Wood is a dynamic medium. Like all organic materials, it has character and quirks, responds to its environment, and changes over time. Because of its “personality,” wood should be treated with understanding and a certain amount of care. For wood flooring professionals, knowing about the properties of wood in general, as well as those of individual wood species, is critical to proper installation. For consumers, it’s important to have realistic expectations about how wood will perform. Most wood used for flooring is essentially a byproduct of more expensive wood-consuming industries (furniture manufacture, for example), so it is usually not the highest grade of lumber. However, it is quite economical in comparison.

This publication provides an overview of the mechanical and physical properties of wood, followed by more detailed information on several species used in flooring. In selecting the species described, the aim has been to offer a fair sampling of some of today’s most popular woods. Other species may be included in later editions of this publication.

Note: The samples chosen to illustrate each species were selected to be as representative as possible. In most cases, the samples are plainsawn, select or better grade flooring. However, there are many variations within each species, and the methods used in sanding and finishing will affect the final appearance of a given species. Also, the samples were photographed only a few days after being sanded and finished. Some species, such as domestic cherry, will change color significantly over time. Therefore, the appearance of any installation may vary from the samples shown in this publication.

Properties affecting appearance

Many different factors, from the nature of the living tree to the way the lumber is sawed, affect the way the finished floor will look.

Heartwood, Sapwood: Heartwood is the older, harder central portion of a tree. It usually contains deposits of various materials that frequently give it a darker color than sapwood. It is denser, less permeable and more durable than the surrounding sapwood.

Sapwood is the softer, younger outer portion of a tree that lies between the cambium (formative layer just under the bark) and the heartwood. It is more permeable, less durable and usually lighter in color than the heartwood.

The relative amounts of heartwood and sapwood in a flooring batch may affect the way it accepts stain and finish and, therefore, the finished appearance of the floor. In general, quartersawn and riftsawn flooring will contain less sapwood than plainsawn flooring (see “Types of saw cut,” next page), and will tend to have a straighter grain and more uniform appearance. Heartwood is also more dimensionally stable than sapwood, so flooring with a high percentage of heartwood will shrink and swell less than flooring that is mostly sapwood.

Wood Grain and Texture: “Grain” and “texture” are loosely used to describe similar properties of wood. Grain is often used in reference to annual growth rings, as in “fine” or...
“coarse” grain; it is also used to indicate the direction of fibers, as in straight, spiral and curly grain. The direction of the grain, as well as the amount of figuring in the wood, can affect the way it is sanded and sawed.

Grain is also described as being either “open” or “closed,” referring to the relative size of the pores, which affects the way a wood accepts stain and finishes.

Texture usually refers to the finer structure of the wood, rather than to the annual rings. It is sometimes used to combine the concepts of density and degree of contrast between spring wood and summer wood in the annual growth rings.

Some wood grain terminology

**Annual rings:** Most species grown in temperate climates produce visible annual growth rings that show the difference in density and color between wood formed early and that formed late in the growing season. The inner part of the growth ring, formed first, is called “spring wood”; the outer part, formed later in the season, is called “summer wood.”

Spring wood is characterized by cells having relatively large cavities and thin walls. Summer wood cells have smaller cavities and thicker walls, and consequently are more dense than those in spring wood. The growth rings, when exposed by conventional sawing methods, provide the grain or characteristic pattern of the wood. The distinguishing features among the various species result in part, then, from differences in growth-ring formation. And within species, natural variations in growth ensure the unique character and beauty of each piece of wood.

**Figure:** The pattern produced in a wood surface by annual growth rings, rays, knots, and deviations from regular grain.

**Medullary Rays:** Medullary rays extend radially from the core of the tree toward the bark. They vary in height from a few cells in some species, to four or more inches in the oaks; they’re responsible for the flake effect common to the quartersawn lumber in certain species.

**Tangential Grain:** Usually called flat grain; easily recognized by its parabolic (arched) effect. Lumber is considered “flat-grained” when the annual growth rings make an angle of less than 45 degrees with the wide surface of the board.

**Radial Grain:** Known as vertical or edge grain; generally more dimensionally stable than flat grain—that is, vertical-grain boards are less likely to expand or contract in width with changes in moisture. Lumber is considered “vertical-grained” when the annual growth rings make an angle of 45 to 90 degrees with the wide surface of the board.

(Note: In hardwoods, plainsawn lumber generally contains mostly flat-grained wood, while quartersawn lumber is nearly all vertical-grained. In softwood lumber, the terms “flat-grained” and “vertical-grained” are used instead of the terms “plainsawn” and “quartersawn,” respectively. See “Types of saw cut” below.)

**Interlocked Grain:** Grain in which the fibers may slope in a right-handed direction for several years, in a left-handed direction for several years, back to right-handed, and so on. A high degree of interlocked grain may make a wood difficult to machine.

**TYPES OF SAW CUT:** Lumber is either plainsawn, quartersawn or riftsawn.

Plainsawing is the most common and least expensive method of sawing; most wood flooring is cut this way. Plainsawn lumber is obtained by making the first saw cut on a tangent to the circumference of the log and remaining cuts parallel to the first. This method is the most economical, because it provides the widest boards and results in the least waste.

Since most of the lumber produced by plainsawing is flat-grained, with some vertical-grained wood included, plainsawn lumber will tend to contain more variation within and among boards than quartersawn lumber, in which nearly all of the wood is vertical-grained. Also, since flat-grained wood is less dimensionally stable than vertical-grained, plainsawn lumber will tend to expand and contract more across the width of the boards than quartersawn lumber.

