGRAM: YOUNG TREES

PUBLICATION Nº
ENH 1062

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Introduction

Trees growing in urban and suburban landscapes offer many benefits to the community. However, when a tree or part of a tree breaks, it can cause extensive damage to people and or property (Figure 1). A preventive pruning program is an important tool to minimize the risks of tree defects. The most common defects are codominant stems and aggressive low branches that either split from the tree or result in large pruning cuts upon removal (Figure 2). Problems such as these result in tree stress, reduce the life span of the tree, and place people and property at risk. Preventive pruning helps to promote good structure, making trees more resistant to storms and other natural forces. A research study in 2006 suggests that pruning trees significantly reduces trunk movement and damage when exposed to 120-mph winds.

Trees with good structure are characterized by a single dominant leader, strong branch unions without bark inclusions and a balanced canopy (Figure 3). Preventive or structural pruning is a process that can help to promote these attributes in trees.

Figure 1

A large limb fell on this car and broke the windshield during a storm. Pruning may have prevented this damage.

Figure 2

The codominant stem (top) split from the tree because of a weak branch connection and included bark. Proper structural pruning could have prevented this defect from failing. The large lower limbs (bottom) of these mahogany trees are too close to the ground and will have to be removed soon to provide for clearance under the canopy. Removing large branches like this can initiate decay and slows growth. Prune earlier to prevent this poor form from developing.

Figure 3

A good structure (top) is characterized by a single dominant leader, and branches that are spaced and not touching throughout the canopy. A bad structure (bottom) has many dominant stems and branches clustered together.

Determine Your Objectives

The major objective of preventive structural pruning is to direct the growth of the tree so that it forms a sustainable structure. This is accomplished by pruning stems and branches that are not growing in the correct direction or position.

Structural issues that cause trees to fail
Codominant stems
Included bark
Unbalanced canopy
Lions-tailing or over-lifting
Large lower limbs

Correction of Structural Issues

Codominant Stems and Included Bark

Codominant stems are stems of equal size originating from the same point on the tree. Included bark is bark pinched between two stems creating a weak union. Codominant stems with a 'V' shaped union are often accompanied by included bark (Figure 4). This union is weak because the bark inclusion prevents any physical connection between the two stems. Instead of overlapping wood creating a strong connection, the two stems push each other apart as they grow and a crack develops. Researchers at the University of Florida have visited several hurricane sites, and found time and time again that trees failed due to structural issues like codominant stems and bark inclusions.

Strong branch unions are 'U' shaped and have a prominent collar (Figure 5). The collar is a swelling formed by overlapping trunk and branch wood. This forms a strong union resistant to breakage.

Unbalanced Canopy

An unbalanced canopy occurs when one side of the tree canopy is much heavier than the other, or when most of the canopy weight is at the tips of branches. The later is a product of lions-tailing or over-lifting, a poor pruning practice that removes all of the live foliage along the lower and interior parts of the main branches (Figure 6). Lions-tailing is generally accepted by professionals as a poor pruning practice that makes trees more susceptible to wind damage. Lions-tailing encourages more growth at the tips of the branches, resulting in a taller and wider tree. This results in foliage exactly where it is unwanted; that is, higher off the ground. Lions-tailing is often performed as a type of thinning; however, this type of pruning routinely encourages sprouting along the main branches and the canopy quickly fills back in with foliage. These sprouts often have weak connections to the stems and break easily in storms. In addition, lions-tailed trees that are damaged in storms are difficult to restore because the branches arborists would normally cut back to have already been removed.

Large Lower Limbs

Removal of lower limbs is important in order to provide clearance for pedestrian and vehicular traffic. Too often lower limbs are removed only when they have become large and have started to droop, many years after planting. Removal of large branches can initiate decay in the trunk, especially in species prone to decay (Figure 7). Large limbs left to grow may also develop structural defects such as excessive end weight. This defect can increase the likelihood of branch failure. It is important to keep in mind that low branches on young trees are temporary and will have to be removed in the future. Manage lower branches to prevent structural defects from forming.

Figure 4

Codominant stems with included bark have weak connections and often split apart in storms (inset).

Figure 5

Strong branch connections have a 'U' shaped union (top) and a prominent branch collar. Some species also show a very distinct branch bark ridge (bottom).

Figure 6

Lions-tailed trees have an unbalanced canopy since all of the foliage is at the tips of the branches. These trees are more susceptible to storm damage and difficult to restore once they are damaged.

Pruning to Promote Strong Structure

Developing a preventive pruning program requires that managers be familiar with the techniques of structural pruning. Structural pruning should be practiced for the first 15 to 25 years of a tree's life. This is the amount of time required to establish strong structure in the canopy and will help to make the tree more resistant to storm damage (Figure 8). In structural pruning, reduction and removal cuts are used to slow the growth of large or rapidly growing branches that compete with the leader. This encourages the one stem you chose as the leader to grow faster.

Components of Structural Pruning	
1	Develop or maintain a dominant leader
2	Identify the lowest branches in the permanent canopy
3	Prevent branches below the permanent canopy from growing too large
4	Keep all branches less than one half the trunk diameter
5	Space main branches along one dominant trunk
6	Suppress growth on branches with included bark

Component 1

Developing or Maintaining a Dominant Leader

Developing a dominant leader starts by identifying the stem that will make the best leader; typically it is the largest stem. This might be easy for some trees and more difficult in others. If all stems are about the same diameter, pick the one that is closest to the center of the canopy as the leader. Then determine which stems are competing with that leader, and decide where to shorten these competing stems (Figures 8 and 9).

Figure 7

Large pruning cuts can initiate pockets of decay in the trunk.

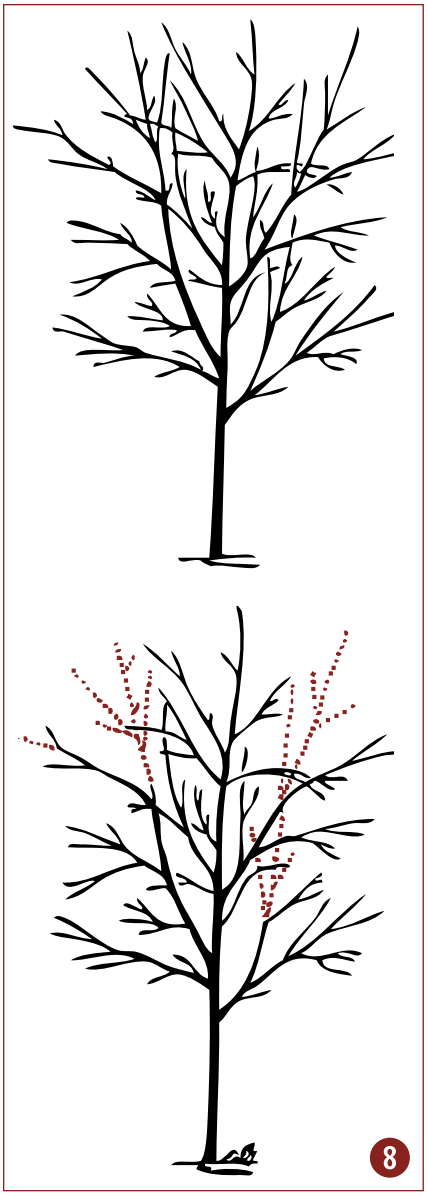


Figure 8

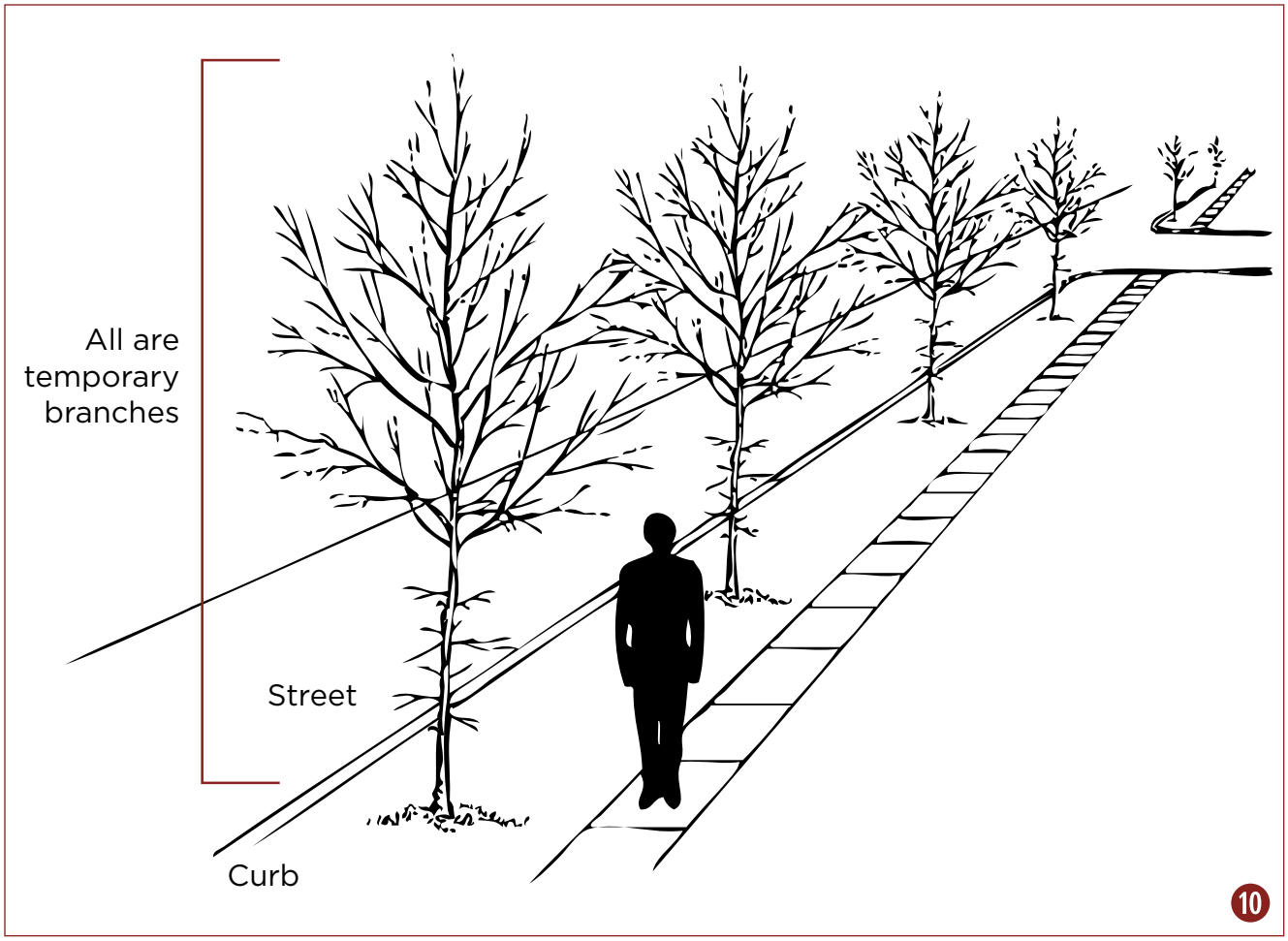
Pruning the stems represented by the dotted lines shortens two of the three codominant stems. This helps establish a single dominant leader in this young shade tree.

