COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

AN INTRODUCTION TO Wood Anatomy Characteristics Common To Softwoods & Hardwoods

Introduction

Those who work with wood should have a basic understanding of wood anatomy so they will be familiar with how different anatomical features influence wood properties and, in turn, how these properties react to different treatments and uses of the wood.

This publication introduces the reader to wood characteristics that are common to both hardwoods and softwoods. Trees can be divided into two classes based on different anatomical characteristics, monocotyledoneae and dicotyledoneae. (For more information on the classification of trees, request a copy of FOR-61 from your local Extension office). There are no commercially important monocot trees in the United States, although some items made from such woods as bamboo, palm, and rattan, are often imported into this country. Although these monocots produce woody stems, their anatomy is quite different from that of dicots and will not be discussed in this publication.

Common Characteristics of Tree Structure

Chemical Composition of Wood

All wood is composed of cellulose, lignin, ash-forming minerals, and extractives formed into a cellular structure. The characteristics and amounts of these components and differences in cellular structures result in significant variations. Some woods are heavier, some lighter, some stiffer, some more flexible, some harder, some softer, and some easier to work with than others. It is these differences that make wood such a unique material.

It is beyond this publication to do more than mention the different chemical compositions of wood. Because harsh chemicals are needed to separate some of these components from others, wood scientists do not know everything about the structures and functions of some of these chemicals. In addition, the components themselves are somewhat altered during the separation processes.

Cellulose

Cellulose is the principal component of the cell walls of trees. It also makes up the cell walls of other plants, including all the higher plants, most algae, and some fungi. It is the most important component for its effect on the properties of wood. Hemicellulose, composed of shorter molecules than cellulose, makes up a large part of wood. It is also important for some properties of wood.

Lignin

Lignin can be thought of as the glue that holds the wood (cellulose and hemicellulose) together. Lignin is important because it gives rigidity to the cells so that a tree can grow large and tall.

Ash

The ash content of wood is made up of inorganic minerals, primarily calcium, potassium, and magnesium. Manganese and silica are two other common minerals. If silica is found in sufficient amounts (0.5% oven-dry[1] weight), it can dull machining equipment.

Extractives

Common characteristics that we use to identify different woods with the naked eye come from extractives in the wood. Without extractives, wood would have to be identified solely by its anatomical structure. Extractives are made up of an extremely wide range of organic compounds. These chemical compounds are not part of the wood but accumulate there.

The amounts and types of extractives help to determine the wood's permeability to liquids and influence other wood properties such as density, hardness, and compressive strength. Extractives give certain woods their resistance to insect or fungi attack. (For more information about insect and decay resistance, see FOR-54.)

Many useful chemicals are made from the extractives found in trees. They also cause the odors and colors attribut-

[1] *Oven-dry refers to the fact that all moisture is forced from samples before weights are obtained.*

ed to most woods. In a number of woods, such as cherry, walnut, and mahogany, the extractive colors make these woods very valuable for furniture, wood paneling, and other products.

In general terms, the chemical composition of wood from trees found in the United States, on an oven-dry basis, can be summarized as follows:

Cellulose	*40 to 50 percent*
Hemicellulose	*20 to 35 percent*
Lignin	*15 to 35 percent*
Ash	*less than 1 percent*
Miscellaneous compounds	*usually 1-2 percent*

How a Tree Grows

Site of New Growth

In both hardwoods and softwoods, new growth, including new wood and new bark, occurs as a sheath covering the main stem, branches, and twigs (Figure 1). Trees grow longer or taller only at the tips of stems.

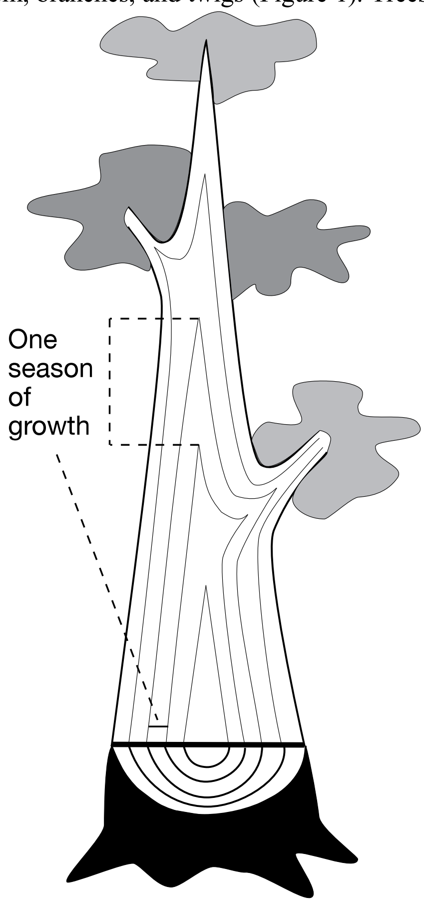

Figure 1. New growth occurs as a sheath covering the main stem, branches, and twigs

You may have seen a cartoon showing someone finding a branch that is perfect for a swing, then returning several years later only to find the branch twenty feet farther off the ground. In reality, this cannot happen because of the way that trees grow. At any point above the ground except at a stem's tip, a tree grows only in diameter. What appears to be the same limb is actually a different one. The old limb has fallen off, and new wood and bark have formed over the old scar.