Other physical differences to consider when choosing plainsawn lumber rather than quartersawn:

- Figure patterns resulting from the annual rings and some other types of figures are usually brought out more conspicuously by plainsawing.
- Shakes and pitch pockets, when present, extend through fewer boards.

In quartersawing, lumber is produced by first quartering the log and then sawing perpendicular to the growth rings. Quartersawing produces relatively narrow boards, nearly all vertical-grained, and cre-
ates more waste, making quartersawn lumber more expensive than plainsawn. However, much quartersawn wood is obtained by culling the vertical-grained wood that naturally results from plainsawing.

For reasons other than cost, most people prefer quartersawn wood, although some people favor the greater variety in figuring produced in plainsawing.

Other physical factors to keep in mind when choosing quartersawn lumber over plainsawn:

- It twists and cups less.
- It surface-checks and splits less during seasoning and in use.
- Raised grain produced by separation in the annual growth rings does not appear as pronounced.
- It wears more evenly.
- Figuring due to pronounced rays, interlocked and wavy grain are brought out more conspicuously.
- Sapwood appears only at the edges, and is limited to the width of the sapwood in the log.

Riftsawing is similar to quartersawing, with many of the same advantages and limitations. It accentuates the vertical grain and minimizes the flake effect common in quartersawn oak. The angle of the cut is changed slightly so that fewer saw cuts are parallel to the medullary rays, which are responsible for the flake effect. Riftsawing creates more waste than quartersawing, making it generally more expensive.

Mechanical properties

MOISTURE CONTENT AND DIMENSIONAL STABILITY: Moisture plays a large part in how wood behaves, both during the machining process and after installation. Installers would do well to study moisture’s effect on wood in some detail; however, a brief discussion is worthwhile here.

Moisture content is defined as the weight of water in wood expressed as a percentage of the weight of oven-dry wood. Weight, shrinkage, strength and other properties depend on the moisture content of wood. In trees, moisture content may be as much as 200 percent of the weight of wood substance. After harvesting and milling, the wood will be dried to the proper moisture content for its end use.

Wood is dimensionally stable when the moisture content is above the fiber saturation point (usually about 30 percent moisture content). Below that, wood changes dimension when it gains or loses moisture.

The ideal moisture content for flooring installation can vary from an extreme of 4 to 18 percent, depending on the wood species, the geographic location of the end product and the time of year. Most oak flooring, for example, is milled at 6 to 9 percent. Before installation, solid wood flooring should be acclimated to the area in which it is to be used, then tested with a moisture meter to ensure the proper moisture content.

(Note: Laminated flooring tends to be more dimensionally stable than solid flooring, and does not require acclimation prior to installation.)

Different woods exhibit different moisture stability factors, but they generally shrink and swell the most in the direction of the annual growth rings (tangentially), about half as much across the rings (radially) and only slightly along the grain (longitudinally). This means that plainsawn flooring will tend to shrink and swell more in width than quartersawn flooring, and that most flooring will not shrink or swell much in length.

The individual species descriptions that follow include an indication of dimensional stability, from “below average” to “excellent,” as well as a comparison to red oak. For example, mesquite (the most dimensionally stable species in this publication) is rated as “excellent,” with a notation that it is 65 percent more stable than red oak — that is, mesquite is likely to shrink or swell 65 percent less. The percentages noted are based on comparing a factor called the “dimensional change coefficient” of each species with that of red oak. Red oak was chosen as the benchmark because of its widespread familiarity and use in the flooring industry. For a comparison of the relative dimensional stability of several species, measured by the dimensional change coefficient, refer to the chart on page 7.

For wood flooring professionals, it’s important to inform end users about the normal behavior of wood in relation to moisture. Most solid wood flooring will contract during periods of low humidity (during the heating season, for example), sometimes leaving noticeable cracks between boards. To minimize this effect, users should stabilize the environment of the building through temperature and humidity control.

HARDNESS AND DURABILITY: Probably the most important strength property for wood used in flooring applications is its side hardness, also known as Janka hardness. Side hardness represents the resistance of wood to wear, denting and marring. It is measured by the load
required to embed a 0.444-inch steel ball to one-half its diameter in the wood. Janka hardness ratings are generally based on an average of tests on both tangential and radial (plain sawn and quartersawn) samples. A comparison chart of the Janka hardness ratings for each of the species described in this chapter appears on page 7. Also, the individual species descriptions include a percentage comparison to indicate each species hardness relative to Northern red oak.

**MACHINING:** The workability of a wood depends on several factors, including density, extent of interlocked or variable grain, hard mineral deposits, and tensions in wood that may cause fibrous and fuzzy surfaces. The degree of checking and separation present will also affect machining ease.

- Interlocked grain is characteristic of many tropical species and causes problems in planing quartersawn boards unless feed rates, cutting angles and sharpness of knives are carefully controlled.
- Hard deposits in the cells, such as calcium carbonate and silica, may have a pronounced dulling effect on cutting tools. This effect generally increases as wood is dried to normal working requirements.

**NAILING:** When nailing some of the denser woods with hand or air nailers, installers may encounter splitting tongues, as well as failure to secure the fastener even after repeated attempts. This can sometimes be corrected by changing the angle of the nail's point of entry. On certain exceptionally dense species, pilot holes may have to be drilled to ease nailing. Blunting the ends of fasteners may also help prevent splitting.

- Though dense, heavy woods normally offer higher nail-withdrawal resistance, less dense species allow the use of more and larger-diameter fasteners to compensate for their lower holding ability.

**SANDING:** Some wood species are highly resinous and tend to clog sandpaper. When working with such species, it may be necessary to use a coarser grit of sandpaper than normal, or to change the sandpaper more often than with other species.

- Also, the wood dust created by sanding some species tends to cause an allergic reaction in some people. This is more likely to occur with imported species than with domestic. However, even North American oak has been known to cause a skin rash or respiratory difficulties in some people. Where applicable, known tendencies to cause allergic reactions are noted.

- As a precaution, flooring mechanics should wear long sleeves, dust masks and eye protection when sanding.

- To test for possible allergic reaction to a species, perform a skin-patch test by placing a small amount of wood dust under a round adhesive bandage on the inside of the forearm. If serious skin irritation is present when the bandage is removed after 24 hours, consider not working with that species.

**FINISHING:** Some woods, especially imports, contain oils and chemical compounds that may adversely react with certain types of finishes to inhibit drying, dramatically change the color of the wood, or both. In addition, many finish formulations are undergoing continual change as their manufacturers move to comply with evolving environmental regulations, making hard-and-fast finishing rules difficult to come by.

- Water-based urethane finishes have gained in popularity over the past 10 years. They are quick-drying and increasingly durable. Some flooring professionals also believe they tend to inhibit the color change certain woods undergo over time, which may be desirable. These finishes tend to leave wood lighter in color. Non-ambering urethanes are often recommended for finishing white or pastel floors.

- Water-based finishes tend to adhere well to most woods, including exotics, whereas some solvent-based finishes have adhesion, drying or color change problems with woods like African cherry, rosewoods, teak, Brazilian and African walnut, purpleheart, padauk and wenge.

For floors that are to be stained to alter the natural color of the wood, flooring professionals should be aware that some species (hard maple, pine and fir, for example) do not accept stain as readily or as evenly as other species.

- A grain filler is sometimes used for wood species with large pores, such as oak and walnut, if a smooth finish is desired.

- When working with a new species for the first time, installers should test stains and finishes on a small sample of flooring before attempting an installation.

### Availability and relative cost

Just as every individual wood species is dynamic and prone to change in response to its environment, so too is the market for all wood flooring species. Where possible, the current state of availability for each species has been listed.

Again, plainsawn select red oak has been chosen as the benchmark for cost because of its widespread use in the flooring industry. For the sake of comparison, a cost multiplier has been assigned to each species. As the benchmark, plainsawn red oak has a multiplier of 1. A species with a multiplier of 2 — heart pine, for example — would be twice as expensive as red oak.

For ease of comparison, please refer to the relative cost and availability charts on page 8.

Both cost and availability estimates were obtained through interviews with industry sources and reflect market conditions in effect during late 1994.
RELATIVE HARDNESS OF SELECTED WOOD FLOORING SPECIES
(Ranked by Janka hardness rating)

The Janka (or side) hardness test measures the force required to embed a .444-inch steel ball to half its diameter in wood. It is one of the best measures of the ability of a wood species to withstand denting and wear. By the same token, it is also a good indicator of how hard or easy a species is to saw or nail. Northern red oak, for example, has a Janka hardness rating of 1290. Brazilian cherry, with a rating of 2350, is nearly twice as hard. If you’re accustomed to working with red oak and decide to tackle a job with Brazilian cherry, you can expect it to be much harder to cut and nail.

• Source: Hardness ratings for most species taken from Wood Handbook: Wood as an Engineering Material (Agriculture Handbook 72, Forest Products Laboratory, Forest Service, U.S. Department of Agriculture; revised 1987), except for Australian cypress, wenge, African padauk, merbau and Santos mahogany, which were provided by International Hardwood Flooring; heart pine by Mountain Lumber, and mesquite by Mesquite Products of Texas.

• Douglas fir rating is an average of ratings for Coast, Interior West and Interior North species.

RELATIVE STABILITY OF SELECTED WOOD FLOORING SPECIES
(Ranked by dimensional change coefficient)

The numbers in the chart reflect the dimensional change coefficient for the various species, measured as tangential shrinkage or swelling within normal moisture content limits of 6-14 percent. Tangential change values will normally reflect changes in plainsawn wood. Quartersawn wood will usually be more dimensionally stable than plainsawn.

The dimensional change coefficient can be used to calculate expected shrinkage or swelling. Simply multiply the change in moisture content by the change coefficient, then multiply by the width of the board.

Example: A mesquite (change coefficient = .00129) board 5 inches wide experiences a moisture content change from 6 to 9 percent — a change of 3 percentage points.
Calculation: 3 x .00129 = .00387 x 5 = .019 inches.

In actual practice, however, change would be diminished in a complete floor, as the boards’ proximity to each other tends to restrain movement.

The chart is best used for comparison.

* Although some tropical woods such as Australian cypress, Brazilian cherry, merbau and wenge appear in this chart to have excellent moisture stability compared to domestic oak, actual installations of many of these woods have demonstrated significant movement in use. To avoid problems later, extra care should be taken to inform potential users of these tendencies prior to purchase.

RELATIVE COST OF SELECTED
WOOD FLOORING SPECIES
(Based on a cost factor of 1.00
for plainsawn select red oak)

How to use this chart: Costs for any species may vary according to current availability, location and other market factors. This chart is intended only to provide a comparison scale. Each species has been assigned a multiplier to be applied to the cost of plainsawn select red oak, chosen as the benchmark because of its widespread use in the flooring industry. Brazilian cherry, for example, has been assigned a cost multiplier of 1.30. If you know the cost of plainsawn select red oak, multiply by 1.3, and you have some idea what Brazilian cherry might cost. Please keep in mind, however, that these figures are only estimates; actual costs can vary greatly by locale, time of year and flooring style.

The above estimates are averages based on interviews with industry sources and reflect market conditions in effect during late 1994.

