



MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #613

Structural Training of Young Shade Trees

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Pruning Basics

Structural training is a multi-year investment requiring evaluation and corrective pruning on an annual basis. Young trees require little pruning. However, the training a tree receives while in the early “growth phase” of its life cycle determines its structural integrity for life. Many trees become prone to wind and snow damage as they mature due to the lack of structural training while young. Proper structural training of the young tree makes it especially resilient to storm damage when mature.

In this *CMG GardenNotes*, we look at the ideal structure for a young tree making it resilient to wind and snow loading. In selecting trees at the nursery, choose trees that will not require extensive pruning to reach the desired structure (e.g., no codominant trunks, straight central leader, evening branching along all sides, etc.). In real world settings, not all trees will fit the ideal description. The objective is to set the direction of what is desirable, recognizing that some trees simply do not meet the preferred structure for storm resilience.

Note: For additional information on a tree’s life cycle, refer to CMG GardenNotes #101, *Plant Health Care*. For additional information on branch collar development refer to CMG GardenNotes #611, *Tree Growth and Decay*. For additional information on types of cuts, refer to CMG GardenNotes #612, *Pruning Cuts*.

Time of year

Structural pruning is typically done in late winter, before trees break dormancy. Pruning is generally avoided during the spring growth flush as bark is rather tender at this point in time. Mid-summer pruning is preferred for tree species prone to bleeding if spring pruned (including birch, black locust, elms, goldenchain tree, hackberry, Japanese pagodatree, Kentucky coffeetree, maples, mulberry, poplars, walnuts, and willows).

Size of branches

Ideally, all pruning cuts are two inches in diameter and smaller. On tree species more resistant to decay, the standard could be pushed to two to four inches, maximum (depending on actual vigor and growth of the tree).

The structural training stage basically ends when pruning cuts would be greater than this standard. Larger cuts become general pruning rather than training of the tree. Any pruning cut four inches and larger must be justified by taking into account the potential for decay.

Structural Training Steps

Structural training follows a series of steps. Considerations at each step determine the direction to take in following steps.

Step 1 – Dosage: Maximum Amount of Live Wood/Foliage to Remove

The maximum amount of foliage/live wood that can be removed per season depends on the actual growth rate of the tree. Look at six to 12 branches around the tree to assess growth rates. Look for what is the typical growth rate for most branches, rather than the fastest or slowest growing branches. [Table 1]

Growth and Annual Growth Rings – Starting at the branch tip, look at the length back to the first *annual growth ring* (*terminal bud scare*). This is where the growth ended the previous year. The annual growth ring looks like a small ring or crown going completely around the twig. On some trees it is easy to identify, on other trees it is only a simple ring. To avoid confusing it with a side bud, the annual growth ring goes completely around the twig. On some trees, a slight change in bark color helps identify where the annual growth rings are located. [Figure 1]



Figure 1. The annual growth rings (terminal bud scar) looks like a small ring or decorative crown going complete around the stem.

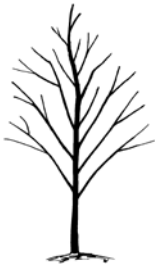
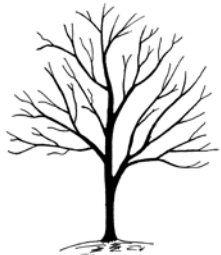
Table 1. Dosage: Maximum Amount of Live Wood/Foliage to Remove per Season on Young, Actively Growing, Trees	
Actual Annual Growth	Estimated Maximum Amount of Live Wood/Foliage to Remove Per Season
3 to 4+ feet.	25% to 50%
1 to 2 feet	10% to 25%
6 to 12 inches	Approximately 10%.
Little annual growth.	Limit pruning to a light dosage, correcting codominant trunks.
Tree under critical stress with minimal annual growth.	Limit pruning to cleaning (removal of dead and damaged branches).

In situations where trees are pruned annually (the ideal situation), the appropriate pruning dose would be light. However, in real world situations, trees are often pruned only once every several years. Here the appropriate pruning dose may be higher. In situations where heavy pruning is needed, complete the work over a period of years.

Excessive pruning can lead to watersprouts (upright, sucker-like shoots emerging on the trunk or branches). Watersprouts, a common response to over pruning and storm damage, are structurally unsound. Excessive pruning also creates a hormone imbalance between auxins (produced in the terminal buds) which stimulates root growth, and gibberellins (produced in the root tips) which stimulates canopy growth. Since roots have multiple regeneration periods each season, this imbalance puts the root system into a decline, resulting in a multi-year decline in canopy growth.