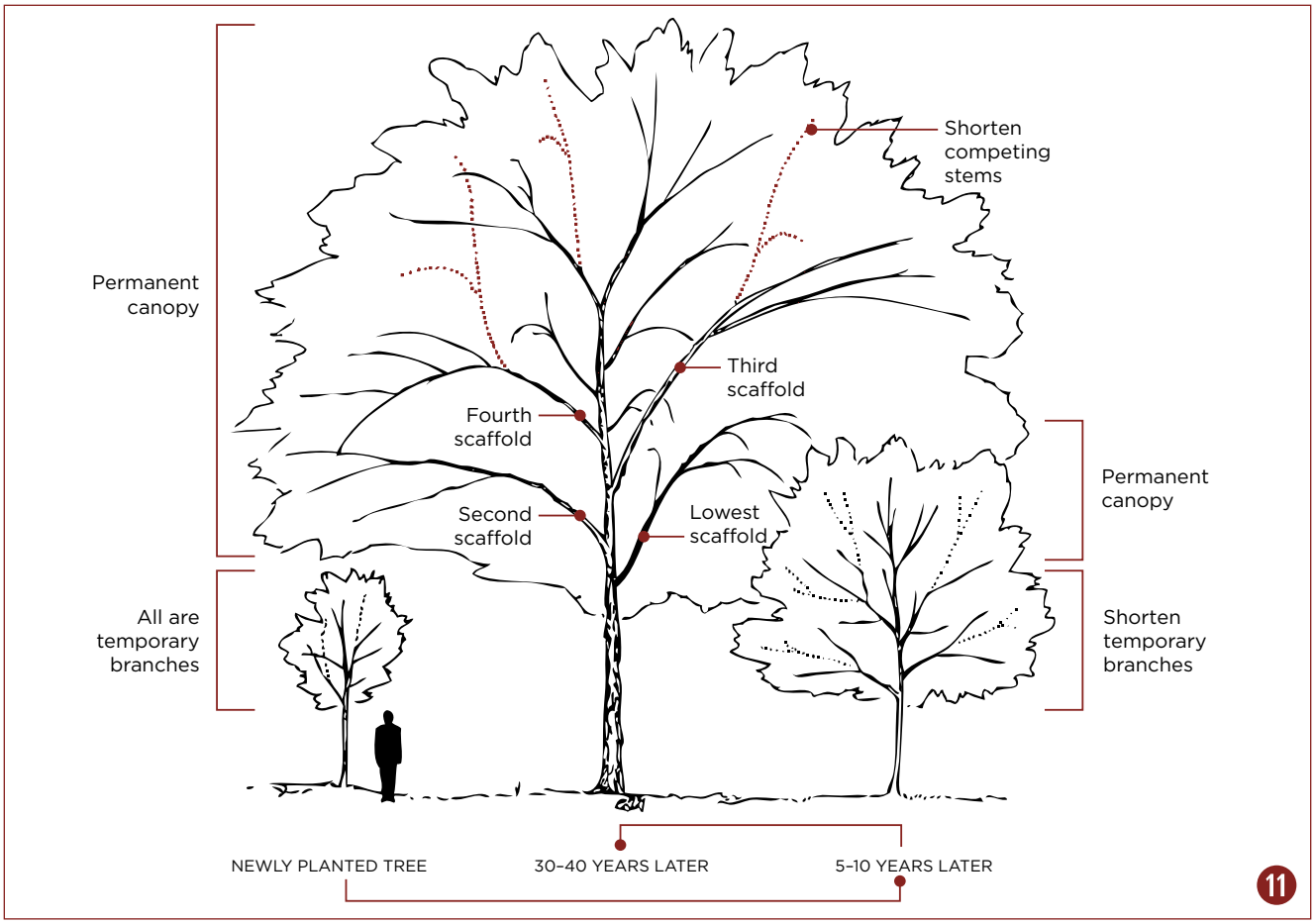
Figure 9

Before and after structurally pruning a young live oak. Notice the arrow indicating where the stem on left side of the leader has been reduced.

Figure 10

All existing branches on these recently planted trees along a street will eventually have to be removed in order to provide clearance for buses, garbage trucks, and tractor trailers.





Component 2

Identifying the Lowest Branches in the Permanent Canopy

First, recognize that branches do not change their position on the trunk as the tree grows. In fact, it may be surprising for some to realize that all branches on trees with less than about 4" caliper will eventually be removed. Identifying the lowest branches in the permanent canopy will facilitate management of lower temporary branches (Figures 10 and 11).

Component 3

Prevent Branches below the Permanent Canopy from Growing Too Large

The lowest permanent branch on many shade trees should be at least 15 to 20 feet off the ground; all lower branches are eventually removed under ideal management. Lower branches should be subordinated (reduced) early to prevent them from becoming too large. This prevents the tree manager from having to make large pruning wounds on the trunk. We do this with reduction cuts to slow growth on these aggressive low branches. This helps to push new growth higher up in the canopy, and will minimize the amount of large cuts that need to be made on the trunk.

Figure 11

Structural pruning cycle over a period of 40 years. Notice how all of the branches on a newly planted tree and half of the branches on a 5- to 10-year-old tree are temporary. These branches are managed with reduction cuts to slow their growth and encourage more growth in the upper canopy, which is the part of the tree that will be around for a long time. In the maturing permanent canopy (center), the large scaffold branches have been identified and spaced evenly along the trunk by shortening or removing nearby branches.

Component 4

Keep All Branches Less than Half the Trunk Diameter

Branches more than one-half the diameter of the trunk lack a branch protection zone. This zone inside the branch union is rich in chemicals that inhibit spread of organisms and decay from the pruning wound into the trunk. Keeping branches less than half the trunk diameter ensures that the branch collar and branch protection zone remain intact.

Component 5

Space Main Branches along One Dominant Trunk

Ideally, main branches (also called scaffold limbs) should be spaced along the dominant leader in two or more rotations around the trunk so that no branch is directly above another (Figure 12). Spacing scaffold limbs allows for the trunk and leader to develop properly, gives the canopy a more balanced form, and reduces wind resistance.

Component 6

Suppress Growth on Branches with Included Bark

Suppress growth on branches with included bark (Figure 13) to minimize the chance of breakage. As mentioned earlier, included bark is a structural defect that causes the union between branch and trunk to be very weak. Reduce branches with included bark to slow their growth until you are ready to remove them.

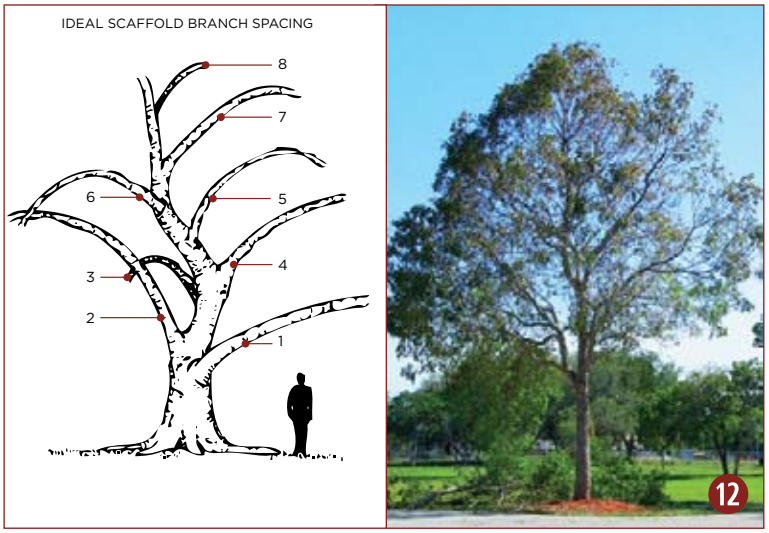


Figure 12

Major scaffold branches on this mahogany tree (right) have been spaced evenly throughout the canopy so that no branch is directly above another, making the tree more structurally sound (left).

Figure 13

Variations of included bark on four different trees.

Determining Pruning Cycle and Pruning Dose

Pruning Cycle

The next step in developing a preventive pruning program is to determine the pruning cycle and pruning dose. A pruning cycle is the interval of time between each pruning event. The interval is affected by many factors. For instance, trees coming from a nursery with sound pruning practices will have a better structure to start out with than trees coming from a nursery with poor pruning practices. These low quality trees may require more pruning at a higher interval than the high quality trees.

Pruning cycles are also affected by growth rate, climate and species. In warm climates where trees grow faster, the intervals between pruning events should be shorter. Species that are prone to decay should also be pruned more often so that the need to make large cuts can be avoided. A typical pruning cycle for an active, preventive urban forestry pruning program in Florida is about three years. If the pruning cycle is too long, defects may become more severe. This results in having to make large pruning cuts, which can initiate pockets of decay in the trunk and branches. A pruning cycle of 3-5 years will require a higher pruning dose to achieve pruning objectives. Conversely, a pruning cycle of 1-2 years will require a smaller dose.

