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Wood Identification for Species Native to Virginia

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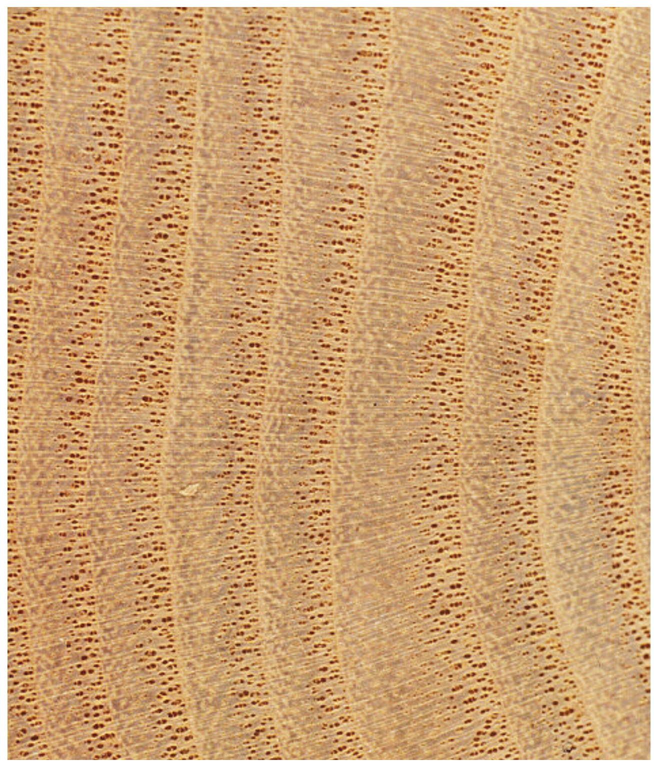
Introduction

Virginia has many tree species that yield a rich variety of wood, each with its own unique structural, physical, and mechanical properties. These differences determine a species' suitability for products. Because wood is a readily available and popular material, it is important that enthusiasts and professionals be able to distinguish between different species. For example, how would a barrel manufacturer tell the difference between red oak, which doesn't hold liquids, and white oak, which does?

Wood of a particular species or species group can be identified by its unique features. These features include strength, density, hardness, odor, texture, and color. Reliable wood identification usually requires the ability to recognize basic differences in cellular structure and wood anatomy.

Each species has a unique cellular structure that creates differences in wood properties and ultimately determines the suitability for a particular use. Cellular characteristics provide a blueprint for accurate wood identification.

Wood is composed of many small cells, and its structure is determined by the type, size, shape, and arrangement of these cells. The structure and characteristics of wood can vary between species and within the same species. With practice, a small hand lens (10 times magnification) can be used to distinguish the different cell types and their arrangements. By using the proper techniques, you can become efficient and accurate at wood identification.



Magnified cross-sectional view of sassafras showing pore size and structure. Photo courtesy of Brian Bond.

This publication provides information on how to identify the wood of several species common to Virginia using a hand-magnifying lens. It includes a wood identification key for some common Virginia species, a list of key species characteristics, and a list of companies that sell wood identification sample sets. Terms in boldface are defined in the glossary at the end of the publication.

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Wood Surfaces

Wood surfaces are classified into three categories, or geometric planes of reference, that indicate the type of surface uncovered after a cut has been made. The three reference planes are the cross section, radial section, and tangential section. Most of the wood cell-structure characteristics discussed in this publication are best viewed from the **cross section** surface of the wood. Figure 1 depicts the three reference planes of wood.

The cross section is produced by cutting the cells perpendicularly to the direction of growth in the tree. This is the same surface seen on a stump after felling a tree. It is important to determine which reference plane you are viewing when identifying wood, because cell structure is three-dimensional and varies based on orientation.

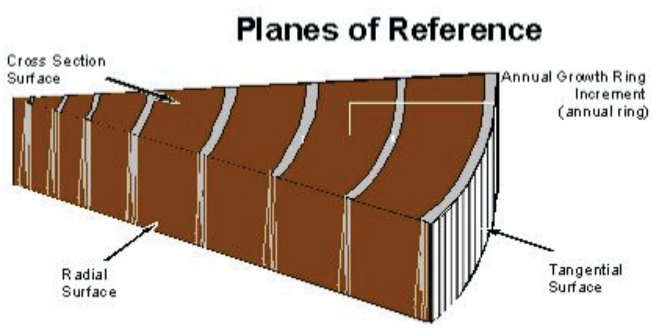


Figure 1. Three-dimensional orientation of wood material. Image courtesy of Paul Winistorfer.

Cross Section Characteristics

By cutting a tree and exposing the cross section, you can observe the bark, phloem (bark-producing layer), cambium (a thin layer inside the bark where cell division takes place), and xylem (sapwood and heartwood; fig. 2).

Heartwood is the common term for the older xylem, located toward the center of the tree, that accumulates extractives (chemical compounds) that create color, aromatic, and decay-resistant characteristics in some woods. These extractives are what give cedar its pleasant aroma, redwood its decay resistance, and walnut its dark color.

The sapwood surrounds the heartwood and is lighter-colored. The size and width of the sapwood will vary greatly between species. For example, the sapwood of locust is a very narrow outer band, and the sapwood of black cherry is very wide. The color and odor of heartwood can also be useful in identifying certain species like red cedar, sassafras, and black walnut.

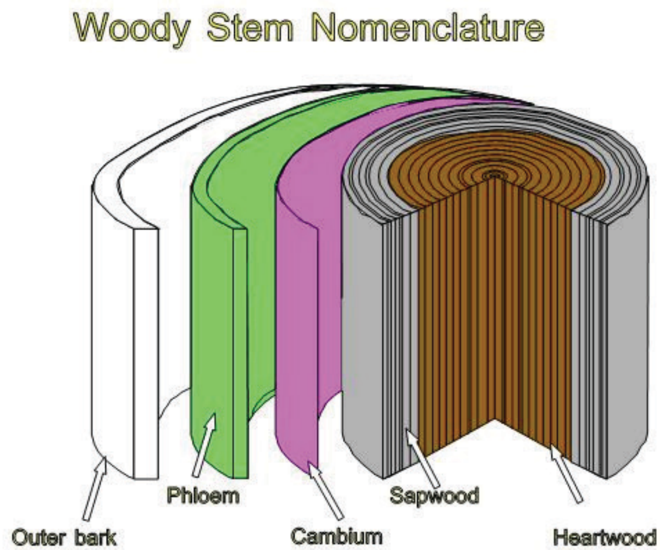


Figure 2. Primary layers of wood tissue through the diameter of a tree. Image courtesy of Paul Winistorfer.

Another visible feature on the cross section are the growth rings. A growth ring represents one year of wood formation. The development of the wood material inside a growth ring is caused by the changes that occur during the growing season.

Earlywood, or springwood, is formed in the spring and early summer at the beginning of the growing season when trees exhibit rapid growth. Earlywood cells have large diameters and thin cell walls.

Latewood, or summerwood, is formed in late summer and fall, toward the end of the growing season when growth and development slow. Latewood occurs at the outer region of a growth ring and is characterized by cells with greatly thickened cell walls and narrow diameters.

Preparing the Wood Surface

To view the cellular characteristics of wood, it is very useful to have a 10-power (10 times magnification) hand lens to magnify the section you are looking at. Preparation of the wood surface is important and can affect your ability to locate and identify specific cell types.

The cross section is the best section to begin your observation of the cell structure in wood. To prepare a cross section for viewing, make a thin, clean cut with a razor blade or sharp knife. Make the cut across the surface at a slight angle. It is important not to take off too much material or to cut too deeply. It is better to make several thin slicing cuts to enlarge the viewing area rather than trying to make one large cut. Using a dull blade or cutting too deeply will create a poor surface and will mask otherwise useful identifying features. A small area with only a few growth rings is adequate for observation and identification.

How to prepare a good surface for viewing wood structure with a hand lens:

- A sharp blade is required for good surface preparation. A razor blade is best.
- A good, clean surface is one where cells have been cleanly cut rather than torn.
- Do not cut too deep. Deep cuts will result in torn fibers in the wood section and possible injury to your hands and fingers!
- Only a few growth rings on the cross section are needed.
- Wetting the surface with water can be helpful in getting a good, clean section.

Identifying wood is a process of elimination. The best strategy is to search for particular features that will help to categorize the species or group of species that have those features and, thus, eliminate others that do not. The use of an identification key, such as the ones included in this publication, can be helpful for this separation.

Separating Hardwoods From Softwoods

After preparing a surface to view, the first step is to determine whether a specimen is a softwood or hardwood. The terms softwood and hardwood are used to reference the taxonomical division that separates a species; they have little to do with the actual hardness of the wood.

Hardwoods are classified as angiosperms — meaning that these trees use flowers for pollination and have covered seeds for reproduction. Most hardwood trees have broad leaves and are deciduous — they lose their leaves at the end of the growing season. Oaks, maples, birches, and fruit trees are examples of hardwood trees.

Softwoods are gymnosperms, meaning they do not have flowers and use cones for seed reproduction. Most softwood trees are conifers (often referred to as evergreens), have needles or scale-like foliage, and are not deciduous, with a few exceptions (larch, for example). Examples of softwoods include pines, spruces, firs, and hemlocks.

Softwood cellular structure is simple and the majority of cells are **longitudinal tracheids**. Longitudinal tracheids function in water conduction and support. The limited number of cell types makes softwoods more difficult to differentiate from one another.

Hardwood structure is more complex than softwood structure and varies considerably between species. The majority of hardwood volume is composed of fiber cells that offer structural support to the stem.

The major difference between hardwoods and softwoods is the presence of **vessel elements, or pores,** that exist in hardwoods only. The main function of vessel elements is water conduction. Vessel elements can very greatly in size, number, and spacing from one species to another, and from earlywood to latewood.

Some species, like oak, have vessel elements that are extremely large and numerous. Other species, such as yellow-poplar, gum, and birch, have vessel elements that are uniform in size and number and are evenly spaced throughout the growth ring. By using a hand lens, you can determine if vessel elements are present or not, thus separating hardwoods from softwoods. Figure 3 illustrates the three-dimensional differences between hardwood and softwood cell structure.

After determining whether a wood sample is a hardwood or softwood — based on the presence or absence of vessel elements — we can begin to look more closely at other cell types for further assistance with identification.

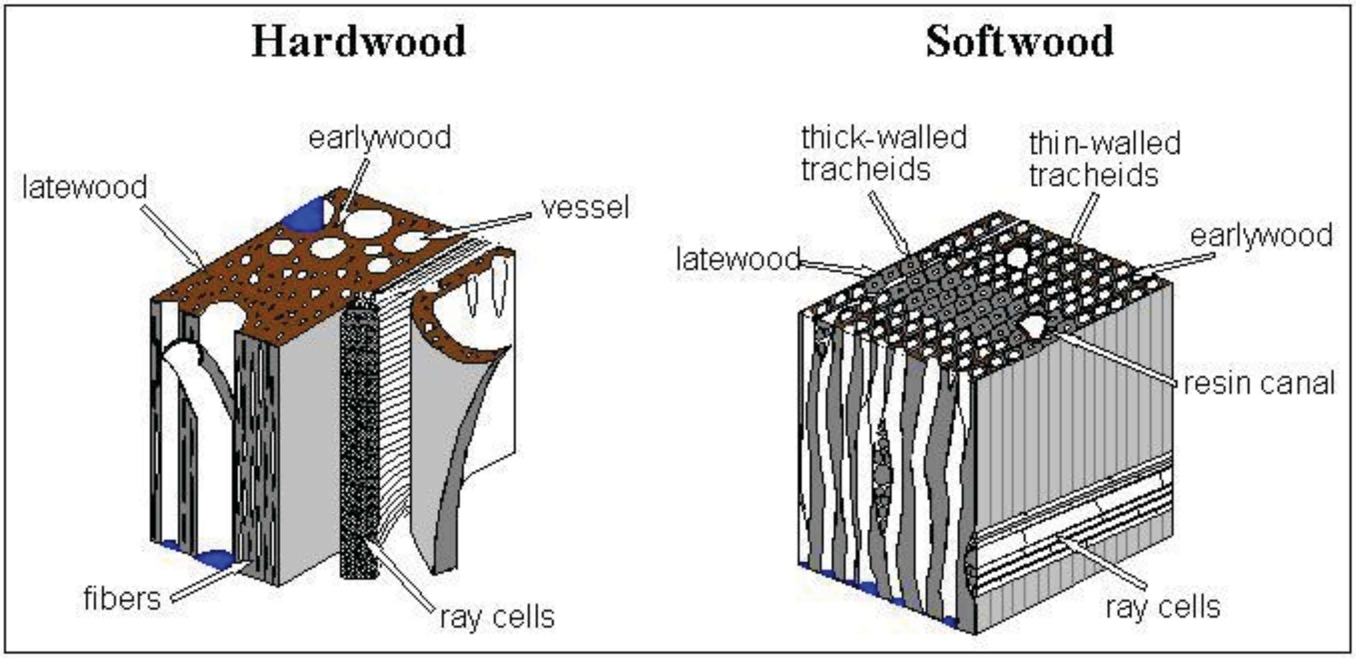


Figure 3. Three-dimensional cell-level comparison between hardwoods and softwoods. Image courtesy of Paul Winistorfer.

Hardwoods

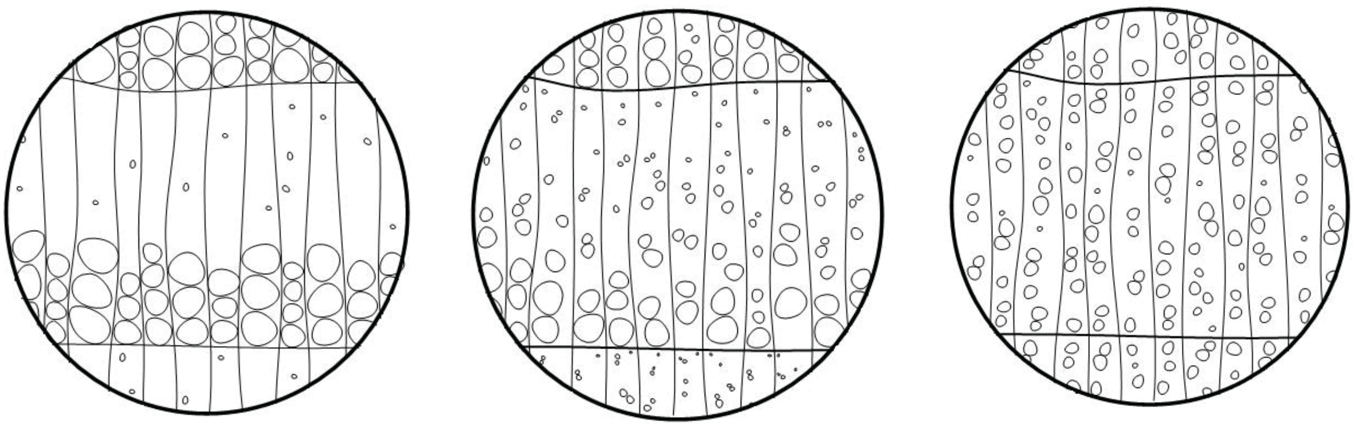
Growth Ring Pore Arrangement

The next major step in identifying hardwoods is to observe and categorize how the change, or transition, in pore size occurs from earlywood to latewood within a growth ring. There are three general classifications for this earlywood/latewood transition, as depicted in figure 4.

1. Ring-porous hardwoods (fig. 4a) – For some groups of species (oaks and elms), the earlywood/latewood transition occurs abruptly and is very distinct. Within each growth ring, a band of large earlywood vessels (pores) is clearly visible to the naked eye, after which a band of latewood vessels appears much smaller and requires the use of a hand lens to see.