RELATIVE AVAILABILITY OF SELECTED
WOOD FLOORING SPECIES

COMMODITY ITEM

HARD MAPLE
OAK
SOUTHERN YELLOW PINE

READILY AVAILABLE

BRAZILIAN CHERRY
DOUGLAS FIR
HICKORY/PECAN

MODERATELY AVAILABLE

AMERICAN BLACK WALNUT
ASH
BIRCH
JARRAH
MESQUITE
PADAUK
SANTOS MAHOGANY

LIMITED

AMERICAN BEECH
AUSTRALIAN CYPRESS
BLACK CHERRY
HEART PINE
MERBAU
PURPLEHEART
TEAK
WENGE

Note: Some wood species — ash, birch and black cherry, for example — may be readily available as rough lumber, but are not often milled into flooring. Availability estimates are based on interviews with industry sources and reflect market conditions in effect during late 1994.
ASH
WHITE
Fraxinus americana

Appearance
COLOR: Heartwood is light tan to dark brown; sapwood is creamy white. Similar in appearance to white oak, but frequently more yellow.
GRAIN: Bold, straight, moderately open grain with occasional wavy figuring. Can have strong contrast in grain in plainsawn boards.
VARIATIONS WITHIN SPECIES AND GRADES: Sometimes confused with hickory; the zone of large pores is more distinctive in ash, similar to that of red oak.

Properties
HARDNESS/JANKA: 1320; 2% harder than Northern red oak.
DIMENSIONAL STABILITY: Above average (change coefficient .00274; 26% more stable than red oak).

Workability
SAWING/MACHINING: Good machining qualities.
SANDING: Sands satisfactorily.
NAILING: Good holding ability; good resistance to splitting.
FINISHING: No known problems. Stains well.
COMMENTS:

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.20

Availability
Moderately available.
BEECH
Fagus grandifolia

Appearance
COLOR: Heartwood is mostly reddish brown; sapwood is generally pale white.
GRAIN: Mostly closed, straight grain; fine, uniform texture. Coarser than European beech.
VARIATIONS WITHIN SPECIES AND GRADES: Only one species is native to the United States. Moderate to high color variation between boards.

Properties
HARDNESS (JANKA): 1300; 1% harder than Northern red oak.
DIMENSIONAL STABILITY: Below average (change coefficient .00431; 17% less stable than red oak).
DURABILITY: Elastic, hard; excellent shock resistance. Wears well and stays smooth when subjected to friction — popular for factory floors.

Workability
SAWING/MACHINING: Difficult to work with hand tools, but good machining qualities.
SANDING: Sands satisfactorily.
NAILING: Good holding ability, but has a tendency to split.
FINISHING: No known problems.
COMMENTS:

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.20

Availability
Limited.
BIRCH
Betula spp.

Appearance
COLOR: In yellow birch (B. alleghaniensis), sapwood is creamy yellow or pale white; heartwood is light reddish brown tinged with red. In sweet birch (B. lenta), sapwood is light colored and heartwood is dark brown tinged with red.
GRAIN: Medium figuring, straight, closed grain, even texture. Occasional curly grain or wavy figure in some boards.
VARIATIONS WITHIN SPECIES AND GRADES: Yellow birch, sweet birch, paper birch. Paper birch (B. papyrifera) is softer and lower in weight and strength than yellow or sweet birch. However, yellow birch is most commonly used for flooring. Boards can vary greatly in grain and color.

Properties
SIDE HARDNESS/JANKA: 1260 (yellow); 2% softer than Northern red oak.
DIMENSIONAL STABILITY: Average (change coefficient .00338; 8% more stable than red oak).
DURABILITY: Hard and stiff; very strong, with excellent shock resistance.

Workability:
SAWING/MACHINING: Difficult to work with hand tools, but good machining qualities.
SANDING: Sands satisfactorily.
NAILING: Excellent holding ability.
FINISHING: No known problems.
COMMENTS:

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.30

Availability
Moderately available.
Cherry Black
Prunus serotina

Appearance
COLOR: Heartwood is light to dark reddish brown, lustrous; sapwood is light brown to pale with a light pinkish tone. Some flooring manufacturers steam lumber to bleed the darker heartwood color into the sapwood, resulting in a more uniform color.
GRAIN: Fine, frequently wavy, uniform texture. Distinctive flake pattern on true quartersawn surfaces. Texture is satiny, with some gum pockets.
VARIATIONS WITHIN SPECIES AND GRADES: Significant color variation between boards.

Properties
HARDNESS (JANKA): 950; 26% softer than Northern red oak.
DIMENSIONAL STABILITY: Above average (change coefficient .00248; 33% more stable than red oak).
DURABILITY: Strong, moderately hard; excellent shock resistance. Usually considered too soft for an entire floor — mostly used for borders and accents.

Workability
SAWING/MACHINING: Good machining qualities.
SANDING: Sands satisfactorily.
NAILING: Good holding ability.
FINISHING: No known problems.
COMMENTS: High in bending strength. Light-sensitive; strong color change upon exposure to light.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.70

Availability
Limited.
DOUGLAS FIR
Pseudotsuga menziesii

Appearance
COLOR: Heartwood is yellowish tan to light brown. Sapwood is tan to white. Heartwood may be confused with that of Southern yellow pine. Radical color change upon exposure to sunlight.

GRAIN: Normally straight, with occasional wavy or spiral texture. Nearly all fir flooring is vertical-grain or riftsawn clear-grade material.

VARIATIONS WITHIN SPECIES AND GRADES: Wood varies greatly in weight and strength. Young trees of moderate to rapid growth have reddish heartwood and are called red fir. The narrow-ringed wood of old trees may be yellowish-brown and is known as yellow fir.

Properties
HARDNESS (JANKA): 660; 49% softer than Northern red oak.

DIMENSIONAL STABILITY: Above average (change coefficient .00267; 28% more stable than red oak).

DURABILITY: Durable but easily dented. Somewhat brittle and splinters easily, especially with age. Used for flooring, but may not be suitable for all applications due to its softness.

Workability
SAWING/MACHINING: Harder to work with hand tools than the soft pines.

SANDING: Sands satisfactorily.

NAILING: Good holding ability.

FINISHING: Some boards develop a slight pinkish to bright salmon color when finished with some products. Because of tendency toward color change, care must be taken to avoid oversanding when refinishing an existing floor.

COMMENTS: Sometimes milled for flooring as end-grain block, which is significantly harder than plainsawn.

Cost
(relative to plainsawn select red oak)

MULTIPLIER: 1.70

Availability
Readily available.
HEART PINE ANTIQUE

(Slow-growth longleaf pine (*Pinus spp.*), often recovered from structural timbers in pre-1900 warehouses and factories, or as sunken logs from river bottoms.)

**Appearance**

**COLOR:** Heartwood is yellow after cutting and turns deep pinkish tan to warm reddish brown within weeks due to high resin content. Sapwood remains yellow, with occasional blue-black sap stain.

**GRAIN:** Dense, with high figuring. Plainsawn is swirled; rift- or quartersawn is primarily pinstriped. Curly or burl grain is rare.

**VARIATIONS WITHIN SPECIES AND GRADES:** Moderate color variation.

**Properties**

**HARDNESS (JANNA):** 1225; 5% softer than Northern red oak.

**DIMENSIONAL STABILITY:** Above average (change coefficient .00263; 29% more stable than red oak).

**DURABILITY:** Natural resistance to insect infestation in heartwood; dense.

**Workability**

**SAWING/MACHINING:** Good machining and hand-tooling qualities.

**SANDING:** Tendency to clog paper due to high resin content; begin with coarse grade.

**NAILING:** Good holding ability.

**FINISHING:** Accepts both surface and penetrating finishes. Some stains may blotch; raising grain first may help. To reduce the wood’s tendency to repel finish coats, surface resins may be removed with a solvent that is compatible with the finish to be used.

**Comments:**

**Cost**

(relative to plainsawn select red oak)

**MULTIPLIER:** 2.00

**Availability**

Limited.
HICKORY/PECAN
Carya spp.

Sample is 3⁄4-by-23⁄4-inch square-edge solid strip. Top portion is finished with water-base urethane; bottom with oil-modified polyurethane.

Appearance
COLOR: Pecan heartwood is reddish brown with dark brown stripes; sapwood is white or creamy white with pinkish tones. Hickory heartwood is tan or reddish; sapwood is white to cream, with fine brown lines.
GRAIN: Pecan is open, occasionally wavy or irregular. Hickory is closed, with moderate definition; somewhat rough-textured.
VARIATIONS WITHIN SPECIES AND GRADES: In both hickory and pecan, there are often pronounced differentiations in color between spring wood and summer wood. In pecan, sapwood is usually graded higher than darker heartwood. Pecan and hickory are traditionally mixed by flooring mills.

Properties
HARDNESS (JANKA): 1820; 41% harder than Northern red oak. Pecan is slightly softer than true hickories.
DIMENSIONAL STABILITY: Pecan, average (change coefficient .00315; 15% more stable than red oak). Hickory, below average (change coefficient .00411; 11% less stable than red oak).
DURABILITY: Combination of strength, hardness, toughness and stiffness found in no other commercial wood; exceedingly high in shock resistance.

Workability
SAWING/MACHINING: Hickory species’ density makes it difficult to season, machine and work with hand tools.
SANDING: Difficult to sand because of density, and because light color makes sander marks show more than on darker woods.
NAILING: Good holding ability; prone to splitting.
FINISHING: No known problems.
COMMENTS:

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.20

Availability
Readily available from specialty wood flooring dealers, although parquet not commonly available.
MAPLE
SUGAR/HARD
Acer saccharum

Appearance
COLOR: Heartwood is creamy white to light reddish brown; sapwood is pale to creamy white.
GRAIN: Closed, subdued grain, with medium figuring and uniform texture. Occasionally shows quilted, fiddleback, curly or bird’s-eye figuring. Figured boards often culled during grading and sold at a premium.
VARIATIONS WITHIN SPECIES AND GRADES: Black maple (B. nigrum) is also hard; other species are classified as soft.

Properties
HARDNESS (JANKA): 1450; 12% harder than Northern red oak.
DIMENSIONAL STABILITY: Average (change coefficient .00353; 4% more stable than red oak).
DURABILITY: Dense, strong, tough, stiff; excellent shock resistance — often used in bowling alleys and athletic facilities. Markedly resistant to abrasive wear.

Workability
SAWING/MACHINING: Density makes machining difficult.
SANDING: Sands satisfactorily.
NAILING: Fair resistance to splitting; good holding ability.
FINISHING: Takes neutral finish well; does not stain uniformly.
COMMENTS: Light color lends itself to contemporary light floors. Extra care must be taken during sanding and finishing, as sanding marks and finish lines are more obvious due to maple’s density and light color.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.30

Availability
Commodity item; figured grains limited.
MESQUITE
Prosopis glandulosa

Appearance
COLOR: Light brown to dark reddish brown.
GRAIN: High in character, with ingrown bark and mineral streaks. Most commonly used in flooring as end-grain block, which has small irregular cracks radiating across the grain.
VARIATIONS WITHIN SPECIES AND GRADES: One grade; moderate color variations.