Suggested minimum pruning cycle
At planting
Year 2 or 3
Year 5 or 6
Year 8 to 10
Year 13 to 15

Pruning Dose

The pruning dose is the amount of live tissue removed from the entire tree at one pruning. More than this can be removed from any particular stem or branch. Typically, arborists estimate this by evaluating how much foliage was removed by the pruning. Customer expectations, size of stems and pruning cycle can influence the pruning dose (Table 1).

With a large pruning dose, you create large pruning wounds and a large void in the canopy, greatly encouraging growth in unpruned portions of the tree. Conversely, a small pruning dose creates smaller pruning wounds and a smaller void in the canopy, encouraging modest growth in the unpruned portions of the tree. Large pruning doses are typically employed only on young trees. Municipalities often use larger pruning doses where aesthetics is less of a concern. A smaller pruning dose along with a shorter pruning cycle is nicely suited for residential and commercial properties where aesthetics are more of a concern. Pruning dose on mature trees should be less than 10% unless there is a good reason (e.g. a major defect) to remove more.

Table 1. Uses of high and low pruning doses

LOW PRUNING DOSE (5–20% of foliage removed)	HIGH PRUNING DOSE (>20% of foliage removed)
Mature or recently planted	Young, established trees
Cooler climates with short growing seasons	Warm climates with long growing seasons
Decay-prone species (poor compartmentalizers)	Decay-resistant species (good compartmentalizers)

Good compartmentalizers of decay (i.e. trees that resist decay following pruning) are those trees such as live oaks and mahogany that resist decay following an injury such as a wound or a pruning cut. When planning a pruning dose for your tree, you might want to set the maximum diameter of pruning cut smaller for a more decay-prone species (Table 2). The limit should be set for both reduction and removal cuts (Figures 14 and 15). Ideally, limit pruning cuts to 2-3 inches on decay-prone trees and 4-6 inches on decay-resistant trees. Large trees that are capable of forming heartwood will begin forming it as branch size increases to 8 inches or more. Exposing heartwood can initiate decay in certain species of trees. Professional arborists keep records of when species begin forming heartwood. This should help them decide when low interfering branches should be removed from trees.

Table 2. Guidelines for determining maximum branch diameter to prune.

BRANCH SIZE	CONSEQUENCE OF REMOVAL	RECOMMENDED ACTION
Less than 1/3 trunk diameter	Not many	Remove if needed
1/3 to 1/2 trunk diameter	Minimal	Shorten instead of removing
More than 1/2 trunk diameter	Some decay	Shorten instead of removing
Large enough to have heartwood	Defects more likely	Shorten instead of removing

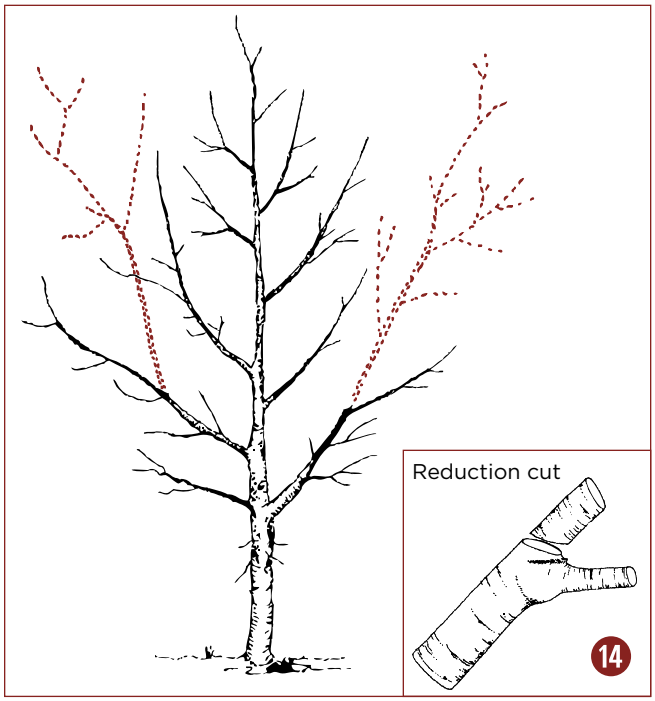
Executing the Pruning Plan

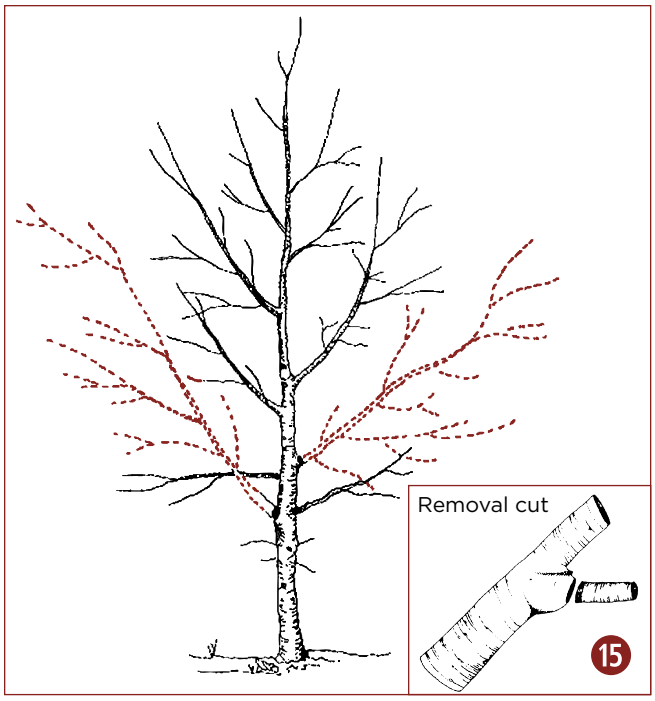
Making Proper Pruning Cuts

An important component of a good preventive pruning program is making proper pruning cuts. There are two types of pruning cuts; these are reduction cuts (Figure 14), and removal cuts (Figure 15).

A good pruning cut begins with an undercut about 12 inches from the trunk (Figure 16). A top cut is then made further out from the limb or directly above the undercut. The majority of the limb is safely removed in this step without causing any damage to the tree. (Disregarding these first two steps could cause damage to the trunk because the branch is often too heavy to hold itself up causing tissue to tear down through the collar.) The last step is to remove the remaining stub with a final cut, being careful not to cut flush against the trunk. It is very important to leave the collar intact (Figure 17). A branch collar is a 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 and typically leave a round-shaped wound, whereas flush cuts are oval-shaped (Figure 18). The branch bark ridge is where trunk bark pushes up into the union as it grows against branch bark (Figure 19). This indicates a strong union. Never cut off the branch bark ridge since this removes the branch protection zone inside the collar. The protection zone helps prevent decay organisms from entering the trunk.

Bad cuts are called flush cuts and are unacceptable in a preventive pruning program (Figure 20). Flush cuts remove the top of the branch bark ridge, and prevent the wound from sealing over properly. Flush cuts typically expose more bark on top of the cut than on the sides and bottom. These cuts typically close first on the sides then on the top and bottom. Severe decay can occur behind flush cuts, especially when they are large in diameter.





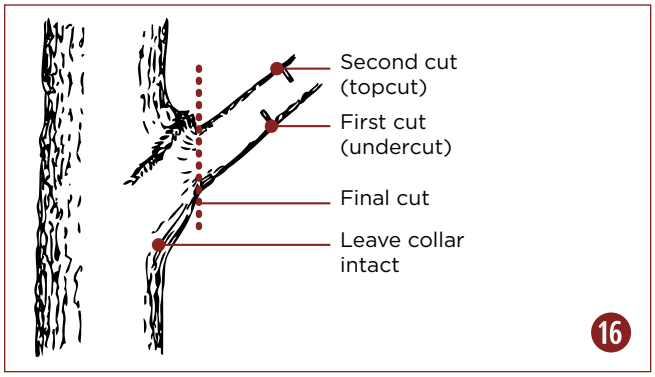


Figure 14

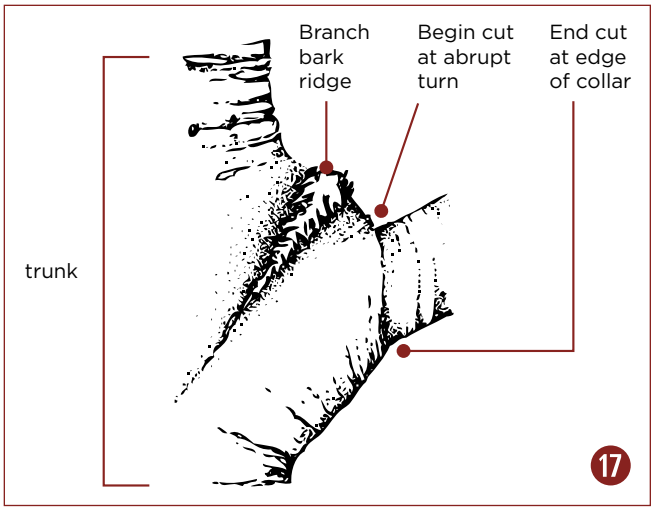
A reduction cut shortens the length of a stem by pruning back to a smaller limb large enough to assume dominance.

Figure 15

A removal cut prunes a branch back to the trunk or parent branch.

Figure 16

There are three steps to making a proper pruning cut that will minimize damage to the tree.