2. Semi-ring-porous hardwoods (fig. 4b) – For another group of species (black walnut, butternut, and hickory), the pore transition from large to small diameter within a growth ring is gradual. The pores in the earlywood zone have a large diameter that gradually decreases in size as pores enter the latewood zone.

3. Diffuse-porous hardwoods (fig. 4c) – The last group of species has vessels (pores) that are uniform in size across the entire growth ring (yellow-poplar, gum, and maple). These vessels are usually small, uniform in size, and are very difficult to see with the naked eye (a hand lens is needed).



(A) Ring-porous (B) Semi-ring-porous (C) Diffuse-porous

Figure 4. Classification of pore transition from earlywood to latewood. Image courtesy of Patrick Rappold.

Vessel (Pore) Arrangement

Vessel elements (pores) can be described by their position relative to each other in a cross section. Different species have unique vessel arrangements. Figure 5 shows some of the more common vessel arrangements.

Solitary pores (fig. 5a) – Single pores that do not touch any other pores, evenly spaced across cross section (maples).

Pore multiples (fig. 5b) – Arrangement where two to five pores appear grouped together. Pore multiples usually occur in radial rows (cottonwood) but can occur in both radial and tangential directions (hickory).

Pore chains (fig. 5c) – Arrangement where pore multiples appear in radial direction only (basswood).

Nested pores (fig. 5d) – When larger numbers of pores contact each other both radially and tangentially, also called a cluster (black locust).

Wavy bands (fig. 5e) – Pores are arranged in irregular concentric bands. Also called "ulmiform" because this characteristic is distinctive of all elms (also hackberry).

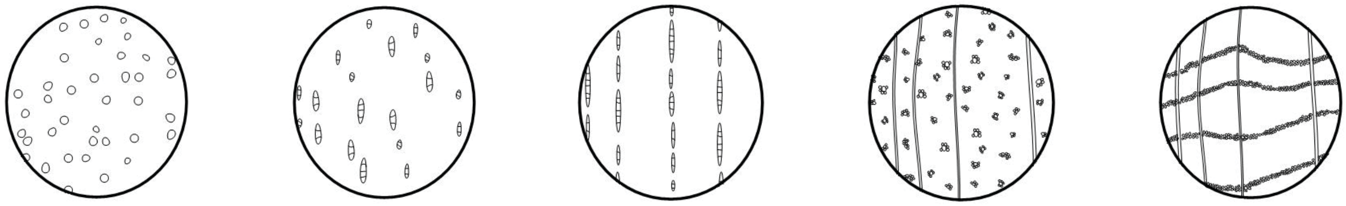


Figure 5. Vessel (pore) arrangement. Image courtesy of Patrick Rappold.

Wood Rays

Once the pore distribution and arrangement have been identified, it is important to look at the size and arrangement of **wood rays**. Wood rays are seen as narrow stripes or lines that extend across the growth rings in the radial direction, from the bark to the center of the tree. Wood rays function to transport food and water horizontally across the diameter of a tree.

The size and distribution of rays on the cross section are quite unique for many species and groups of species. Species such as red and white oak have very wide rays (many cells wide) that are easily seen without a hand lens. Species such as yellow-poplar, ash, and maple have numerous and extremely narrow rays (just one to two cells wide). The distribution of rays can also be used to separate some species. For example, beech and sycamore both have large, conspicuous rays with fine, narrow rays running between them.

Another useful characteristic of rays that can be observed on the cross section of some species is the presence of nodes, a swelling of the ray at the intersection of a new growth ring where the earlywood zone begins. Ray nodes are seen in yellow-poplar, beech, and sycamore.

When viewing a piece of wood from either the radial or tangential surface, wood rays can be a key characteristic to help identify the species. Rays vary not only in width but also in height. The height of a ray is best observed from the tangential surface. Ray height varies between species from imperceptibly small to several inches high. For example, in red oak, ray height never exceeds 1 inch, while in white oak, the height of the rays are consistently greater than 1 1/4 inches.

When wood is cut radially — across the plane where rays extend through the diameter of the cross section surface — many rays are split and exposed in patches on the radial surface. In many species — maple, sycamore, and beech especially — these patches of split rays contrast in color from the longitudinal tissue around them and form a freckled pattern on the radial surface called "ray fleck."

Parenchyma

Parenchyma are small, thin-walled, longitudinal cells that provide nutrient storage. These cells are sparse in softwoods but are often quite significant in hardwoods. Parenchyma are often very small and difficult to see. However, there are many species with visible and unique arrangements of parenchyma cells that offer a clear structural feature for decisive identification.

There are two basic types of parenchyma: paratracheal and apotracheal. Paratracheal parenchyma make contact with pores or vessel elements, while apotracheal parenchyma is separated from pores by fibers or rays. Figure 6 shows the various types of paratracheal and apotracheal parenchyma.