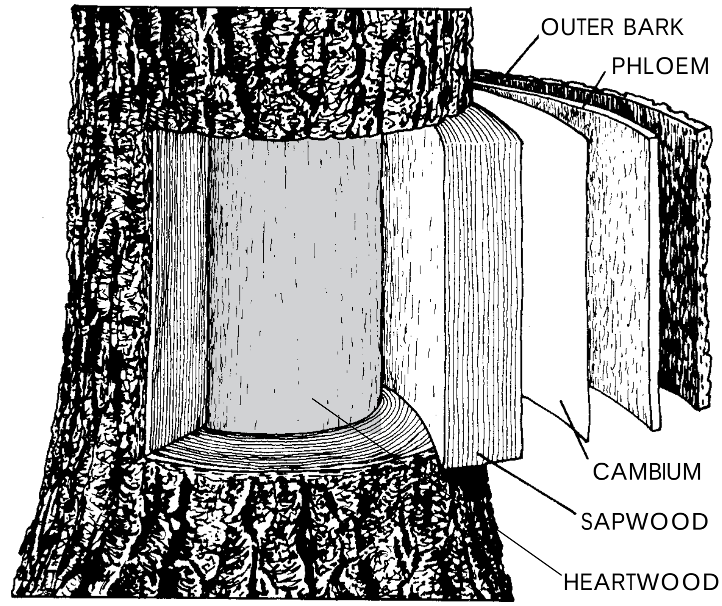

Figure 2. Parts of a tree system.

New Growth of Bark

Bark is an important element in tree growth (Figure 2). The outer bark protects the tree from the outside world and against extreme weather elements. It helps keep moisture in the tree during dry periods. It further protects the tree against diseases and insects.

The inner bark or phloem acts as the pipeline through which the food produced in the leaves passes to the rest of the living tree. This section of cells lives for only a short time before it becomes part of the outer bark.

Between the bark and the wood is a thin layer of living cells (those that contain protoplasm) known as the cambial layer or cambium. The cambium represents the growing part of the trunk. Technically speaking, the cambium is only one cell thick. This cell produces bark on one side and wood on the other. Hormones, known as auxins, are produced in leaf buds in the spring. These auxins are transported through the phloem to the cambium. The auxins cause the cambium cells annually to produce new bark on one side and new wood on the other. Eight to ten times more wood is produced than bark.

Sapwood

Sapwood, or new wood, provides a pipeline for the movement of water and nutrients through the trunk and into the leaves, where the process of photosynthesis occurs. In this process, oxygen is released into the air and carbon dioxide is taken up. Sunlight and chlorophyll, the chemical that causes leaves to have a green color, are two other important components for photosynthesis. During this process, sugars are made that the tree uses for food. The sap, made up of water and dissolved nutrients, carries the sugars from the leaves through the phloem to the cambium layer where the energy is used to produce new bark and wood. As new rings of sapwood are laid on top, the older sapwood loses its vitality and turns into heartwood.

Heartwood

Heartwood forms the central support of the tree. Although it is made up of dead cells, it will never decay or lose strength as long as the sapwood and bark remain intact. Accumulation of extractives gives the heartwood of many species a darker color than that of the sapwood.

Annual Growth Rings

In temperate climates, where there is a growing season followed by a dormant season, the seasonal production of new wood produces the annual growth rings that are visible on the cross section of a tree stem. A year's formation of wood begins with larger cells in the spring and ends with smaller cells in the summer. The larger cells, called early-wood or springwood, form as the tree is more actively growing. The smaller cells, called latewood or summerwood, form as the tree is growing more slowly.

Growth rings on the lower portion a tree trunk can be counted to estimate the age of a tree, but false rings can sometimes form because of drought, late frosts, or defoliation by insects or harsh weather. The trauma causes the tree to produce latewood cells. If conditions improve, the tree can produce another ring of earlywood and then latewood cells, thus producing two or more rings in a single year.