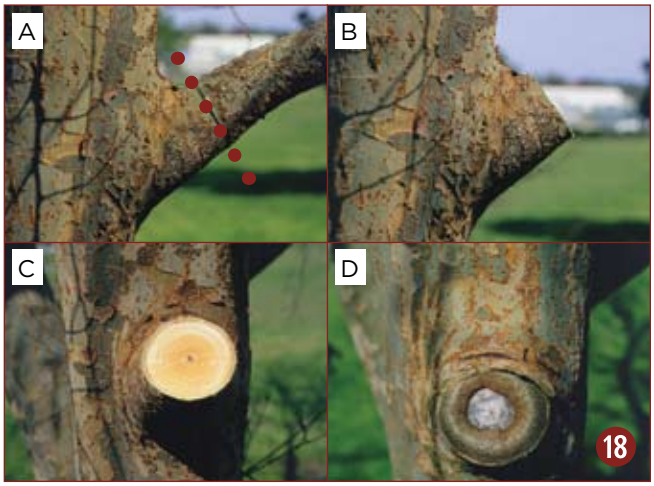


Figure 17

A close-up illustration showing where to make a removal cut.

Figure 18

A proper removal cut is made by cutting on the dotted line (A). When done correctly, a removal cut leaves the collar intact (B). The wound from a removal cut should be round in shape (C). Callus formation around a proper removal cut wound should be symmetrical (D). A good way to teach yourself and others how to properly prune is to practice making cuts to look like C and D.

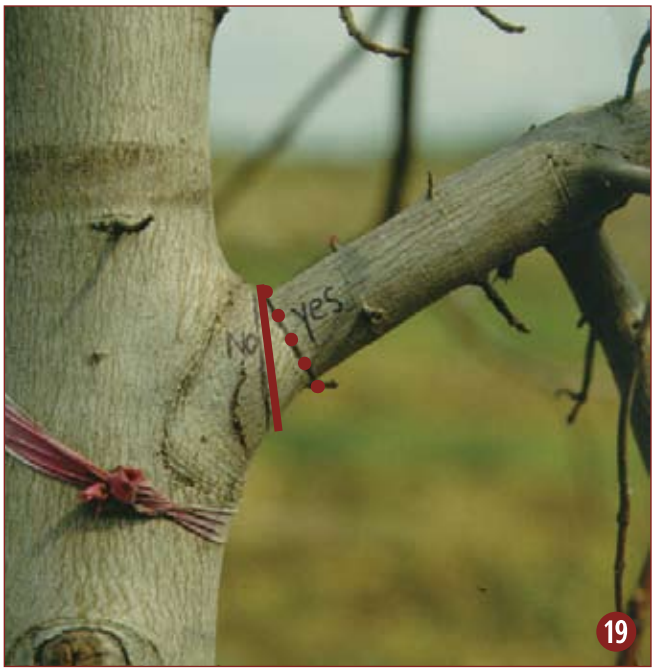


Figure 19

The “yes” (dotted) line represents an appropriate removal cut. Cutting through the “no” (solid) line cuts through the collar and represents a flush cut.

Figure 20

Flush cuts remove the top of the branch bark ridge, and typically expose more bark on top of the cut than on the sides and bottom (top). Flush cuts prevent the wound from sealing over properly, and typically close first on the sides then on the top and bottom (bottom). Severe decay can occur behind flush cuts, especially large ones.

Pruning Plans

With six to seven pruning events in the first 25 to 30 years after planting, a good structure can be developed that will place the tree on the road to becoming a permanent fixture in the landscape. Less frequent pruning may be required if good quality nursery trees were planted with a dominant leader and trees were irrigated appropriately until established. However, even well structured nursery trees will require regular pruning after planting. The following is an example pruning program for the first 30 years of a tree's life.

First Five Years after Planting

In the first five years after planting, most of the branches are temporary; however, do not remove more than 35% of the live foliage at any one pruning visit. This will minimize any stress the tree may experience from loss of foliage. Reduce all branches greater than 1/2 the diameter of the trunk. Select one stem to be the leader, and reduce or remove all branches competing with it. Reduce and/or remove large, vigorous branches low in the canopy, and remove any broken, cracked, or severely damaged branches. The pruning cycle and dose for these first five years should be determined individually for each tree type and size—for example, a pruning visit could be scheduled for year two and year four, or only one visit may be necessary during this period.

Five to Twenty Years after Planting

During this portion of the pruning program do not remove more than 25-30% of the live foliage at one time. Select the lowest permanent limb in the canopy and reduce/remove branches lower than this. Continue to reduce all branches greater than 1/2 the diameter of the trunk. Identify the largest scaffold limbs of the permanent canopy and reduce all branches within 18 inches of these. Reduce branches with included bark, and reduce or remove competing leaders. This can be done in stages if there are more than three competing leaders. Again, the pruning cycle will vary. At least three pruning visits should be scheduled during this period.

Twenty to Thirty Years after Planting

Remove all branches below the first permanent limb by twenty to thirty years after planting. Identify 5-10 permanent scaffold limbs, and reduce branches within 18-60 inches of these to avoid clustered branches. Continue to prevent the development of defects by reducing branches with included bark and those branches competing with the main leader.

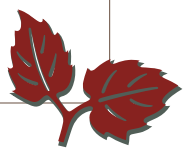
Additional Reading

Illustrated Guide to Pruning

Gilman, E. F. 2002. , 2nd edition. Delmar Publishers, Albany NY.

Landscape Plants

http://hort.ifas.ufl.edu/woody/pruning



This document is ENG 1062, one of the Urban Forest Hurricane Recovery Program series of the School of Forest Resources and Conservation and the Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date September 2007. Reviewed February 2011. Visit the EDIS website at http://edis.ifas.ufl.edu and http://hort.ifas.ufl.edu/treesandhurricanes.

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Design and layout: Mariana Wallig & Julie Walters.

CHAPTER 13

DEVELOPING A PREVENTIVE PRUNING PROGRAM IN YOUR COMMUNITY: MATURE TREES

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Introduction

A preventive pruning program should be designed to create structurally sound trunk and branch architecture that will sustain a tree for a long time. The goal with mature trees is to develop and maintain a sound structure to minimize hazards such as branch failure. This task is easier provided a good structure was established earlier in the tree's life.

When properly executed, a variety of benefits are derived from pruning. Benefits include reduced risk of branch and stem breakage, better clearance for vehicles and pedestrians, improved health and appearance, and enhanced view. When improperly performed, pruning can harm a tree's health, stability, and appearance. Several consequences occur when pruning is not performed at all (Figure 1). These consequences include development of low limbs; weak, codominant stems; defects such as included bark; and accumulation of dead branches. Formation of codominant stems and defects such as included bark can lead to increased risk of breakage.

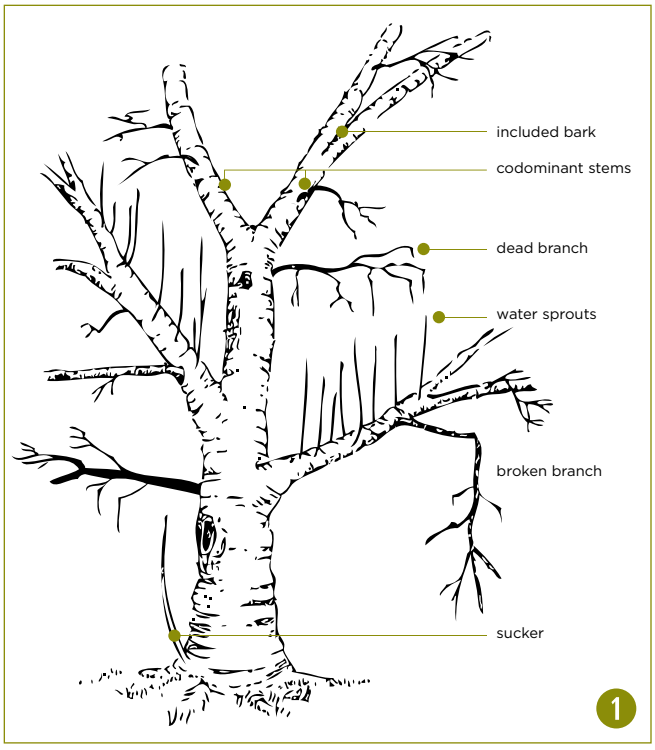


Figure 1

Problems that can develop on trees include codominant stems, included bark, broken and dead branches and large removed limbs that result in trunk decay.

One of the most common defects in planted trees is formation of large, low limbs. Branches of this nature could overextend and break, or they may droop under their own weight and have to be removed later, leaving a large pruning wound. Removal of large branches and those more than about half the trunk diameter is more likely to initiate decay than removal of smaller branches (Figure 2). Measures should be taken to avoid the occurrence of this defect.

With mature trees it is important to minimize hazards such as branch failure. Failures not only hurt the tree, but can also cause damage to people and property. Live branch removal is less desirable on mature trees, but it is sometimes necessary, for instance to remove a cracked live branch over a house. Hidden cracks often have elongated swellings such as seen at the arrows in Figure 3. A horizontal crack greatly affects the structural integrity of this branch. As such, it is a good candidate for reduction and/or thinning. The goal is to alleviate forces at the base of the branch. This is accomplished by reducing weight at the end of the branch so that the risk of breaking is minimized. Cleaning the crown by removing dead, diseased, or broken branches is a highly recommended practice on mature trees.

When planning a pruning program, it is essential to first evaluate the tree and the customer's needs. This will aid in determining which objectives should be accomplished with pruning. Appropriate pruning methods can be chosen to meet these objectives. The arborist then enters the tree and makes appropriate pruning cuts for the chosen pruning methods. This decision is based on an understanding of branch attachment and tree biology.

Figure 2

Large low branches (top) are starting to get in the way of traffic and will need to be removed. Removal of large branches can cause decay in the trunk (bottom). It is best to keep low branches small by regularly reducing their length should they have to be removed later.

Figure 3

Cracks in branches (top and bottom) and dead spots can result in branch failure, damage to structures, and injury to people. Dead spots often occur on top of branches.