In most species, apotracheal parenchyma are not useful in identifying wood with just a hand lens. One exception is yellow-poplar, which has a fine, clear, bright line of marginal apotracheal parenchyma at the edge of every growth ring. Because yellow-poplar is a diffuse, porous species, the presence of marginal parenchyma aids tremendously in its identification. Paratrachal parenchyma appear in many forms and are often more useful for identification. For example, in hickory, the banded parenchyma look like a reticulate, web-like formation as it connects between the rays and pores. This web-like appearance is unique to hickory**.**

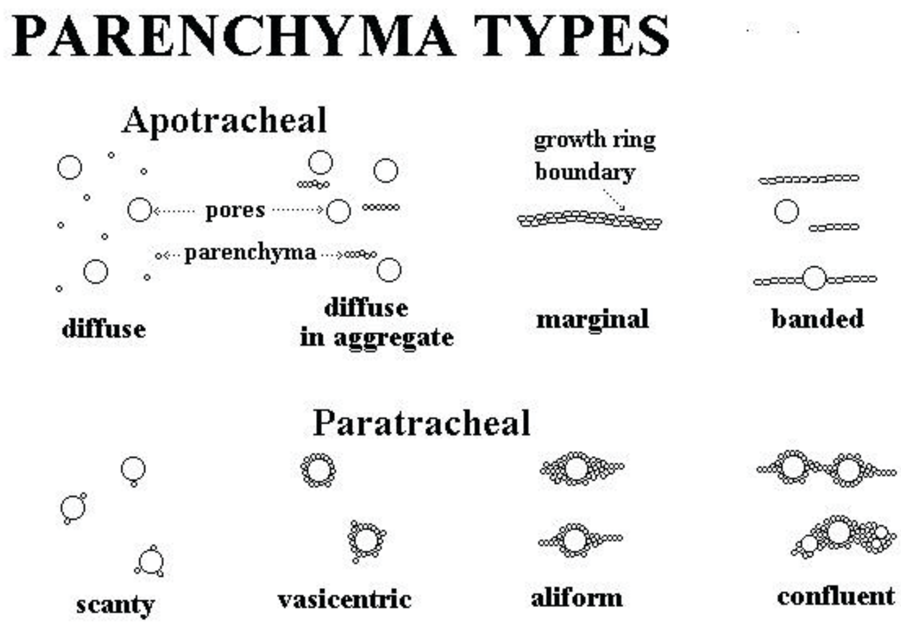


Figure 6. Classification of parenchyma arrangements around hardwood pores (cross section view).
Image courtesy of Paul Winistorfer.

Tyloses

Tyloses are occlusions that form inside the vessels of some hardwoods. Because tyloses are unique to certain hardwood species, they are useful for wood identification. Tyloses are outgrowths of parenchyma cells into the hollow lumens of vessels, and they look like bubbles or cellophane-like structures clogging the openings of the vessel elements. Tyloses may be absent or sparse, as in red oak; variable, as in the case of chestnut and ash; or densely packed and abundant, as they appear in white oak and locust. Tyloses effectively clog the vessels and subsequently restrict moisture movement. The presence of tyloses is the reason white oak is used for making whiskey barrels instead of red oak.

Color, Odor, and Density

Color, odor, and density are other characteristics of wood species that are fundamental to wood identification. These characteristics are remarkably variable in hardwoods and often provide the first clue to identify a particular wood species.

Hardwoods come in a variety of colors and shades that often allow immediate and unmistakable recognition. Consider the lush reddish brown of black cherry, the deep chocolate brown of black walnut, or the creamy white of hard maple.

Less obvious, but certainly helpful to wood identification are odor characteristics. Many hardwoods have distinctive natural odors. Black cherry, for example, has an unmistakably fragrant aroma, while red oak is more bitter and acidic smelling. Both color and odor characteristics can change or become less distinct over time.

Hardwoods also vary significantly with respect to density. The density of wood is related to its hardness, strength, and weight. Typically, a dense species of wood is heavier, harder, and stronger than a less-dense species. Hardness is particularly useful when distinguishing between hard and soft maples. Soft maples can be easily dented with your fingernail or sliced with a razor blade, while it is much more difficult to make an impression in hard maples. Hickory, black locust, and osage-orange are quite heavy compared to most other species. Wood hardness can roughly be gauged by how difficult or easy it is to make a cut on the cross section of a piece of wood when preparing the surface for examination.

Softwoods

Resin Canals

The first step after making the determination that a wood specimen is softwood due to the absence of pores is to inspect the cross section surface for the presence of **resin canals**. Resin canals are tubular passages in wood that exude pitch, or resin, to seal off wounds that occur due to insect or mechanical damage. Resin canals most often occur in or near the latewood zone of the growth rings. Softwoods can be separated into two classifications based on the presence or absence of resin canals. Species that have resin canals are pines, spruces, larches, and Douglas-fir. The species in Virginia that do not have resin canals include firs, hemlocks, cedars, redwood, yew, and baldcypress.

Woods with resin canals are further separated into two groups: (1) those with large resin canals — pines, and (2) those with small resin canals — Douglas-fir, spruce, and larch. Using a sample wood identification set to compare the size and number of resin canals of different species is useful in determining how much they can differ between species.

For example, most pines have quite large and numerous resin canals that can be seen without the aid of a hand lens. Spruce and larch, on the other hand, have much smaller resin canals that occur less frequently. Douglas-fir has many small resin canals. Because the presence of resin canals is quite variable, it may be necessary to make several cuts on the cross section of a specimen to uncover enough surface area to make a good determination.

Growth Rings: Earlywood and Latewood

In softwoods, earlywood/latewood characteristics can provide useful information for identification. The features to compare are: (1) the nature of the earlywood/latewood transition — abrupt or gradual, and (2) the percentage of latewood occupying the growth ring.