Wood Rays

Most transfers of water, nutrients, and chemicals occur up and down in a tree. However, there is some transfer across the tree. Sap moves down the tree through the phloem. The sap, containing water and nutrients, is transported horizontally to the cambium through structures called wood rays. Wood rays also act as storage areas for the carbohydrates that the tree uses as food.

If you carefully examine a cross section of wood with a 10X hand lens, you can see the wood rays as narrow stripes or lines crossing the growth rings and extending from the bark to the pith or center of the tree. Wood rays of oaks and beech can easily be seen with the naked eye. Wood rays of other kinds of trees, including most softwoods, are hard to see even with a 10X hand lens.

Three Primary Surfaces of Wood

Because of the way trees grow, you can generally view three very different surfaces of wood, including transverse, radial, or tangential surfaces (see Figure 3).

The transverse or cross-sectional surface is what you see when you look at the end of a board or log, and down on a tree trunk. Growth rings are very apparent and appear as part of a circle on this surface. The radial surface parallels the stem and passes through the pith. If you split a log in half, you will produce two radial surfaces. The tangential surface is named because it is the surface tangent to the growth rings. It is perpendicular to the direction of the wood rays.

The three surfaces of wood are important because wood structures appear very different depending on which surface is being viewed. Wood workers can alter the appearance of their wood projects by working with the different surfaces for the same kinds of wood. Figure 4 illustrates how wood grain in boards can be altered by the way the board is cut from a log.

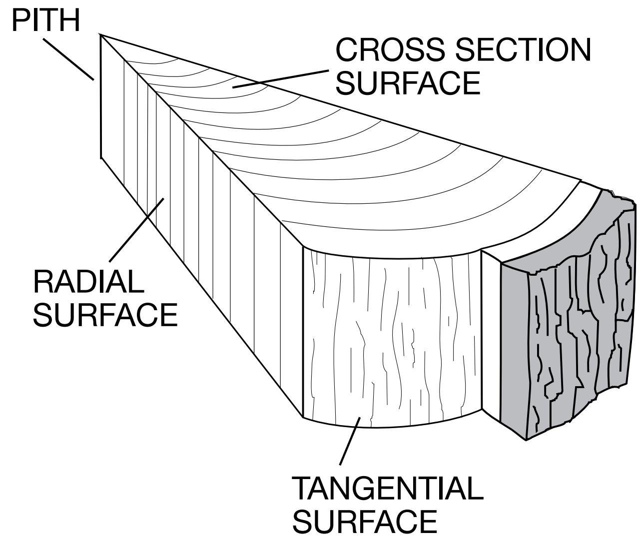

Figure 3. This diagram shows the three wood faces (radial, tangential and cross-section)

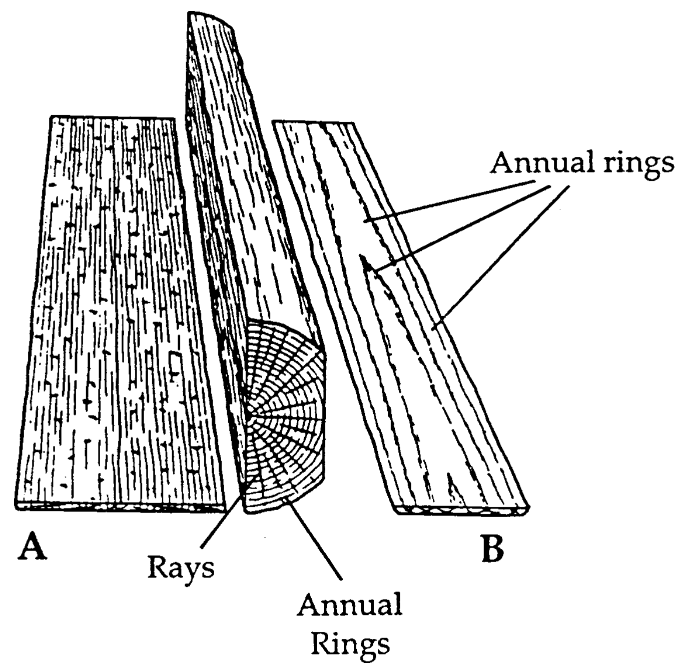

Figure 4. (A) Edgegrained or quartersawn (B) Flatsawn

Grain in wood is caused by the annual growth rings, wood rays, and other cell structures in the wood. The grain runs in the direction of height growth. Lumber sawed across the growth rings and parallel with the wood rays exposes the radial surface. The boards produced are said to be edge-grained or quartersawn. Lumber sawed parallel to the growth rings shows a chevron-shaped pattern. The boards produced are said to flatsawn or plainsawn.

For more information on wood anatomy contact your county Cooperative Extension Agent or a specialist at the Department of Forestry at the University of Kentucky.

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