Properties
HARDNESS (JANKA): 2345; 82% harder than Northern red oak.
DIMENSIONAL STABILITY: Excellent (change coefficient .00129; 65% more stable than red oak).
DURABILITY: Dense and very strong. End-grain cut has excellent resistance to abrasion and shock.

Workability
SAWING/MACHINING: Very good machining qualities.
SANDING: Plainsawn can be sanded to a smooth surface; end-grain requires #16 grit sandpaper to flatten.
NAILING: Good holding ability, but splits easily.
FINISHING: No known problems.
COMMENTS: End-grain block usage results in a hard, high-wear surface. Produces only small size boards.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 2.50

Availability
Moderately available.
OAK
RED
Quercus spp.

Appearance
COLOR: Heartwood and sapwood are similar, with sapwood lighter in color; most pieces have a reddish tone. Slightly redder than white oak.
GRAIN: Open, slightly coarser (more porous) than white oak. Plainsawn boards have a plumed or flared grain appearance; riftsawn has a tighter grain pattern, low figuring; quartersawn has a flake pattern, sometimes called tiger rays or butterflies.
VARIATIONS WITHIN SPECIES AND GRADES: More than 200 subspecies in North America; great variation in color and grain, depending on the origin of the wood and corresponding differences in growing seasons. Northern, Southern and Appalachian red oak can all be divided into upland and lowland species. Because they grow more slowly, upland species generally have a more uniform grain pattern than lowland species, with more growth rings per inch.

Properties
HARDNESS (JANKA): Northern 1290 (benchmark).
DIMENSIONAL STABILITY: Average (change coefficient .00369).
DURABILITY: Stiff and dense; resists wear, with high shock resistance, though less durable than white oak.

Workability
SAWING/MACHINING: Above average in all machining operations except shaping.
SANDING: Sands satisfactorily, better than white oak.
NAILING: Good resistance to splitting; excellent holding ability.
FINISHING: Strong stain contrast because of large pores.
COMMENTS: Red oak generally works better than white for bleached floors, because it is more porous and accepts bleach better, and because tannins in white oak can discolor floor.

Cost
(relative to plainsawn select red oak)
MULTIPLIER:
1.00 (plainsawn)
1.30 (quartersawn)
1.65 (riftsawn)

Availability
Commodity item, available in all types, styles and sizes of flooring, including parquet, strip, plank and veneer, both unfinished and prefinished.
Appearance

COLOR: Heartwood is light brown; some boards may have a pinkish tint or a slight grayish cast. Sapwood is white to cream.

GRAIN: Open, with longer rays than red oak. Occasional crotches, swirls and burls. Plainsawn boards have a plumed or flared grain appearance; riftsawn has a tighter grain pattern, low figuring; quartersawn has a flake pattern, sometimes called tiger rays or butterflies.

VARIATIONS WITHIN SPECIES AND GRADES: Considerable variation among boards in color and grain texture, but variations not as pronounced as in red oak.

Properties

HARDNESS (JANKA): 1360; 5% harder than Northern red oak.

DIMENSIONAL STABILITY: Average (change coefficient .00365; 1% more stable than red oak).

DURABILITY: More durable than red oak. Tannic acid in the wood protects it from fungi and insects.

Workability

SAWING/MACHINING: Excellent machining qualities.

SANDING: Sands satisfactorily.

NAILING: Good resistance to splitting; excellent holding ability.

FINISHING: Absorbs finishes more evenly than red oak. Does not bleach well.

COMMENTS: During the finishing process, tannins at the surface can react with some liquids to turn the wood green or brown. This effect tends to be more pronounced with products that have a high water content, such as bleach and water-based finishes.

Cost

(relative to plainsawn select red oak)

MULTIPLIER: .95

Availability

Commodity item, available in nearly all types, styles and sizes of flooring, including parquet, strip, plank and veneer, both unfinished and prefinished.
PINE
SOUTHERN YELLOW
Pinus spp.

Sample is ¾-by-2¼-inch square-edge solid strip. Top portion is finished with water-base urethane; bottom with oil-modified polyurethane.

Appearance
COLOR: Heartwood varies from light yellow/orange to reddish brown or yellowish brown; sapwood is light tan to yellowish white.
GRAIN: Closed, with high figuring; patterns range from clear to knotty.
VARIATIONS WITHIN SPECIES AND GRADES: Longleaf pine (P. palustris), shortleaf pine (P. echinata), loblolly pine (P. taeda), slash pine (P. elliottii). All have many of the same characteristics as Douglas fir. Old-growth lumber in these varieties has substantially higher density and is more stable than second-growth material.

Properties
HARDNESS (JANNA): Loblolly and shortleaf 690, 47% softer than Northern red oak; longleaf 870, 33% softer than N. red oak.
DIMENSIONAL STABILITY: Above average (change coefficient .00265; 28% more stable than red oak).
DURABILITY: Soft, fairly durable, although not as resistant to scuffs, dents and abrasions as the hardwoods. Often used for flooring, but may not be suitable for all applications due to its softness.

Workability
SAWING/MACHINING: Good machining qualities.
SANDING: Resin in wood tends to clogs abrasives; frequent sandpaper changes are required.
NAILING: Good holding ability and resistance to splitting.
FINISHING: A durable finish can help minimize wear.
COMMENTS: Generally manufactured for flooring with no end-match; sometimes flooring is “distressed” to create an antique look.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 0.95

Availability
Commodity item, available as unfinished strip and plank flooring in a variety of widths and thicknesses through specialty wood flooring dealers and some lumberyards.
Appearance

COLOR: Heartwood ranges from a deep, rich dark brown to a purplish black. Sapwood is nearly white to tan. Difference between heartwood and sapwood color is great; some flooring manufacturers steam lumber to bleed the darker heartwood color into the sapwood, resulting in a more uniform color.