When identifying hardwoods, the size and distribution of pores between earlywood and latewood is a discriminating factor. Because softwoods have no pores, the difference between the earlywood and latewood zones in the growth ring occurs due to effects the growing season has on the longitudinal tracheids (the dominant cell type in softwoods). The earlywood zone of a growth ring typically consists of thin-walled, larger-diameter cells, while the latewood zone features thick-walled, smaller-diameter cells. Thus, for many species, the earlywood zone appears lighter in color, contrasting with the latewood zone, which is often a darker or browner shade.

For some species, the transition from the lighter-colored earlywood to the darker-colored latewood is distinct and abrupt (southern yellow pine, Douglas-fir, redwood). For other woods, this transition is extremely gradual and even imperceptible (white pine, cedars). Some species have an earlywood and latewood transition that falls between gradual and abrupt (spruce, fir, hemlock).

Color, Odor, and Density

As with the hardwoods, color, odor, and density are useful characteristics in identifying softwoods. Some species have distinct color differences, while others do not. Eastern white pine is consistently yellowish-white, darkening to light brown with age. Eastern red cedar has a distinctive deep purplish-red color, and redwood is a deep reddish-brown.

Examples of odors include the "piney" fragrance of pines, the cedar-chest scent of eastern red cedar, and the relative absence of smell in spruce, firs, and hemlocks. As with hardwoods, distinguishing color and odors can fade with time.

Softwoods also vary substantially in density. Because many species are quite dense and strong, softwood lumber is typically used for structural or construction purposes. Southern yellow pine, spruce, hemlock, fir, and Douglas-fir are all commonly used in the construction industry. White pine and cedars, on the other hand, are considerably less dense and lighter in weight than the other species; they are easier to slice with a razor blade when preparing a surface for identification.

Using the Keys for Identification

Both a hardwood key (fig. 7) and a softwood key (fig. 8) are provided to assist with species identification.

The first step is to identify if the piece of wood in question is a hardwood or softwood. This is done by observing the cross section for the presence of vessel elements or pores. If this feature exists, start with the hardwood key. If vessels elements are absent, start with the softwood key.

Each key outlines the order of important anatomical features that are present in particular species. As you follow through the key, identifying characteristics will become smaller and require more skill to observe. Also, as you progress through the key, the species of wood will be identified by a specific anatomical structure.

A different approach is to use the checklists provided (tables 1 and 2). You can check off the anatomical features present in your sample until the species is identified. The checklist is easier to use once you have gained some experience using the species key.