Step 2 – Growth Habit

The desired branching structure depends on the natural growth habit of the tree. Trees with an *excurrent* growth habit develop with a *central leader* (single trunk) to the top. Examples of excurrent trees include aspen, linden, and pines. Trees with a *decurent* growth habit develop a more rounded form with multiple *scaffold branches* (secondary trunk-like branches) or secondary trunks originating from the trunk. Examples of decurent trees include maple, ash, elm, and honeylocust. Table 1 shows comparisons in pruning objective of excurrent and decurent trees. [Table 2]

Table 2 – Structural Training Objectives for Young Trees		
	 Excurrent Trees Single trunk to the top	 Decurrent Trees Scaffold branches arise from the trunk becoming the main structural system
Training Objective 1	Remove dead and damaged branches.	
Training Objective 2	Maintain single trunk to top of tree.	Maintain single dominant trunk to at least two-thirds of the tree's mature height.
Training Objective 3	Select lowest permanent branch.	Select lowest scaffold branch.
Training Objective 4	Maintain diameter of all branches less than one-half the diameter of adjacent trunk.	Select other scaffold branches.
Training Objective 5	Manage temporary branches removing them over time (before they reach a two inch diameter).	

Step 3 – Pruning Objectives

Structural training of young shade trees is based on five pruning objectives. Evaluation of all five is generally done before actual pruning occurs, as considerations are interrelated.

Objective 1 – Remove Dead and Damaged Branches

Actual pruning begins with the removal of dead, broken, and damaged branches. [Figure 2]

Competing branches (branches growing in the same space) are also a consideration. However, which one to keep and which ones to remove generally sorts out in the other steps.



Figure 2. Rubbing branches

Objective 2 – Develop Trunk

The primary pruning objective is to eliminate multiple trunks. If multiple trunks start to develop, remove all but one. If the leader is killed, select a side branch to become the new leader, removing its competition (a multi-year process). It may be helpful to loosely tie the new leader to a stick to bend it to an upward orientation.

Codominant Trunks

In training trees, arborists have zero tolerance for *codominant trunks* (adjacent trunks of similar diameter). Codominant trunks account for the majority of wind and snow related tree failures in Colorado and other snowy climates.

With codominant trunks, no branch collar develops to wrap the two trunks together. (The *branch collar* is the area where trunk wood wraps around the branch wood creating a structurally strong branch union.) The *branch union* (crotch) is structurally weak and prone to breakage as the trunks reach a size greater than 3-4 inches in diameter. [Figure 3]

Note: In selecting a tree, it is advisable to avoid purchasing trees with codominant trunks.

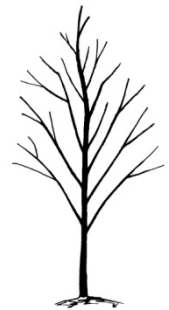
Figure 3. Codominant trunks – A branch union with two trunks of similar size is structurally weak and prone to storm damage. “Included bark” (hidden bark) between the trunks prevents the wood from growing together. Without a branch collar, wood of the two trunks does not knit together. In structural pruning, there is zero tolerance for codominant trunks.



Excurrent Trees – Maintain Single Trunk to Top of Tree

On excurrent (central leader) trees, maintain a single trunk to the top of the tree. If a side branch begins growing upright in a trunk-like fashion, prune it back to redirect the growth to an outward direction or removed it entirely. Generally, do not prune or “head back” the central leader (trunk). [Figure 4]

Figure 4. On excurrent trees, maintain a single trunk to the top.



Decurrent Trees – Maintain Single Dominant Trunk to at Least Two-thirds of the Tree’s Mature Height

The overall objective with decurrent trees is to develop a structural system of *scaffold branches* rather than secondary trunks. *Scaffold branches* are the major structural, trunk-like branches that originate off of the trunk. By definition, a scaffold branch must be less than one-half the size of the adjacent trunk. Less than

one-third is preferred. This allows for a branch collar to develop, creating a structurally strong branch union. In contrast, *secondary trunks* lack the size relationship for branch collar development, creating structurally weak branch unions.

In an open landscape setting, most decurrent trees naturally develop multiple secondary trunks often arising at the same location predisposing the tree to storm damage.

On decurrent trees, maintain a single dominant trunk to at least two-thirds of the tree's mature height. For example, if the mature tree height is 30 feet, a single trunk should dominate to at least 20 feet. If the mature tree reaches 60 feet, a single trunk dominates to at least 40 feet. Scaffold branches become the secondary framework of the tree. By training, secondary trunks are avoided. [Figure5]

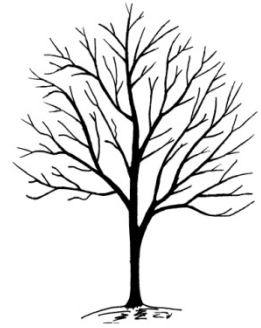


Figure 5. On decurrent trees, maintain a single dominant trunk to at least two-thirds of the tree's mature height.