GRAIN: Mostly straight and open, but some boards have burlled or curly grain. Arrangement of pores is similar to hickories and persimmon, but pores are smaller in size.

VARIATIONS WITHIN SPECIES AND GRADES: Great variety of color and figure within species, as well as variation in color among boards, especially in lower grades and from material that isn’t steamed prior to kiln-drying.

Properties

HARDNESS (JANKA): 1010; 22% softer than Northern red oak.

DIMENSIONAL STABILITY: Excellent (change coefficient .00274; 26% more stable than red oak).

DURABILITY: Moderately dense, very strong, good shock resistance. Not as dent-resistant as oak.

Workability

SAWING/MACHINING: Easily worked with hand tools, and has excellent machining qualities.

SANDING: Sands satisfactorily.

NAILING: Fair resistance to splitting; good holding ability.

FINISHING: Finishes nicely, with a handsome grain pattern.

COMMENTS: Distinctive sweet aroma when worked. Frequently used as a highlight material for borders or other inlay techniques.

Cost

(relative to plainsawn select red oak)

MULTIPLIER: 3.00

Relative availability

Moderately available, normally in unfinished parquet, strip and in various plank widths as a special order. Available in fancy parquet patterns as a special order or custom mill.
BRAZILIAN CHERRY

Jatoba

Hymenaea courbaril

Appearance

COLOR: Sapwood is gray-white; heartwood is salmon red to orange-brown when fresh, and becomes russet or reddish brown when seasoned; often marked with dark streaks.

GRAIN: Mostly interlocked; texture is medium to rather coarse.

VARIATIONS WITHIN SPECIES AND GRADES: Moderate to high color variation.

Properties

HARDNESS (JANKA): 2350; 82% harder than Northern red oak.

DIMENSIONAL STABILITY: Average (change coefficient .00300; 19% more stable than red oak). However, actual installations have demonstrated significant movement in use.

DURABILITY: Dense and very strong.

Workability

SAWING/MACHINING: Sawing is difficult due to high density; requires frequent resharpening of tools. Planing is difficult due to interlocked grain. Can be machined to a smooth surface. Carbide tooling recommended.

SANDING: Sands well.

NAILING: Good holding ability, but due to hardness may require adjustment of angle of penetration and/or height.

FINISHING: No known problems.

COMMENTS: Light-sensitive; darkens rapidly upon exposure to sunlight.

Cost

(relative to plainsawn select red oak)

MULTIPLIER: 1.30

Availability

Readily available.
Appearance
COLOR: Cream-colored sapwood; heartwood is honey-gold to brown with darker knots throughout.
GRAIN: Closed.
VARIATIONS WITHIN SPECIES AND GRADES: High degree of color variability.

Properties
HARDNESS (JANKA): 1375; 6% harder than Northern red oak.
DIMENSIONAL STABILITY: Excellent (change coefficient .00162; 56% more stable than red oak). However, actual installations have demonstrated significant movement in use.
DURABILITY: Excellent.

Workability:
SAWING/MACHINING: Good machining qualities.
SANDING: Sands satisfactorily.
NAILING: Can be brittle (like Brazilian cherry); splits easily.
FINISHING: No known problems.
COMMENTS: Respiratory allergic potential.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.30

Availability
Limited.
**JARRAH**

*Eucalyptus marginata*

**Appearance**

**COLOR:** Heartwood is uniformly pinkish to dark red, often a rich, dark red mahogany hue, turning a deep brownish red with age and exposure; sapwood is pale. Frequent black streaks with occasional in-grown grain.

**GRAIN:** Frequently interlocked or wavy. Texture is even and moderately coarse.

**VARIATIONS WITHIN SPECIES AND GRADES:** Moderate to high color variation.

**Properties**

**HARDNESS (JANKA):** 1910; 48% harder than Northern red oak.

**DIMENSIONAL STABILITY:** Below average (change coefficient .00396; 7% less stable than red oak).

**DURABILITY:** Dense and very strong; high resistance to wear.

**Workability**

**SAWING/MACHINING:** Difficult to work because of high density and irregular grain; carbide tooling recommended.

**SANDING:** Sands well, but dust can stain fabric and wall treatments.

**NAILING:** Good holding ability.

**FINISHING:** Red color can bleed into some finishes — a problem when mixing species.

**COMMENTS:** Resistant to termites and fungus.

**Cost**

(relative to plainsawn select red oak)

**MULTIPLIER:** 1.55

**Availability**

Moderately available.
MAHOGANY
SANTOS
Myroxylon balsamum

Sample is 3/4-by-3/4-inch square-edge solid strip. Top portion is finished with water-base urethane; bottom with oil-modified polyurethane.

Appearance
COLOR: Dark reddish brown.
GRAIN: Striped figuring in quartersawn selections; texture is even and very fine.
VARIATIONS WITHIN SPECIES AND GRADES: Moderate color variation.

Properties
HARDNESS (JANKA): 2200; 71% harder than Northern red oak.
DIMENSIONAL STABILITY: Above average (change coefficient .00238; 36% more stable than red oak).
DURABILITY: Excellent.