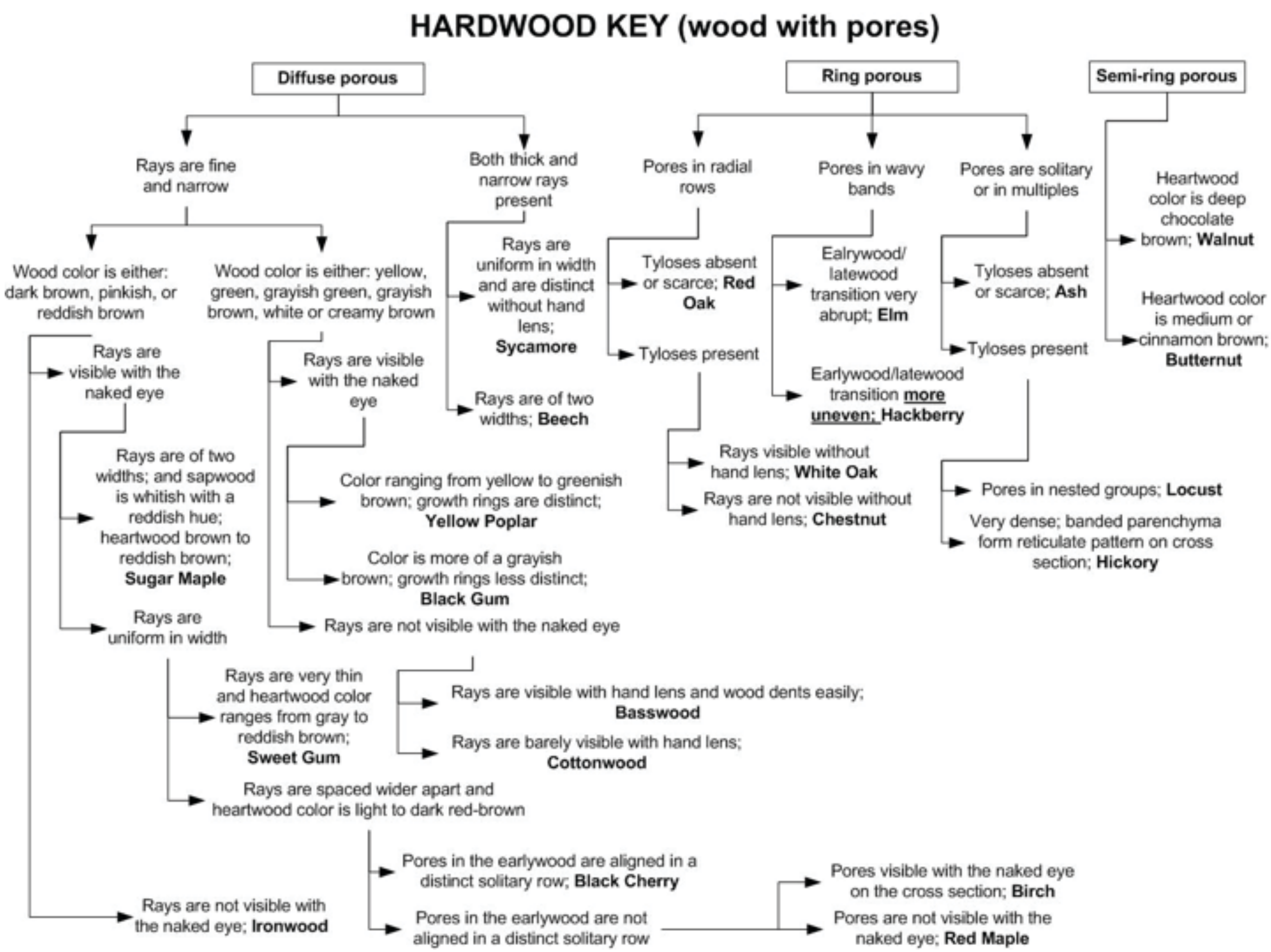


Figure 7. Hardwood key. Image courtesy of Brian Bond and Patrick Rappold.

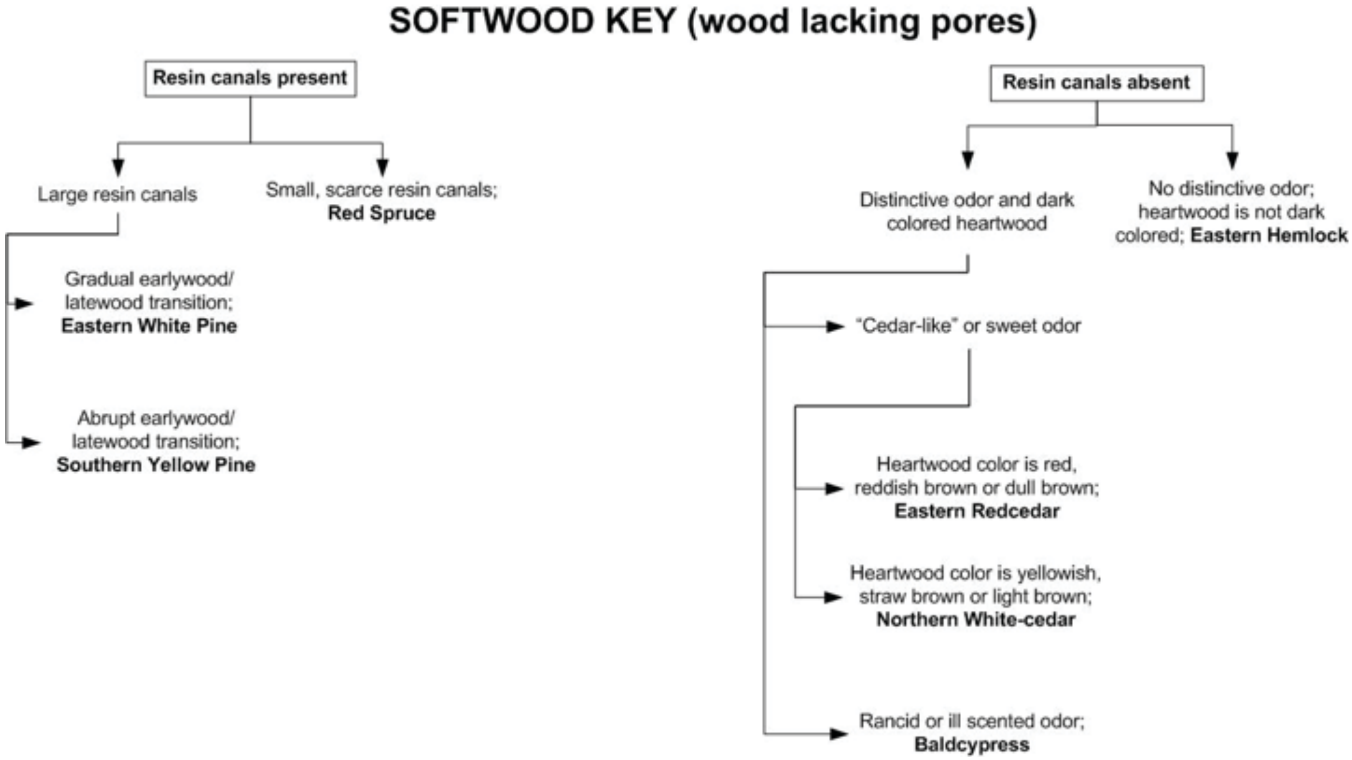


Figure 8. Softwood key. Image courtesy of Brian Bond and Patrick Rappold.

Table 1. Checklist of features for hardwoods.