If vigorously upward-growing side branches begin to compete with the central leader, prune back the branch to a more outward growing side branch. Some tree species naturally put out many upward growing secondary trunks. Heavy pruning over a period of years will be desirable to establish a dominant central leader with subordinate smaller side branches.

Generally, do not “head-back” (prune) the central leader.

Objective 3 – Select Lowest Branch

It is often desirable to *raise* the canopy (remove lower branches) so they are out of the way of human activities like mowing the lawn and lawn games. For shade trees in lawns, patios, and along sidewalks, the lowest permanent branch generally starts 7 to 10 feet above ground level. On smaller specimen trees in a garden bed, lower branching may be preferred. Over streets, the lowest branches start at 14 feet. In wooded settings, the canopy is raised to 10 feet as a fire prevention technique.

Many gardeners mistakenly plan to remove lower branches as the tree reaches a more mature size. Removing these larger branches as the tree matures opens the tree to internal decay. On decurrent trees, these lower branches typically make up a significant portion of the tree.

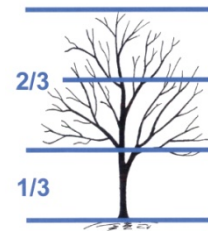
The objective is to identify what will be the lowest permanent branch at this early time in life, allowing the gardener to manage and remove lower branches over time. Branches below the lowest permanent branch are called *temporary branches*. Management and removal of the temporary branches will be discussed in Objective 5.

The lowest branch on any tree should originate in the bottom one-third of the tree. In establishing the lowest branch, don't “limb-up” a young tree too early in its growth. To develop a trunk taper resilient to wind, one-half of the leafing area should be found in the lower two-thirds of the tree. Lower *temporary branches*

should be removed only as the tree grows in height, but before they reach two-inches in diameter. (Refer to Objective 5 for details). [Figure 6]

Figure 6. To develop a strong trunk taper, at least one-half of the foliage must be in the lower two-thirds of the tree.

Temporary branches below the lowest permanent branches will be removed over time. (Refer to Objective 5.)



On excurrent trees, select the lowest permanent branch. Branches below this point become temporary branches.

On decurrent trees, select the lowest permanent branch, which will become the first *scaffold branch*. Other scaffold branches will be selected based on the location of this branch. Branches below the lowest (first) scaffold branch become temporary branches.

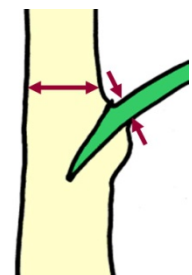
Objective 4 – Developing Branching Structure

In Objective 4, branches are managed differently for excurrent and decurrent trees.

Excurrent Trees: Maintain Diameter of All Branches Less Than One-Half the Trunk Diameter

For structural integrity, side branches must be less than one-half the diameter of the adjacent trunk. Less than one-third is preferred. Without this important size ratio, the branch collar fails to develop, creating a weak branch union. [Figure 7]

Figure 7. For a branch collar to develop, the side branch must be less than one-half the diameter of the adjacent trunk.



If the diameter of a branch is growing too fast compared to the trunk, prune the branch back by 1/3 to 2/3s to slow its growth rate.

Spacing of branches along the trunk is not a critical structural issue on excurrent trees, as long as the trunk to side branch ratio is within limits. Many species of excurrent trees develop branches in a whorl. This is structurally acceptable as long as the branch to trunk size ratios are within limits. On some species of trees, thinning of competing branches (branches growing in the same space with the potential to rub and damage each other) may be desirable.

Decurrent Trees: Select Other Scaffold Branches

In the structural pruning of decurrent trees, an overall intent is to guide development of the branching structure, creating *scaffold branches* and eliminating secondary trunks. The intent is to create strong branch unions with a branch collar. For the branch collar to develop, the branch must be less than one-half (less than one-third preferable) the size of the adjacent trunk. Without the branch collar, secondary trunks are structurally weak and prone to breakage as the tree matures.

The selection of other scaffold branches takes place over a period of years as the tree grows in height. Branches along the trunk not destined to become scaffold branches are managed as *temporary branches* being removed over time.

In selecting other scaffold branches, consider branch spacing and branch union (crotch) angles. In an open landscape setting, decurrent trees naturally develop more branches than is desirable, predisposing the tree to wind and snow damage as the tree matures. The objective of training is to correct this situation while the tree is young.

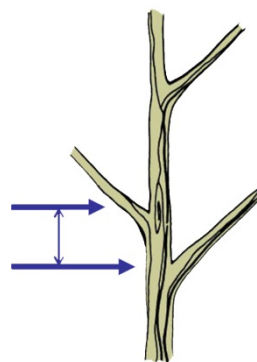
Branch spacing – Desired spacing for scaffold branches depends on the mature height of the tree. The rule of thumb is to allow at least 6 inches per 10 feet of mature tree height. Table 2 shows spacing for various mature heights. [Table 3]

Table 3 – Minimum Spacing for Scaffold Branches

<u>Mature Tree Height</u>	<u>Minimum Scaffold Branch Spacing</u>
20 feet	1 foot
30 feet	1.5 feet
40 feet	2 feet
50 feet	2.5 feet
60 feet	3 feet
70 feet	3.5 feet
80 feet	4 feet

Select scaffold branches with even distribution around the tree trunk. Where a scaffold branch is growing directly above another, vertical spacing should be at least 60 inches on trees with a mature height of 30 feet and taller, and 18 to 36 inches on smaller trees. [Figure 8]

Figure 8. Minimum scaffold branch spacing is based on the mature height of the tree at 6 inches per 10 feet of mature height. A tree that will grow to 30 feet should have scaffold branches spaced at least 18 inches apart.



Multiple branching at one location — When multiple scaffold branches arise from the same area, the branch collars cannot knit together into a strong branch union. These branches become vulnerable to wind and snow damage. In training a young decurrent tree, eliminate multiple branches arising at the same location. Many common shade trees, including maples, cottonwoods, poplars, and elms naturally develop multiple branching at the same location. [Figure 8]

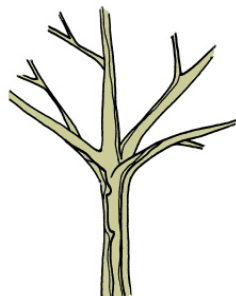


Figure 8. Multiple branches originating from the same location are structurally weak. An objective in structural training is to space scaffold branches.

Branch union angles – The problem with a narrow branch union (crotch) angle is the development of *included bark* (bark against bark inside the branch union) as the tree grows. With included bark, the branch collar cannot wrap the trunk wood around the side branch wood, creating a weak branch union. A branch union with a wide angle of attachment is also more resistant to the spread of decay.

In selecting scaffold branches, select outward growing branches with a wide angle of attachment rather than upward growing branches.

Objective 5 – Manage Temporary Branches, Removing Them Over Time

Temporary branches on the lower trunk are important to the tree's early growth. *Photosynthates* (carbohydrates and proteins produced by photosynthesis) produced in the lower canopy help develop the natural trunk taper giving wind resilience. Shading by the lower foliage helps reduce sunscald of the tender bark.

Manage growth on temporary branches by keeping them short and removing them over time as the tree grows in height. Ideally, temporary branches are pruned back to a few buds. On temporary branches that have grown significantly before training begins, start by cutting them back by about 50%, removing more over time.

Temporary branches are removed before they reach a two inch diameter. Pruning back a temporary branch slows the growth, giving more time before the branch must be removed due to size.

Keeping temporary branches short suppresses their rapid growth while encouraging the desired growth up in the scaffold branch structure. During the early training process, a young tree will have a cylinder of short temporary branches along the lower trunk (below the lowest permanent branch), with the tree's significant growth developing up in the permanent branch structure. [Figure 10]

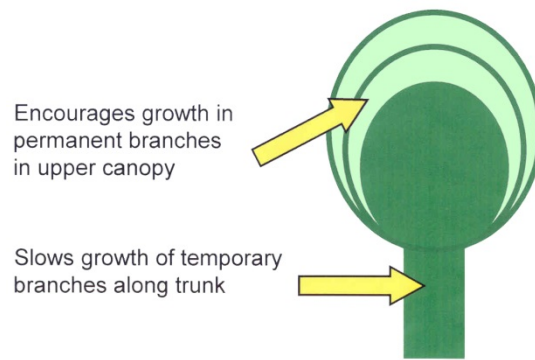


Figure 910 of a young tree: temporary branches on the lower trunk (below the lowest permanent branch) create a narrow cylinder of short branches.

Preferred vertical spacing of temporary branches is four to six inches. Thus some branches would be removed outright. On decurrent trees, no temporary branch should be within six inches of a scaffold branch. Branches between scaffold branches are also considered temporary branches. Maintain these temporary branches for one to five years, removing them before they reach a two-inch diameter.

On decurrent trees, it generally takes several years to manage and eventually remove temporary branches. Remember that the total amount of foliage that can be removed per season depends on the growth rate of the tree. In purchasing, select trees that require minimum corrective pruning to make them structurally sound.

Authors: David Whiting (CSU Extension, retired), with Alison O'Connor and Eric Hammond (CSU Extension). Photographs and line drawings by David Whiting; used by permission.

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