Workability
SAWING/MACHINING: Moderately difficult due to hardness; carbide tooling recommended.
SANDING: Sands satisfactorily.
NAILING: Good holding ability.
FINISHING: No known finishing problems.
COMMENTS: Some respiratory allergic potential.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 1.55

Availability
Moderately available.
MERBAU
Ipil, kwila
*Intsia spp.*

**Appearance**

**COLOR:** Heartwood is yellowish to orange-brown when freshly cut, turning brown or dark red-brown upon exposure.

**GRAIN:** Straight to interlocked or wavy; coarse texture.

**VARIATIONS WITHIN SPECIES AND GRADES:** Moderate to high variation in color.

**Properties**

**HARDNESS (JANKA):** 1925; 49% harder than Northern red oak.

**DIMENSIONAL STABILITY:** Excellent (change coefficient .00158; 57% more stable than red oak). However, actual installations have demonstrated significant movement in use.

**DURABILITY:** Strength is comparable to hickory, but density is somewhat lower.

**Workability**

**SAWING/MACHINING:** Sawing is difficult; wood gums saw teeth and dulls cutting edges; carbide tooling recommended.

**SANDING:** Sands satisfactorily.

**NAILING:** Good holding ability.

**FINISHING:** Wood stains black in contact with ferrous metals or moisture.

**COMMENTS:** High resistance to termites.

**Cost**

(relative to plainsawn select red oak)

**MULTIPLIER:** 1.25

**Availability**

Limited.
PADAUK
AFRICAN
Pterocarpus soyauxii

Appearance
COLOR: Heartwood is vivid reddish orange when freshly cut, darkening to reddish- or purple-brown or black over time. Sapwood is cream-colored. Very uniform in color.
GRAIN: Straight to interlocked; coarse texture.
VARIATIONS WITHIN SPECIES AND GRADES: Slight variation in color.

Properties
HARDNESS (JANKA): 1725; 34% harder than Northern red oak.
DIMENSIONAL STABILITY: Excellent (change coefficient .00180; 51% more stable than red oak).
DURABILITY: Average to high durability.

Workability
SAWING/MACHINING: Saws well, but requires a slow feed rate; carbide tooling recommended. Machines easily, with some tearing of the interlocked grain.
SANDING: Sands satisfactorily.
NAILING: Good holding ability.
FINISHING: Takes finishes well; some have found that water-based finishes hold color better. Has a tendency to bleed.
COMMENTS: Dermatological and respiratory allergic potential.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 4.50

Availability
Moderately available.
PURPLEHEART
Amaranth
Peltogyne spp.

Appearance
COLOR: Heartwood is brown when freshly cut, turning deep purple to purplish brown over time. Sapwood is a lighter cream color.
GRAIN: Usually straight; medium to fine texture.
VARIATIONS WITHIN SPECIES AND GRADES: Moderate to high color variation.

Properties
HARDNESS (JANKA): 1860; 44% harder than Northern red oak.
DIMENSIONAL STABILITY: Excellent (change coefficient .00212; 43% more stable than red oak).
DURABILITY: Very strong and dense.

Workability
SAWING/MACHINING: Moderately difficult due to hardness; frequent sharpening of tools required; slow feed rate and carbide tooling recommended.
NAILING: Good holding ability.
SANDING: Sands satisfactorily.
FINISHING: Takes finishes well; some have found that water-based finishes hold color better. Tendency to bleed with some finishes.
COMMENTS: Heartwood is very resistant to dry-wood termites. Presence of minerals in some boards may cause uneven coloration.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 2.30

Availability
Limited.
Teak
Thai/Burmese
Tectona grandis

Appearance
COLOR: Heartwood varies from yellow-brown to dark golden brown; turns rich brown under exposure to sunlight. Sapwood is a lighter cream color.
GRAIN: Straight; coarse, uneven texture.
VARIATIONS WITHIN SPECIES AND GRADES: Moderate to high color variation.

Properties
HARDNESS (JANKA): 1000; 22% softer than Northern red oak.
DIMENSIONAL STABILITY: Excellent (change coefficient .00186; 50% more stable than red oak).
DURABILITY: Strength values are similar to those of American oak.

Workability
SAWING/MACHINING: Moderate ease in working with hand and machine tools; silica in wood dulls tools quickly; carbide tooling is recommended.
SANDING: Clogs abrasives; frequent sandpaper changes are required.
NAILING: Good holding ability.
FINISHING: Natural oils may interfere with adhesion and drying of some finishes. To reduce the wood’s tendency to repel finish coats, surface resins may be removed with a solvent that is compatible with the finish to be used.
COMMENTS: Has an oily feel. Unique in that it does not cause rust or corrosion when in contact with metal. Respiratory and dermatological allergic potential.

Cost
(relative to plainsawn select red oak)
MULTIPLIER: 2.50

Availability
Limited.
Appearance

COLOR: Heartwood is yellow-brown when freshly cut, turning dark brown to almost black with alternate layers of light and dark. Sapwood is yellowish-white and clearly demarcated from heartwood.

GRAIN: Straight when quartersawn; coarse texture.

VARIATIONS WITHIN SPECIES AND GRADES: Moderate variations in color.

Properties

HARDNESS (JANKA): 1630; 26% harder than Northern red oak.

DIMENSIONAL STABILITY: Excellent (change coefficient .00201; 46% more stable than red oak). However, actual installations have demonstrated significant movement in use.

DURABILITY: Average.

Workability

SAWING AND MACHINING: Difficult due to rapid dulling of tools; carbide tooling recommended.

SANDING: Sands satisfactorily.

NAILING: Good holding ability.

FINISHING: Some solvent-based stains do not dry well.

COMMENTS: Dermatological and respiratory allergic potential.

Cost

(relative to plainsawn select red oak)

MULTIPLIER: 5.50

Availability

Limited.
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