

Finishing and Restoring Wood and Structures



Yellow-Poplar Lumber for Exterior Architectural Applications in New Construction and for Historical Restoration

Daniel L. Cassens, Professor of Wood Products and Extension Specialist, Purdue University

Michael O. Hunt, Professor Emeritus of Wood Science, Purdue University

H. Michael Barnes, W.S. Thompson Professor of Wood Science and Technology, Mississippi State University

Selecting the most appropriate and economical wood species for exterior architectural applications is critical for long-term performance. Important factors to consider include the wood's resistance to decay and insects, its dimensional stability, and its ability to be machined, to take and hold fasteners, and to be painted.

Yellow-poplar (also called tulip poplar and American tulip) has shown a resurgence in popularity in recent years due to its cost and greater abundance. Unfortunately, decay in yellow-poplar lumber can be a serious issue in just a few years (Figures 1 and 2). This publication will discuss the positive and negative attributes of yellow-poplar as an exterior millwork product and describe ongoing efforts to improve its durability.

applications (Figure 3). As yellow-poplar was depleted in these areas, the timber industry moved west and south for new sources of lumber. As a result, western and southern pine species replaced yellow-poplar.

For exterior applications, where decay and insect attack were more likely, redwood and western red cedar became the preferred woods. Cypress was used in the south. The timber from old-growth stands of these species — stands that were 150 years old or more — was rated as resistant to decay and insects.



www.fnr.purdue.edu

Explore the World of Wood in
Historic Preservation Web site
www.agriculture.purdue.edu/fnr/faculty/hunt

Yellow-Poplar's Place in History

Until the early part of the 20th century, yellow-poplar (*Liriodendron tulipifera* L.) was used extensively throughout its range (the Mid-Atlantic, Mid-South, and Midwest) for exterior and interior



Figure 1. The decay shown in this yellow-poplar siding on a new construction started about six years after installation.



Figure 2. This residence in Historic New Harmony, Indiana, has deteriorating yellow-poplar.



Figure 3. This 1880s Midwestern house originally used yellow-poplar for siding and architectural adornment. Restorers replaced about one-third of the siding with a mix of yellow-poplar sapwood and heartwood.

As we enter the 21st century, those high-quality old-growth sources of redwood, cypress, and western red cedar lumber are in short supply and costly. Much of today's redwood, cypress, and western red cedar lumber is coming from second- or third-growth stands that contain substantial amounts of white sapwood, making them susceptible to decay and insects. In the mean time, however, the yellow-poplar resource has recovered and plentiful supplies of relatively inexpensive lumber are available. And because yellow-poplar was once an excellent species for exterior millwork, many individuals are again using it in those applications.

Resource and Costs

Yellow-poplar is an abundant, fast growing, fast drying, easily worked, relatively low-valued, and excellent hardwood timber species (Figure 4). It ranges in much of the eastern United States (Figure 5), and constitutes about 9 percent of the sawtimber in the eastern hardwood forest (Smith et al, 1997). Only the oaks exceed yellow-poplar in available hardwood sawtimber volume.

In terms of its availability and properties, yellow-poplar is a very viable resource when compared to the traditional western softwoods, including Ponderosa and Jeffrey pines. See Table 1 for a comparison of lumber prices.



Figure 4. These yellow-poplar logs show a wide sapwood band and brown heartwood. Logs of this excellent size and quality are commonly available.

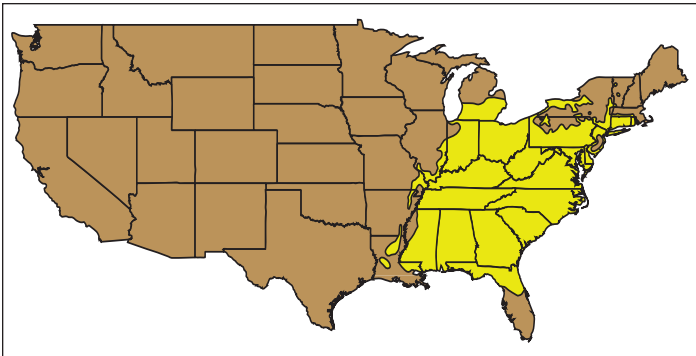


Figure 5. Yellow-poplar range.

Table 1. Lumber Price Comparison

Wood	Price (per thousand board feet)
yellow-poplar	\$650-\$750
Ponderosa pine	\$810
radiata pine	\$1,000
western red cedar	\$1,320-\$2,350

Price information from *Hardwood Review Weekly*, 2008, and *Random Lengths*, 2008. Prices based on best quality grades available for each lumber type.

Durability of Yellow-poplar

Historically, old-growth yellow-poplar was used for interior millwork, general construction lumber, and for aboveground exterior architectural applications such as house and barn siding, fascia, soffits, corbels, windows and doors, and trim and other applications. Many of these structures remain, demonstrating just how well yellow-poplar performed.

Intuitively, it would seem yellow-poplar could be used for the same applications today. Unfortunately, many have learned that with periodic wetting, the material rots and is no longer serviceable in just a few years. Two factors probably explain why decay is more common in new lumber than it was in the old.