Species	Pore transition			Vessel (pore) arrangemnt					Rays		Parechyma type		Tyloses	
	Ring-porous	Semi-ring-porous	Diffuse-porous	Solitary pores	Pore multiples	Pore chains	Nested pores (clusters)	Wavy bands (ulmiform)	Thick	Thin	Apotracheal	Paratracheal	Present	Absent
American chestnut *Castanea dentata*	•				•					•	1[a]	A[b]	•	
American elm *Ulmus americana*	•							•		•		a	•	
Ash *Fraxinus* spp.	•			•	•					•		b	•	
Black locust *Robinia pseudoacacia*	•						•			•		b	•	
Hackberry *Celtis occidentalis*	•							•		•	1		•	
Hickory *Carya* spp.	•				•					•	1		•	
Northern red oak *Quercus rubra*	•			•					•		4			•
White oak *Quercus alba*	•			•					•		4		•	
Black walnut *Juglans nigra*		•		•	•					•	4	b	•	
Butternut *Juglans cinerea*		•		•	•					•	4		•	
American basswood *Tilia americana*			•		•					•	3			•
American beech *Fagus gandifolia*			•	•	•				•		4			•
Black cherry *Prunus serotina*			•	•						•	Absent			•
Black gum *Nyssa sylvatica*			•		•					•	1	a		•
Eastern cottonwood *Populus deltoides*			•		•					•	3			•
Eastern hophornbeam *Ostrya virginiana*			•		•					•	4			•
Sweetgum *Liquidambar styraciflua*			•		•	•				•	1	a		•
Sycamore *Platanus occidentalis*			•	•					•		1	a		•
Sugar maple *Acer saccharum*			•	•						•	1	a		•
Red maple *Acer rubrum*			•	•						•	1	a		•
Yellow birch *Betula alleghaniensis*			•		•					•	1			•
Yellow-poplar *Liriodendron tulipifera*			•		•					•	3			•

[a] Apotracheal parenchyma types : 1 = diffuse, 2 = diffuse in aggregate, 3 = marginal, 4 = banded.
[b] Paratracheal parenchyma types : a = scanty, b = vasicentric, c = aliform, d = confluent.

Table 2. Checklist of features for softwoods.

Species	Resin canals		Growth ring transition		Color	Odor	Texture/density
	Large	Small	Abrupt	Gradual			
Baldcypress *Taxodium distichum*	Absent		•		Yellow to dark brown	Rancid	Coarse
Eastern red cedar *Juniperus virginiana*	Absent			•	Reddish brown	Cedar chest	Very fine
Eastern white pine *Pinus strobus*	•			•	Yellowish white	Piney	Soft
Hemlock *Tsuga canadensis*	Absent		•		Light	None	Medium coarse
Northern white cedar *Thuja occidentalis*	Absent			•	Straw brown	Pungent	Medium fine
Red spruce *Picea rubens*		•		•	Light	None	Soft
Southern yellow pine *Pinus* spp.	•		•		Yellowish red	Pine	Medium

Summary

If you know what to look for and where to look, your eye can be trained to pick up unique wood characteristics, enabling accurate wood identification. While this publication outlines the general principles of wood identification using a hand lens, anyone seeking more in-depth and complete methods should refer to one of the publications listed in the Resources section.

Resources

Other Publications Related to Wood Identification

Core, H. A., W. A. Cote, and A. C. Day. 1979. *Wood Structure and Identification.* 2nd ed. Syracuse, N.Y.: Syracuse Univeristy Press.

Hoadley, R. B. 1990. *Identifying Wood: Accurate Results With Simple Tools*. Newton, Conn.: Taunton Press.

Panshin, A. J., and C. de Zeeuw. 1980. *Textbook of Wood Technology*. New York: McGraw-Hill.

Tree Talk Inc. 1994. *Woods of the World*. CD-ROM. Burlington, Vt.: Tree Talk.

Sources of Wood Samples for Identification

Firewood Treasures
604 Scarlet Oak Ct.
Woodsboro, MD 21798
www.firewoodtreasures.com/woodkit1.asp

Heritage Woods Inc
6543 Thornapple River Dr.
Alto, MI 49302
800-809-9644
www.heritagewoodsinc.com

International Wood Collectors Society
13249 Hwy. 84 N
Cordova, IL 61242-9708
309-523-2852
www.woodcollectors.org/

Woodcraft Supply LLC
1177 Rosemar Rd.
P.O. Box 1686
Parkersburg, WV 26102
800-225-1153
www.woodcraft.com

For more information or to inquire about wood identification short courses hosted by the Department of Wood Science and Forest Products at Virginia Tech, please contact:

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Glossary

Cross section –The cross section is produced by cutting the cells perpendicularly to the direction of growth in the tree

Earlywood or springwood – Cells formed in the spring and early summer at the beginning of the growing season when trees exhibit rapid growth. Earlywood cells have large diameters and thin cell walls.

Latewood or summerwood – Cells formed in late summer and fall, toward the end of the growing season when growth and development slow. Latewood occurs at the outer region of a growth ring and is characterized by cells with greatly thickened cell walls and narrow diameters.

Longitudinal tracheids – Simple cell structure; cells function in water conduction and support. Most common cell type in softwoods.

Parenchyma – Small, thin-walled, longitudinal cells that provide nutrient storage. These cells are sparse in softwoods but are often quite significant in hardwoods.

Resin canals – Tubular passages in wood that exude pitch, or resin, to seal off wounds that occur due to insect or mechanical damage.

Vessel elements or pores – Cell type that exists in hardwoods only. The main function of vessel elements is water conduction. Vessel elements can very greatly in size, number, and spacing from one species to another and from earlywood to latewood.

Wood rays – Cells seen as narrow stripes or lines that extend across the growth rings in the radial direction, from the bark to the center of the tree. Wood rays function to transport food and water horizontally across the diameter of a tree.