Determine Pruning Objectives

No tree should be pruned without first establishing clearly defined objectives. Seven main objectives are described below, along with pruning methods that help meet those objectives. These objectives serve as examples and can be expanded or shortened to meet site conditions and customer expectations. Removing the correct stems and branches to accomplish specified objectives is as important as making correct pruning cuts. Even with proper pruning cuts, if the wrong branches or too many branches are removed, nothing of merit has been accomplished.

a. Reduce Risk of Failure

Reduce failure risk by learning to recognize the structural problems in trees that can lead to failure (Figure 4). Risk of tree failure can be reduced by establishing a structural pruning program that begins at planting and could carry through the first 25 years or more, depending on species. This program should be designed to create structurally sound trunk and branch architecture that will sustain the tree for a long period. Some structural pruning can be conducted on older trees as well. Medium-aged and mature trees can be cleaned, thinned, reduced, raised, or restored to manage risk. The choice among these pruning methods depends on the tree and the situation. See Chapter 12 for a more detailed description on structural pruning.

b. Promote Human Safety

Pruning can prevent expensive damage to people and or property (Figure 5). If hazardous structural issues in trees can be recognized prior to a storm, pruning can help to mitigate their damaging effects. Developing a preventive pruning program for mature trees will help to reduce the likelihood of serious damage from trees.

Figure 4

The codominant stem (top) broke because of a bark inclusion at the branch union. Trees with decayed or severed roots fall over in storms (bottom).

Figure 5

If hazardous structural issues in trees can be recognized prior to a storm, pruning can help to mitigate their damaging effects.

c. Allow for Safe Passage

Growth can be directed away from an object such as a building, security light, or power line by reducing or removing limbs on that side of the tree. However, trees often grow back to fill the void created by pruning. Regular pruning is required to maintain artificial clearance. Shortening or removing low branches can raise the crown. Crown reduction or pollarding helps maintain a tree smaller than it would be without pruning. Utility pruning keeps limbs clear of overhead wires and other utility structures (Figure 6).

d. Increase Sun Penetration to the Ground

A lawn, ground covers, or shrubs can receive more sunlight when live foliage is removed from the crown of large overstory trees (Figure 7). The tree's resistance to wind can also be reduced with pruning. Thinning, reduction, and pollarding are used to accomplish this.

e. Maintain Health

Health can be maintained by cleaning the crown, especially in medium-aged and mature trees. Removing dead, diseased, and rubbing branches in the crown of young trees also is important.

f. Influence Flower or Fruit Production

Pruning can influence the number and/or size of flowers or fruit. Fruit size can be increased on certain plants, such as peach, by removing some of the developing fruit or flowers. Flower cluster size can be increased on certain species, such as crape myrtle, by heading. Fruit production can be eliminated by removing flowers or developing fruit.

g. Improve Aesthetics

A tree can be pruned to improve appearance. Cleaning, reducing, thinning, pollarding, and restoring can be used to meet this objective.

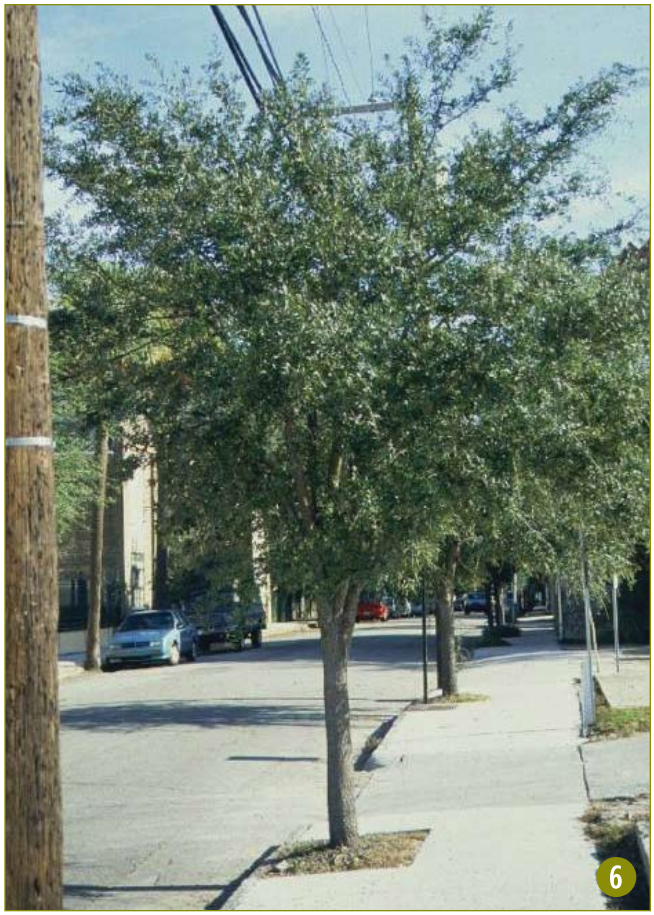


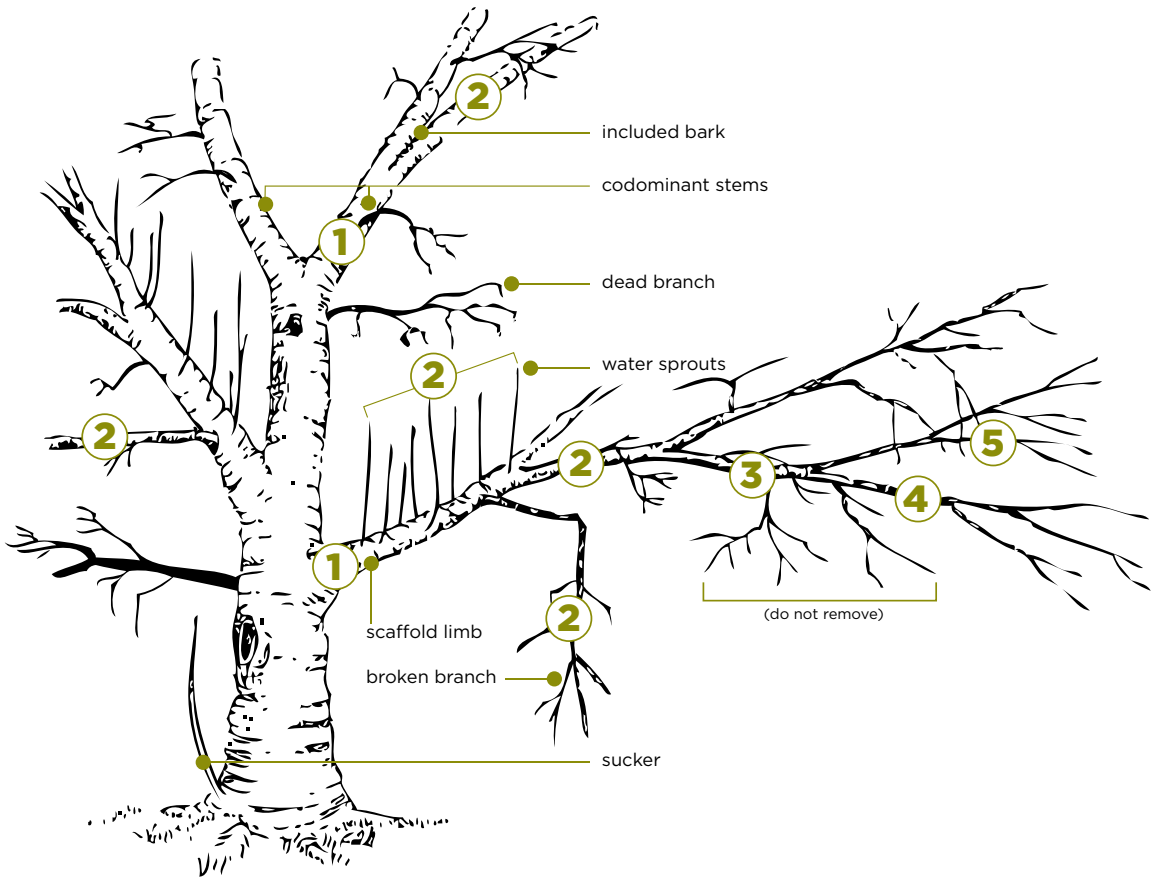
Figure 6

This live oak will have to be pruned often to provide clearance from the power lines. A better less expensive option is to plant a lower-growing species.

Figure 7

Before (top) and after thinning (bottom). The circle shows the area that has been opened up for more light and air to pass through. This can reduce likelihood of breakage in storms. Note interior branches were NOT removed.

Pruning Guidelines for Mature and Over-mature Trees



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Determine Pruning Cycle and Dose

Energy reserves (starch, sugars, and oils) are stored in branches, stems, trunk, and roots. Energy reserves can be preserved by removing the fewest number of live branches necessary to accomplish the desired objective. Excessive branch removal depletes these reserves and reduces the ability of the tree to photosynthesize more energy. There needs to be a good reason to remove live branches on mature and over mature trees (Figure 8). Many trees generate adventitious sprouts in response to over pruning as they attempt to replace the stored energy. Live branch pruning, however, is an essential ingredient to forming good structure, so it is a necessary procedure in an urban tree care program.

Figure 8

Only the lower right branch on this tree has been drawn to completion. The rest have been truncated for illustration purposes. When pruning an old tree, make cuts primarily on smaller branches toward the canopy edge only. Removing primary branches such as scaffold limbs may leave large pruning wounds and remove too much live tissue. Large old branches may have poor ability to restrict spread of decay following removal. Consider shortening or thinning the limb by removing tertiary and smaller branches instead of removing the branch entirely.

Execute the Preventive Pruning Plan

Make Proper Pruning Cuts

Three general types of cuts are used in arboricultural pruning: branch removal cuts, reduction cuts, and heading cuts. Removal cuts are the preferred type of cut because they leave the branch protection zone intact. The maximum and/or minimum diameter of pruning cuts should be stated before the work begins. Such specifications define the size of parts to be removed and the size of pruning wounds that result from the pruning to be performed.

Use Appropriate Pruning Methods

Pruning strategies for mature trees are quite different than those used for young trees. Often, it may be too late to make drastic structural changes to a mature tree. Good structure is something that should have been instilled in the beginning years of the tree's life. For mature trees your preventive pruning strategies are to 1) minimize hazardous conditions by cleaning and reducing weight where needed, 2) raise canopy where needed, and 3) maintain small-diameter interior branches for health and vigor.

These strategies are achieved through structural pruning, cleaning, thinning, raising, reducing, and balancing. Other important pruning tactics include root pruning, palm pruning, and restoration pruning.

Pruning for Structure

Structural pruning is the removal of live branches and stems to influence the orientation, spacing, growth rate, strength of attachment, and ultimate size of branches and stems (Figure 9). Structural pruning is used on young and medium-aged trees to help engineer a sustainable trunk and branch arrangement. If young trees are pruned to promote good structure, they likely will remain serviceable in the landscape for more years than trees that have not been structurally pruned. Waiting until the tree grows larger makes structural pruning much more difficult.

Structural pruning of large-maturing trees such as maples and oaks reduces certain defects and spaces main branches along one dominant trunk. It also reduces branches so they remain smaller than half the trunk diameter, which helps prevent structural failure later. In some cases, it may be too late to make meaningful structural changes to an already mature tree (Figure 10).

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Figure 9

Structural pruning shortens stems and branches (indicated by bracket) that are competing with the leader or main trunk. Pruning cuts range in size from 1–3 inches for trees that are prone to decay. Pruning cuts can be up to 6 inches or more for trees that resist decay. A medium aged tree such as this one can withstand up to about 25 percentage of foliage at one pruning. More can be removed on any individual branch.

Figure 10

Structural pruning of young trees can correct defects as shown by the tree on the top which was pruned twice in the last three years. Note the dominant leader. If structural pruning is not performed when trees are young, defects can become severe and are unable to be fixed. Trees with massive codominant stems and included bark can become hazardous and can split apart unexpectedly in storms. These trees can be reduced in size to minimize likelihood of failure in storms.

Structural pruning can be summed up as: subordinate or remove codominant stems. Four procedures should be considered when structural pruning. The first procedure is to clean the canopy by removing dead, broken, diseased, and dying branches. The second procedure is to choose and develop a dominant leader (Table 1). Multiple prunings over time (for example, 15 to 25 years) usually are required to develop a dominant leader. For medium aged and mature trees, it is important to maintain the leader that has been established (Figures 11 and 12). To do this, competing stems and branches are subordinated (reduced in length or thinned) or removed. Subordination is usually preferred over removal, especially if the problem stem (or stems) is larger than half the trunk diameter. Subordination of large stems may cause less trunk decay than removal, and the offending stem can always be removed later, if necessary.

Table 1. Steps to establish and maintain a dominant leader.
1. Choose the one stem that will make the best leader.
2. Identify which stems and branches are competing with this leader.
3. Decide how much to shorten these competing stems.
4. Prevent branches from growing larger than half the trunk diameter by regular pruning.

Figure 11

Competing stems in the upper right canopy were too long and heavy with foliage (top). Several cuts were made to subordinate some of the competing stems (center). The cuts can be easily seen in the following winter (bottom). Note that lower branches were not pruned.

Figure 12

This is the size of the branch that was removed with the first reduction cut shown in Figure 11. Three of these were removed from the upper right side of the canopy.

The third procedure is to select and establish the lowest permanent scaffold limb if the tree is old enough. Establish the lowest permanent limb by shortening vigorous branches below it and reducing any lower branches that grow up into the crown (Figure 13). The height of the lowest limb is determined by the location and intended function of the tree. For example, the lowest permanent limb on a street tree might be higher than that on a tree in your yard.

The fourth procedure is to select and establish scaffold limbs by subordinating or removing competing stems/branches. Scaffold selection can take 10 to 20 years or more depending on climate, the type of tree, and its location. Scaffold limbs are located above the lowest permanent limb and provide the base on which to build the permanent crown. Scaffold limbs should be free of serious defects such as included bark and cracks, should be among the largest on the tree, and should be appropriately spaced apart. Vertical spacing should be at least 18 inches or more for large-maturing trees and about 12 inches for smaller trees.

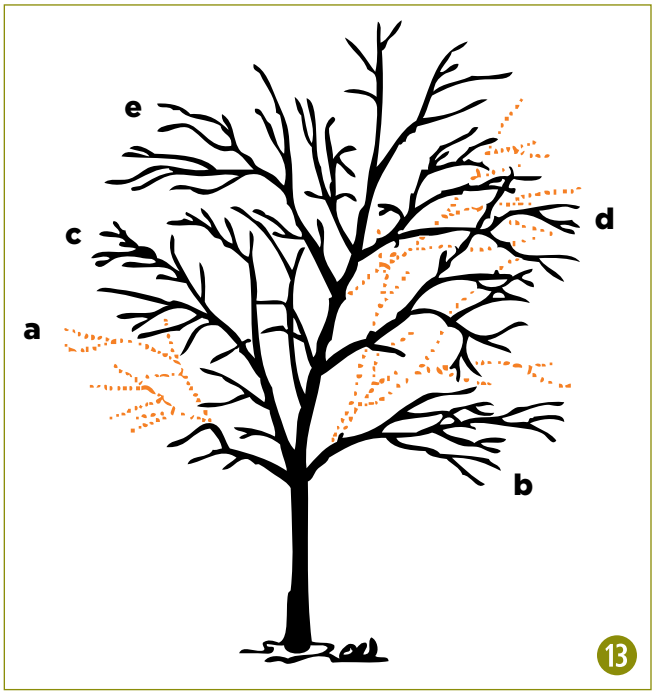

Figure 13

1) Cut back on branches *a* and *b* so branch *c* will become the scaffold branch at this position on the trunk. The portion of *b* was removed because it was growing up into the canopy; 2) remove or cut back (removal is shown) the main branch opposite *e* so *e* can become the scaffold branch at this point on the trunk. Branches *c*, *d* and *e* are now spaced along the trunk. The two small branches left on the trunk opposite branch *d* can remain because they are not likely to grow fast to compete with *d*.

Pruning to Clean

Cleaning is the selective removal of dead, diseased, detached, and/or broken branches (Figure 14). This method of pruning is done to reduce the risk of branches falling from the tree and to reduce the movement of insects and diseases from dead or dying branches into the rest of the tree. It can be performed on trees of any age but is most common on medium-aged and mature trees. Cleaning is the preferred pruning method for mature trees because it does not remove live branches unnecessarily. Cleaning removes branches with cracks that may fail when the interior wood dries.

Figure 14

Although dead branches normally cause less damage in hurricanes than live branches with defects, removing dead branches represents good tree care. Any damage caused by these small broken branches would be minimal compared to the threat of damage from larger branches.

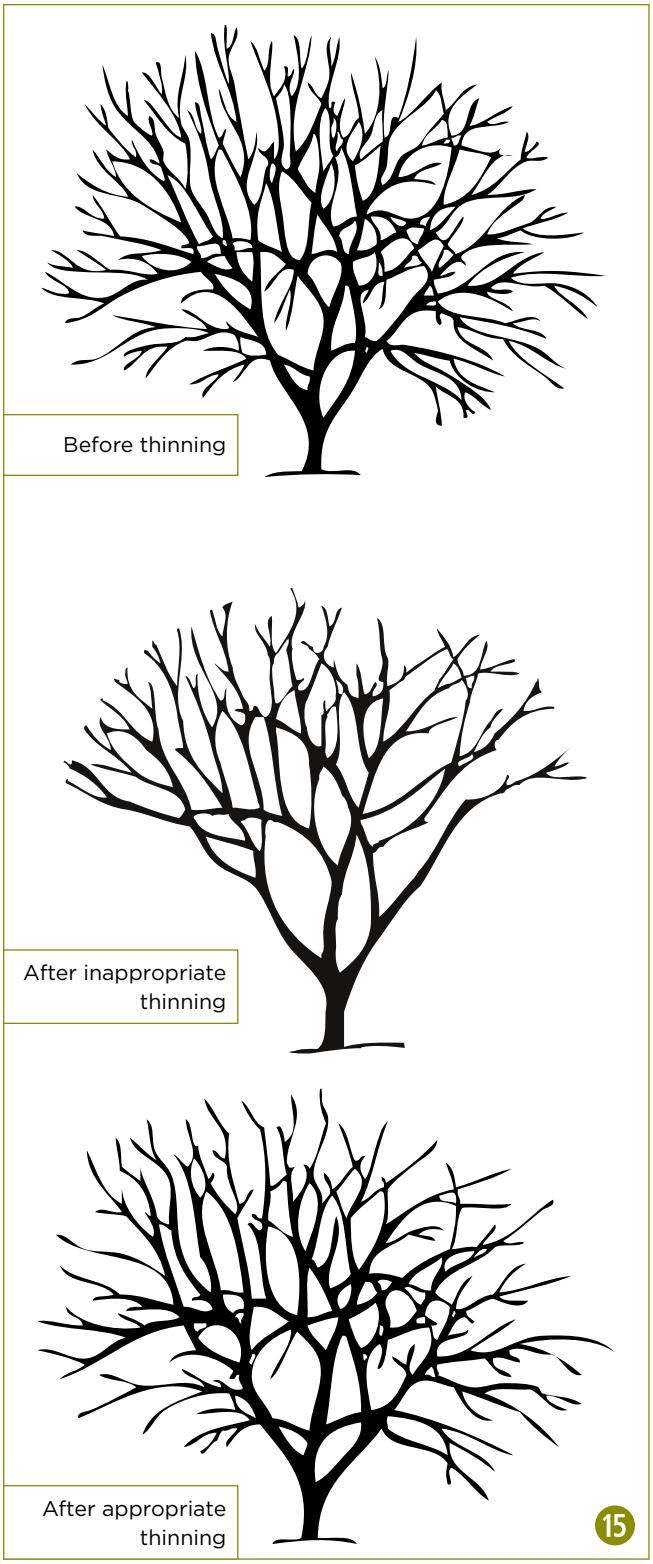

Figure 15

Inappropriate thinning only leaves branches at the edge of the crown, making trees more vulnerable to wind damage. Appropriate thinning leaves live branches distributed all along the limbs by removing branches primarily from the edge of the crown.