First, young, fast-growth yellow-poplar trees will contain a wide band of white sapwood, the live part of the wood that carries water and nutrients through the tree. It is well established that sapwood from any tree

species has no resistance to decay. Large, old-growth trees contained smaller percentages of sapwood and greater percentages of heartwood.

The second reason decay may be more common is modern milling practices. Clear lumber, which is often required for millwork applications, comes from the outside portion of today’s logs, which have more sapwood. As a result, the lumber tends to have a very high percentage of sapwood — it can even be entirely sapwood.

Although it appears that the old-growth yellow-poplar used in the past has stood the test of time, published data indicates that yellow-poplar heartwood has little or no resistance to decay (MacLean, 1952). However, these studies don’t document whether these low ratings are for old- or new-growth yellow-poplar heartwood. Studies have clearly established that age is a factor in decay resistance in other species. Studies on redwood and cypress have shown that younger timber does not have the resistance of old-growth material (Campbell and Clark, 1960; Clark and Scheffer, 1983). And a study on western red cedar showed that the outer portions of the heartwood in trees had greater durability than the smaller core (Scheffer, 1957).

When yellow-poplar trees are felled and the logs rapidly processed into lumber, the sapwood is white. If the logs or lumber are allowed to set, especially in hot weather, the sapwood can oxidize and turn gray. With time, the white or discolored sapwood, further darkens to light brown, making differentiation from heartwood somewhat difficult, especially after the surface accumulates dirt and grime over time.

Yellow-poplar heartwood does have some resistance to termites. Fortunately, termites are usually controlled by other means, so natural resistance or chemical treatment of the wood is usually not critical.

Paint Holding Characteristics

Traditional softwoods such as cedars (especially western red cedar), redwood, and cypress have excellent paint holding characteristics because they do not shrink or swell much with changes in humidity.

The grain patterns in these woods are very uniform and much of the lumber was vertical grained (quarter sawn in hardwoods), which reduces shrinking and swelling (dimensional movement) across the width of the piece as compared to today's mostly flat sawn lumber.

Yellow-poplar is rated as high as any hardwood and just one level below western red cedar, redwood, and cypress for its ability to hold latex paint (*Wood Handbook*, 1999). However, research reported by Feist (1987) showed that yellow-poplar has finishing and weathering characteristics similar to those of softwoods like ponderosa pines, firs, hemlock, and spruce. And in recent field weathering tests of painted wood construction (Hunt et al. 2003), yellow-poplar equals the paint performance of the generally acknowledged gold standard species, western red cedar. Thus, yellow-poplar accepts and holds paint well.

Physical and Mechanical Properties

Workability

Yellow-poplar has an intermediate rating for its planing, shaping, turning, and boring qualities. Because it has intermediate density, the wood can have a tendency to fuzz or tear. However, using sharp tools should eliminate most problems.

Strength

At 12 percent moisture content, a standard measure for lumber, yellow-poplar wood is relatively light, weighing 29.4 pounds per cubic foot. However, the wood's weight can vary substantially. Due to this light weight, the mechanical properties of yellow-poplar wood are less than those of the denser hardwood species.

However, yellow-poplar wood's bending strength (given as Modulus of Rupture, or MOR) and its stiffness, which measures how well it resists deformation (given as Modulus of Elasticity, or MOE), are relatively high compared to other woods of similar densities. For construction lumber, the mechanical properties of yellow-poplar are comparable to a widely used softwood lumber category called spruce-pine-fir (SPF) and the widely imported radiata pine. Construction grades of yellow-poplar are listed in the *National Design Specification for Wood Construction*

(NDS) published by the American Forest and Paper Association.

Steam Bending

A U.S. Forest Products Laboratory study rates yellow-poplar's bending quality relatively low. The wood is seldom bent in commercial manufacturing processes.

Drying

Yellow-poplar wood dries easily with a moderate kiln schedule. However, if it is not properly stacked and weighted, some warping can result.

Shrinkage

Yellow-poplar wood is intermediate in shrinkage. In use, the wood is somewhat unstable (Figure 6). Therefore, it should be conditioned to the average moisture content it will experience in use and fastened securely. Standard ring shank siding nails and the use of power driven screws will help alleviate stability problems.



Figure 6. This tongue and groove yellow-poplar barn siding was air dried well before it was installed (to about 15 percent moisture content), and accepted paint well. Before installation, a water repellent preservative was applied to all sides, edges, and ends of boards. On this fully exposed west-facing wall, the lumber dried to about 8 percent moisture content in the summer, shrunk, and exposed the unpainted tongue. A north-facing wall did not experience the same problem.

Grading

Yellow-poplar shipments should contain only the one species. However, magnolia is very similar and is sometimes mixed in yellow-poplar lumber shipments from southern states. The senior author

of this publication also has seen both boxelder and aspen mixed with yellow-poplar. Each of these species, however, can be separated with certainty.

Better quality yellow-poplar lumber is graded standard except some mineral stain is allowed. Lumber rated No. 1 Common grade can have some slight sap stain, and lumber rated No. 2A can have unlimited sap stain. