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MASTER GARDENER

Tree Growth and Decay

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Outline. . .

As forest scientists observed how trees respond to wounds, pruning techniques changed and pruning objectives were clarified. Plants don't heal. Instead, tissues in the injured area, called the **reaction zone**, undergo chemical changes to **compartmentalize** or seal-off the damaged area from the surrounding tissues in an attempt to suppress the spread of decay.

This fact sheet provides background information on how trees grow and decay and the implications of pruning cuts and structural training. Refer to other fact sheets for additional details on pruning cuts and structural training.

Note: throughout this fact sheet, we use the term "trunk" to refer to a parent branch and "branch" to refer to a side branch arising from the trunk (parent branch). The same relationship exists between a side branch and a secondary side branch.

How Trees Grow

Xylem tissues – Each year a tree puts on a new ring of wood (xylem tissue) toward the outside (under the bark), resulting in the increased diameter of a trunk or branch. The number of rings indicates the limb's age and the width of individual rings indicates that year's growing conditions.

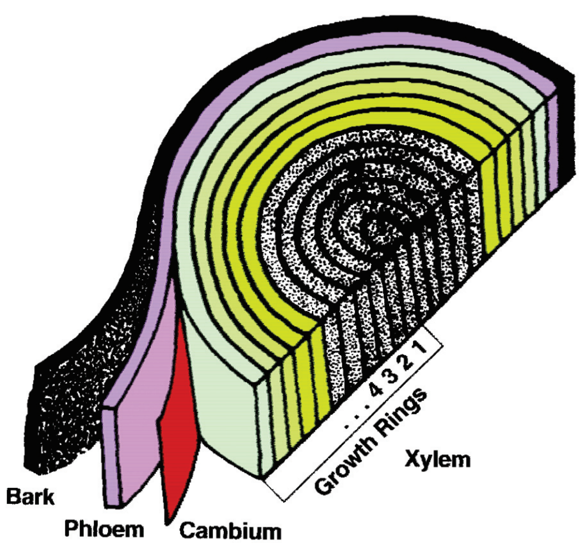

Figure 1. Cross section of a tree
Bark – outer protective covering
Phloem – tissue layer just under the bark – Sugars and carbohydrates produced in the leaves by photosynthesis move throughout the tree in the phloem tissues, including down to feed the roots.
Cambium – layer of active cell division
Xylem – Each year the tree adds a new ring of xylem tissues towards the outside, resulting in a growth in limb diameter. Xylem tissues are the technical name for the wood.

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Putting Knowledge to Work

Figure 2. The wood of a tree is the xylem tissues. Xylem tissues that grew in the spring and early summer enlarge and are the tubes in which water with minerals flows from the roots to the leaves. In a cross-section of a log, these are light-colored rings. Xylem tissues that grew midsummer, at the end of the growth cycle, are higher in fiber content, creating a wall to the outside. In a cross-section of a log, these are the darker colored annual growth rings.

Ray cells grow through the annual growth rings functioning like a staple or nail to hold the growth rings together. Ray cells also function as the path to move carbohydrates in and out of storage in the xylem tissues. On some species, ray cells are not readily visible. On other species, ray cells create interesting patterns in the wood.

Figure 3. The cracks on this willow stump show ray cells. Ray cells hold annual growth rings together like a nail and serve as the path to move carbohydrates in and out of storage in the xylem tissues.

The trunk is a series of boxes or compartments framed by the **annual growth rings** (xylem tissue high in fiber that grew towards the end of the annual growth cycle) and **ray cells**. Each compartment is filled with xylem tissues, tubes in which water with minerals move from the roots to the leaves.

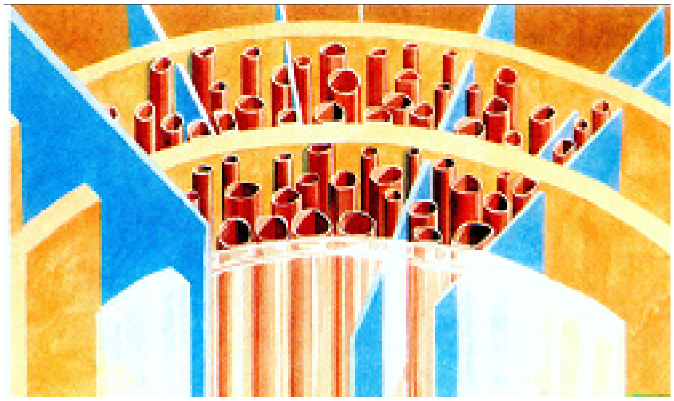


Figure 4. The trunk is a series of boxes framed by the annual growth rings.

CODIT – How Trees Decay

Unlike animals and people, trees don't replace damaged tissues. Rather, cells in the damaged area undergo a chemical change in an effort to seal-off or "compartmentalize" the damaged area from the spread of decay. This area of chemical change is called the **reaction zone**. In most species, a reaction zone appears as darker colored wood.

The reaction zone response is very weak up and down the xylem tubes. If it weren't, the tubes would plug and stop the flow of water and kill the plant. Instead, decay can readily spread up and down in the xylem tissues. (Side note: A few diseases, like Dutch Elm Disease and Oak Wilt, kill the limb as fungal activity plugs the xylem tissues thus restricting water and nutrient flow.)

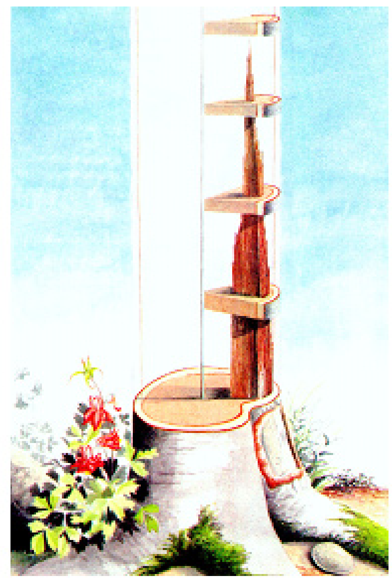
The wall into the older xylem tissues (towards the center of the tree) is also weak. The walls created by the ray cells are somewhat resistant to spreading decay around the tree (depending on species). The wall towards the outside (made by the new annual growth ring laid down after injury occurs) is resistant to decay.

Resistance to the spread of decay by the outside annual growth ring and ray cells creates a pipe-like structure with a decayed center. This concept of how decay spread in a tree (as controlled by the **annual growth rings** and **ray cells**) is call CODIT, for Compartmentalization of Decay in Trees.

Impact of Decay on Structural Strength

Figure 5. Spread of decay in trees

1. Decay readily moves up and down in the xylem tubes (right).
2. The wall towards the center of the tree, created by older annual growth rings, is weak and decay moves into the interior of the limb (2 below).
3. Sidewalls created by the ray cells are moderately resistant to decay, slowing the spread of decay around the growth ring (3 below).
4. The wall created toward the outside, by the newer annual growth ring, is highly resistant to decay (4 below).



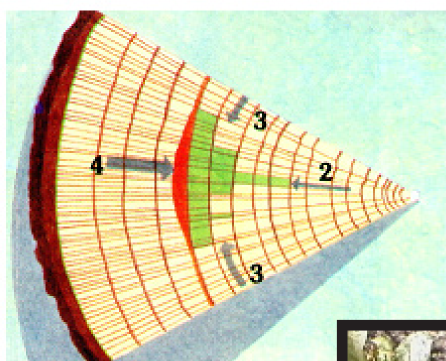


Figure 6. Decay in a tree creates a pipe-like structure with a hollow center. Note the darker ring of the reaction zone between the hollow center and the healthy, lighter-colored wood.

A trunk or branch with some internal decay is not necessarily at risk for failure. Structural strength is based on 1) the minimum thickness of the healthy wood (xylem tissues) and 2) the type of wood.

In evaluating potential hazards, arborists (tree care professionals) work with a technical term called **percent shell**. Percent shell is calculated by dividing the thickness of the healthy wood at the thinnest point (not including bark, reaction wood, or decaying tissue) by the radius of the trunk/branch (not including bark).

33 percent shell = hazardous tree – Trees with a 33 percent shell or less are termed "hazardous" with a statistically high probability of failure in a storm event. For example, a 6-inch trunk/branch but only a 1-inch thick ring of healthy wood would have a 33 percent shell with a hollow center. It would be considered "hazardous" with a high potential to fail in a storm. If injury or property damage would occur upon tree failure, corrective action (removal of the defective branch or removal of the tree) should be considered.

20 percent shell = critical risk – Trees with a 20 percent shell or less are considered a "critical risk" with a very high probability of failure in storms. For example, a tree with a 10-inch trunk/branch but only 1-inch ring of healthy wood would be considered a critical risk. If injury or property damage would occur upon tree failure, corrective action (removal of the defective branch or removal of the tree) should be taken.

Percent shell formula is valid only when the decay column is centered in the trunk/branch. Researchers are developing other formulas to evaluate off-sided decay and open cavities, which are significantly weaker.

Figure 7. This cottonwood branch has a 25 percent shell, making it a potential hazard. Percent shell is measured by dividing the thickness of the healthy wood at its narrowest point (not including the reaction wood [darker ring towards the center] and the bark) by the radius of the limb (not including bark).

Measuring Decay (Percent Shell)

So, how thick is the healthy wood in a trunk or branch? Researchers are working to address this big question. At the present time, arborists are limited in their ability to measure and evaluate the internal structure of a trunk or limb. The following are procedures with limited potential to evaluate the internal structure of trees.

Coring devices:

Note: All coring devices have a small potential to spread decay, as the coring tools break the strong exterior wall of a reaction zone and brings decaying tissues out though healthy wood in the removal. Thus, they generally are not used on living trees except when there is a special need to evaluate hazard potential. All coring devices only indicate the decay potential at the point of drilling and don't represent the entire trunk or branch.

Increment Borer is a hand tool that removes a small core from a trunk or branch. The relative effort it takes to drill the borer through various layers of the tree and examination of the core removed gives the arborist some ideas about the internal structure at this location.

Drill with small drill bit – Drilling the trunk or branch with a small (1/4 inch) drill bit is a tool used by some arborists. Pressure to push the drill through the annual growth rings and examination of the sawdust removed gives the arborist some idea about the internal structure at this location.

Resistograph is a specialized drill that graphs the pressure needed to push a small drill bit through various layers of annual growth rings. The graph gives a visual indication of internal structure at this location.

Digital Microprobe, a specialized drill bit rotating at 7,000 rpm, measures the pressure needed to drill/burn it's way through tissues. Data if fed into a computer database for evaluation and printout. This equipment is new to the industry and cost prohibitive for most arborists

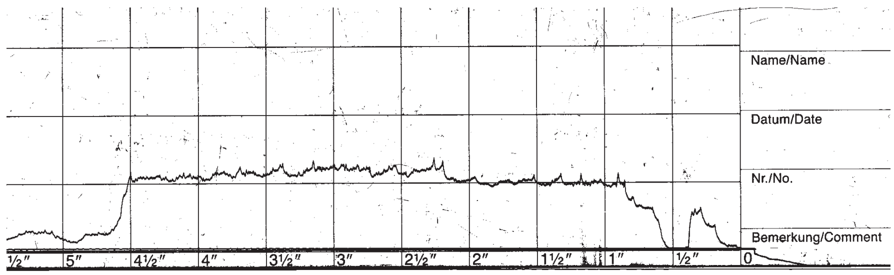


Figure 8. Sample printout of resistograph – This tree has a decayed center at 4-1/2 inches from the outside bark.

Listening devices:

Rubber mallet – Tapping the trunk/branch with a rubber mallet and listening for a hollow sound may give some indication of critical internal decay. It won't give any percent shell to help evaluate hazard potential, and on thick bark trees (like old cottonwoods) may not be very effective. However, don't totally discount this technique. It often is all that is available.

PiCUS Sonic Tomography – A new device that listens to how sound waves move through the trunk/branch. A series of listening devices are strapped around the trunk/branch and connected to a computer. When the tree is tapped with a mallet, the computer measures how the sound moves through the wood and creates a graphic cross-section of the trunk/branch interior. Measurements taken at multiple heights up the trunk can generate a three-dimensional printout. This type of equipment has the potential to totally change tree care when it becomes available to arborists. Currently the cost is prohibitive for most commercial arborists.

Tree Radar – A hand held radar device is run around the trunk/branch. The computer database is sent to the company for evaluation. Currently the cost is prohibitive for most commercial arborists.

Visual indicators of decay:

Large pruning wounds suggest the potential for internal decay. Often decay may be observed within the pruning wound.

Cankers suggest the potential for internal decay. If the canker extends down into the soil, decay organisms will always actively develop.

Valleys, ridges, cracks, and splits along the trunk/branch suggest the potential for decay.

Wildlife living inside the tree is a sign of decay.

Abnormal swellings or shapes could be a sign that the tree is growing around a decayed area.

Figure 9. Structural strength is significantly compromised when the pipe-like structure of a trunk has a break in the cylinder wall.

Breaks in the Pipe-Like Structure

When a wound or pruning cut breaks the pipe-like structure of a trunk/branch, the tree is especially weak at this location, creating a higher potential for tree failure.

Creating Strong Branch Unions

Most storm damage in Colorado landscape trees results from failures at the **branch union** (crotch). A primary objective in training young trees is to develop strong branch unions and eliminate structurally weak branch unions.

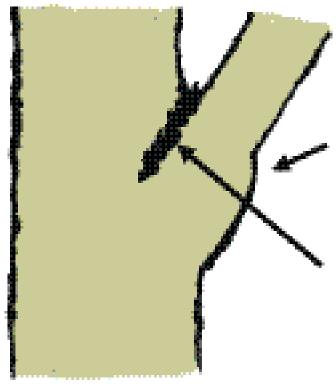


Figure 10. Structural strength of the branch union (crotch) is based on the development of the branch collar.

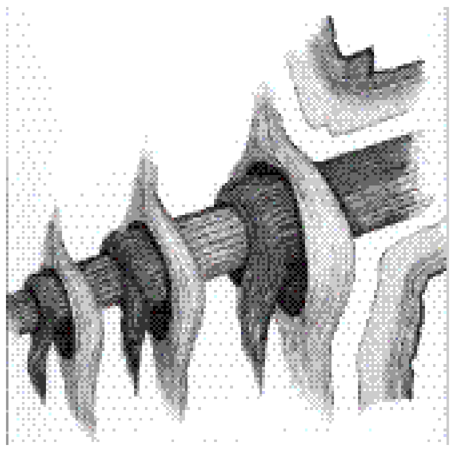
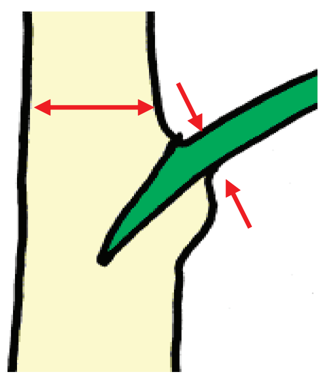


Figure 11. The branch collar is where annual growth rings of the trunk overlap the annual growth rings of the branch like shuffling a deck of cards. This creates a very solid section of wood, known as the "knot" in lumber.



Structural strength of a branch union is based on the development of a **branch collar**.

The branch collar is where the annual growth rings of the trunk overlap the annual growth rings of the branch like shuffling a deck of cards. In lumber, the branch collar is called the knot.

Figure 12. As a branch grows, branch tissues connect into the trunk in a wedge-shape, making a structurally strong unit.

For the branch collar to develop, the branch must be less than half the diameter of the adjacent trunk. Less than one-third is preferred.

A branch collar will not develop on co-dominant trunks (adjoining trunks of similar size) making this branch union structurally weak.

Multiple branches arising at the same location comp speci

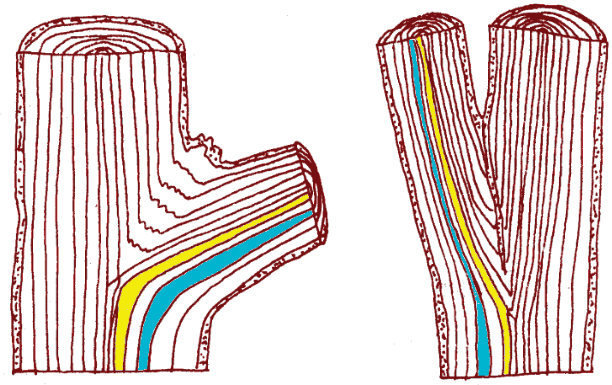


Figure 13. Branch unions that form a right angle are also highly resistant to decay. While a branch union with co-dominant trunks is highly prone to the spread of decay.

develop multiple branches at one location. This predisposes the tree to storm damage if the situation is not corrected by structural training when the tree is young.

Implications of Growth and Decay on Pruning

In pruning, it is imperative that we minimize the potential for decay with any pruning cuts. **Thinning cuts**, when properly made, minimize the potential for decay. **Reduction cuts** on large branches and/or trees under stress will predispose the tree to decay. For details on types of pruning cuts, refer to fact sheet 7.821, *Pruning Cuts*.

To minimize the potential for decay, all pruning cuts should be made on branches less than 2-inch diameter. Any cut on a branch larger than 4-inch diameter should be justified, taking into account the potential for decay.

Avoid large cuts that break the pipe-like structure, creating a structural weakness.

In training trees for structural integrity, the arborist has zero tolerance for co-dominant trunks. Co-dominant trunks are highly prone to storm damage. Co-dominant trunks frequently develop on many species of trees.

In training trees for structural integrity, give attention to developing strong branch unions with branch collars. That is, to branch spacing and branch union (crotch) angles.

Additional Information

Fact Sheets on Pruning

- *7.820,* Tree Growth and Decay
- *7.821,* Tree Decay and Pruning Cuts
- *7.822,* Structural Training of Trees with a Central Leader
- *7.823,* Structural Training of Trees with Multiple Scaffold Branches
- *7.824,* Structural Training of Trees – Pruning Flow Chart
- *7.825,* Pruning Mature Shade Trees
- *7.826,* Pruning Flowering Shrubs
- *7.827,* Pruning Evergreens

Books

Edward F Gilman. An Illustrated Guide to Pruning*, Second Edition. Delmar. 2002*

Web

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

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