Pruning to Thin

Thinning is the selective removal of small live branches to reduce crown density (Figure 15). Because the majority of small branches are at the outside edge of the crown, thinning is focused in that area. Proper thinning retains crown shape and should provide an even distribution of foliage throughout the crown (Figure 16).

Thinning increases sunlight penetration and air movement through the crown. Increased light and air stimulates and maintains interior foliage, which can encourage taper on scaffold branches. Thinning can reduce the wind-sail effect of foliar clumps in the crown, and it can reduce the load on branch unions. Thinning a limb should be considered if cabling would be performed. Thinning also can remove suckers from the base of the tree and some water sprouts on the interior. Excessive removal of water sprouts often produces more water sprouts, so it is not recommended. Vigorous production of water sprouts on interior limbs often is a sign of overthinning or lion tailing (Figure 17).

Photos courtesy of C. Wayt Hoyt

Figure 16

Proper thinning retains crown shape and should provide an even distribution of foliage throughout the crown.

Excessive branch removal on the lower two-thirds of a branch or stem (lion tailing) can have adverse effects on the tree and therefore is not an acceptable pruning practice (Figure 17). Lion tailing transfers weight to the ends of branches and may result in sunburned bark tissue, water sprouts, cracks in branches, reduced branch taper, increased load on branch unions, and weakened branch structure. Lion tailing also changes the dynamics of the limb and often results in excessive branch breakage and sprouting.

Pruning to Raise (Elevate, Lift)

Raising is the selective removal of branches to provide vertical clearance (Figure 18). Crown raising shortens or removes lower branches of a tree to provide clearance for buildings, signs, vehicles, pedestrians, and vistas.

Excessive removal of lower limbs can slow development of trunk taper, can cause cracks or decay in the trunk, and transfers too much weight to the top of the tree (Figure 19). Mature trees could become stressed if large-diameter lower branches are removed. Clearance can sometimes be achieved by shortening some of the low branches rather than removing them to prevent these problems. Structural pruning should be considered along with raising.

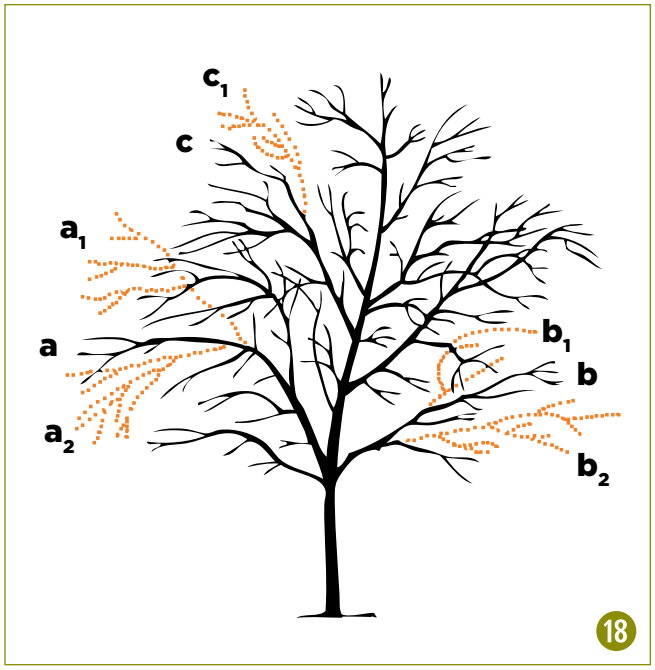

Figure 17

A lion-tailed tree (left) is stripped of foliage on the interior of the canopy. This produces excessive end weight at branch tips and makes the trees more susceptible to breakage in storms. Water sprouts (right) often result from stress in years following lion tailing.

Figure 18

Lower branches *a* and *b* can be removed to raise the crown. However, subordinating branches a and b by removing upper and lower branches *a-1*, *a-2*, *b-1*, and *b-2* will cause less stress for the tree. Removing *a-2* and *b-2* helps raise the crown. Removing *a-1* and *b-1* ensures that the branches will not grow up to become part of the permanent canopy. Left unpruned, these branches are likely to remain vigorous and form low, codominant stems. Because structural pruning is important as well, branch *c* should be reduced to keep it from competing with the leader.

Figure 19

Over raising (left) often results in large pruning cuts and stress, leading to the production of water sprouts (right).

Pruning to Reduce (Shape, Drop-Crotch)

Reduction is the selective removal of branches and stems to decrease the height and/or spread of a tree or shrub (Figure 20). This type of pruning can be used to make the entire tree or portions of the tree smaller, which can reduce the likelihood of failure and direct branch growth away from buildings or signs. Portions of the crown, such as individual limbs, can be reduced to balance the canopy, provide clearance, or reduce likelihood of breakage on limbs with defects (Figure 21). Occasionally, the entire crown is reduced (Figures 22 and 23). Reducing or thinning should be considered if cabling is to be performed. Crown reduction should be accomplished with reduction cuts, not heading cuts.

Not all tree and shrub species can be reduced. Therefore, the species and plant health should be considered before starting work. Old, stressed, or mature trees could decline or become more stressed as a result of this treatment. When a limb on a mature tree is cut back to a lateral, no more than one half of its foliage should be removed. More can be removed on a young tree to accomplish particular objectives. More decay can enter the tree following reduction than following other pruning methods.

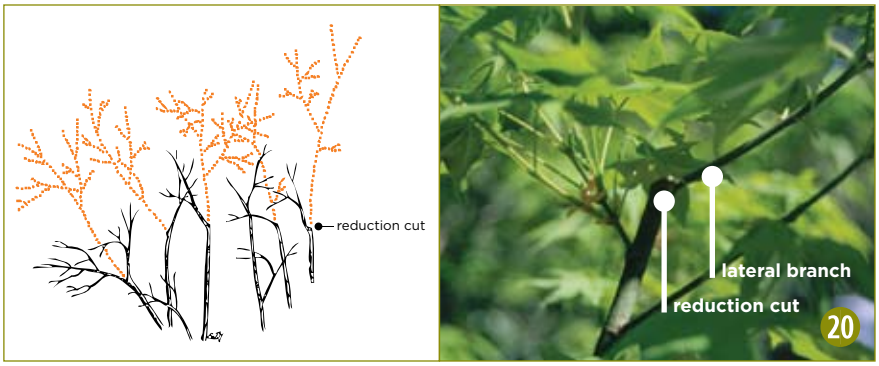

Figure 20

Reduction shortens stems and branches back to live lateral branches. (Left: removed stems and branch sections as shown by the dotted lines.) Notice that live, un-pruned branches remain on the edge of the new, smaller canopy, and no heading cuts were used. Properly done, this technique provides a more pleasing, un-pruned natural look to the tree compared to topping. Compared to topping, less decay is likely to enter the tree following reduction.

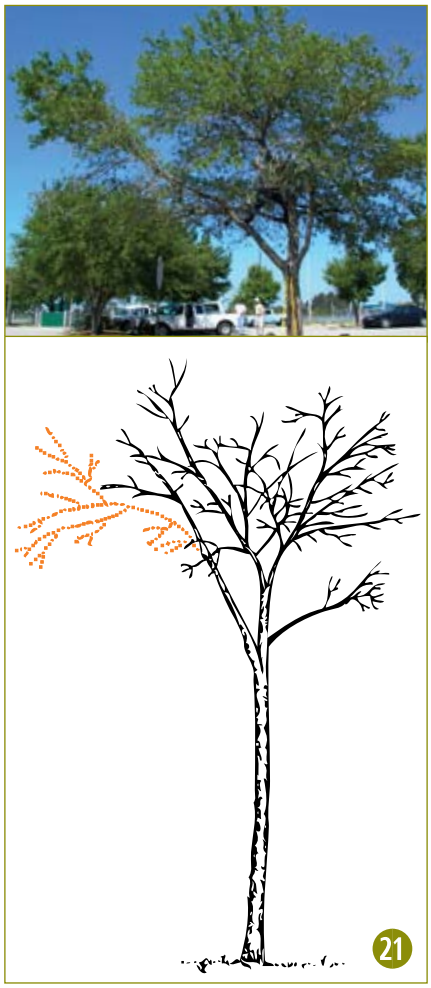

Figure 21

Reduction can be used to prevent the likelihood of failure on branches with excessive end weight (top). Branches may need to be shortened to balance the canopy or to prune it away from a structure or a sidewalk. This can be accomplished with small or large doses or reduction (bottom).

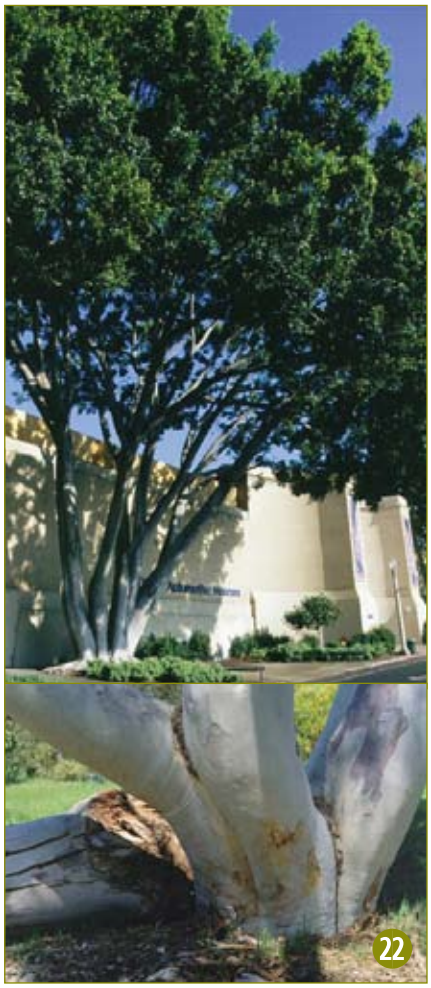

Figure 22

Clumped trees form a nice symmetrical canopy (top) but each individual tree is very one-sided. These individual trees are leaning away from the others as they grow. They are often lacking symmetry in their root systems as well. Roots on the opposite side of a lean play a large role in keeping a tree upright. Trees that lack roots to one side are prone to falling over (bottom). These trees are good candidates for canopy reduction and cabling to help prevent breakage.

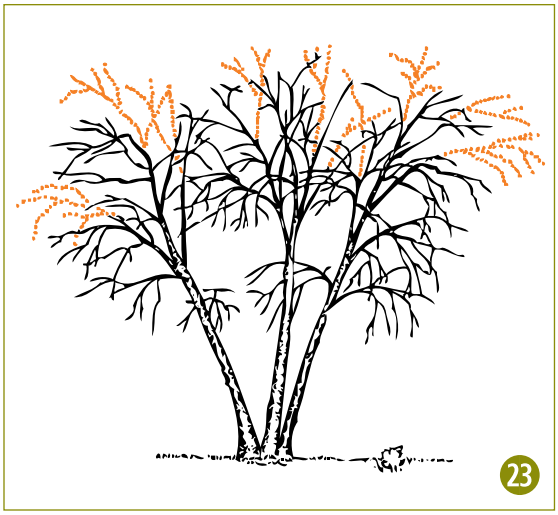

Figure 23

Use reduction cuts on clumped trees to reduce the weight of each tree, especially leaning ones. Consider installing hardware (cables or braces) to help hold the stems together.

Photo courtesy of Norm Easey

Figure 24

Restoration after a storm will take time, but it is possible.

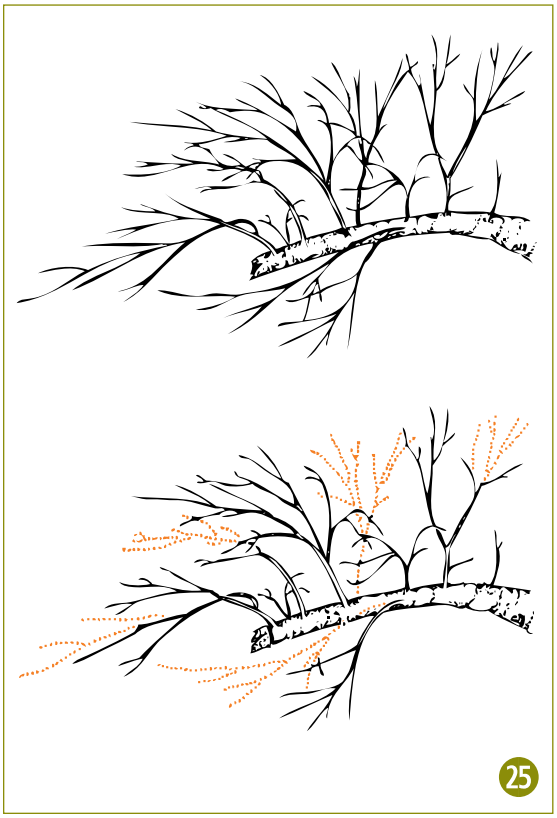

Figure 25

Many sprouts form from the cut ends of topped or storm-damaged trees (top). Some sprouts also develop below the cuts. Initially they are poorly attached to the tree and can break easily. Begin by removing dead stubs, removing some sprouts completely, and shortening others using reduction cuts (dotted lines bottom). This leaves several unpruned sprouts to grow into branches. The shortened branches help protect the sprouts that remain (bottom).

Pruning to Restore

Restoration is the selective removal of branches, sprouts, and stubs from trees and shrubs that have been topped, severely headed, vandalized, lion tailed, broken in a storm, or otherwise damaged (Figure 24). The goal of restoration is to improve a tree or shrub's structure, form, or appearance.

On trees with many sprouts originating at the tips of branches, one to three sprouts on main branch stubs are selected to become permanent branches and to re-form a more natural-appearing crown. To accomplish this, consider shortening some sprouts, removing others, and leaving some untouched (Figure 25). Some vigorous sprouts that will remain as branches may need to be shortened to control growth and ensure adequate attachment for the size of the sprout. Lion-tailed trees can be restored by allowing sprouts to develop along the interior portion of limbs for one to three years depending on size, age, and condition of the tree (Figure 26). Then remove and shorten some of

Figure 26

Newly emerging sprouts developing along the interior portion of a limb (top). Remove and shorten some so untouched ones are spaced apart (bottom).

the sprouts along the entire length of the limbs so the untouched sprouts are evenly spaced apart. Restoration usually requires several prunings over a number of years.

Pollarding

Pollarding is a training system that involves severe heading through small stems the first year followed by annual sprout removal to maintain trees or shrubs at a predetermined size or to maintain a "formal" appearance (Figure 27). Pollarding is not topping (Figure 28).

Pollarding historically was used for shoot generation for fuel, shelter, and various products because of the abundance of adventitious sprouts that a tree or shrub produces in this process. The pollarding process should be started on deciduous trees when the tree is young by making heading cuts through stems and branches no more than about three years old. Severe heading (topping) through older tissue may kill or start a decline syndrome on some tree species (Figure 28).

To pollard a tree, make heading cuts at strategic locations so that the sprouts from all cuts have access to sunlight. After the initial cuts are made, no additional heading cuts should be necessary. After a few pruning cycles, pollard heads (also called knuckles or knobs) develop, and the tree produces sprouts from these knuckles. Sprouts that grow from knuckles should be removed during the dormant season, taking care not to cut into or below the knobs. The knobs are the key differentiating factor between pollarding and topping. If knobs are damaged or removed in subsequent pruning, the branches react as they would on a topped tree.

Pruning Conifers

Some pruning methods are not appropriate for all conifers. For example, branch spacing and scaffold limb development in conifers usually is not necessary. Few conifers respond well to pollarding or reduction.

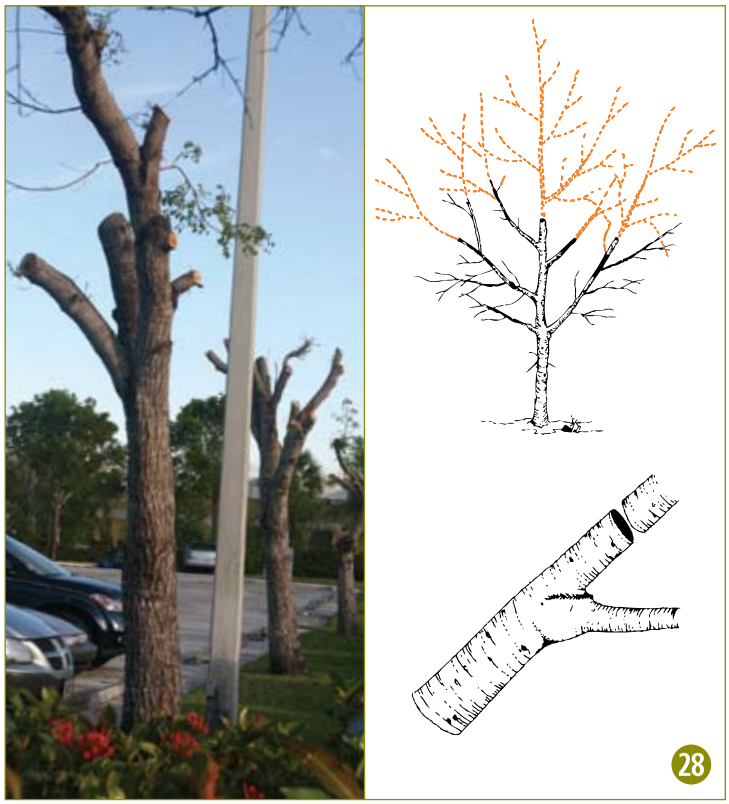

Figure 27

Sprouts pruned back to pollard heads (left). Pollarded trees flushing out with new sprouts (right). All sprouts are removed annually, typically in the dormant season.

Figure 28

Topping (left) is an inappropriate way to reduce a canopy. This type of pruning uses heading cuts (right) and can result in more problems in the future such as decay and structural defects. Large heading cuts are made between branches and result in stubs.

When to Prune

The best time to prune live branches depends on the desired results. Removal of dying, diseased, broken, rubbing, or dead limbs can be accomplished at any time with little negative effect on the tree.

Growth is maximized and defects are easier to see on deciduous trees if live-branch pruning is done in the winter or before growth resumes in early spring. Pruning when trees are dormant can minimize the risk of pest problems associated with wounding and allow trees to take advantage of the full growing season to close and compartmentalize wounds.

The timing of pruning can be an important part of a plant health care program. For example, one of the ways to reduce the spread of oak wilt fungus is to prune during the dormant season and avoid pruning susceptible species during April, May, and June.

Plant growth can be reduced if live-branch pruning takes place during or soon after the initial growth flush. This is the period when trees have just expended a great deal of stored energy to produce roots, foliage, and early shoot growth so pruning at this time usually is not recommended because of the potential stresses. Do not prune live branches from stressed trees at this time because they need all their live foliage to help recover.

Flowering can be prevented or enhanced by pruning at the appropriate time of the year. To retain the most flowers on landscape trees that bloom on current season's growth, such as crape myrtle (*Lagerstroemia* spp.) or linden (*Tilia* spp.), prune these trees in winter, prior to leaf emergence, or in the summer just after bloom. Plants that bloom on last season's wood, such as crabapples (*Malus*) and cherries (*Prunus*), should be pruned just after bloom in order to preserve the flower display. Fruit trees can be pruned during the dormant season to enhance structure and distribute fruiting wood, and they are pruned after bloom to thin fruit.

Certain species of trees, such as maples (*Acer* spp.) and birches (*Betula* spp.), drip sap (bleed) when pruned in the early spring when sap flow is heavy. Although unattractive, sap drainage has little negative effect on tree growth or health, and some of it can be avoided by pruning in summer or at other times of the year.

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This document is ENG 1063, one of the Urban Forest Hurricane Recovery Program series of the School of Forest Resources and Conservation and the Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date September 2007. Reviewed February 2011. Visit the EDIS website at http://edis.ifas.ufl.edu and http://hort.ifas.ufl.edu/treesandhurricanes.

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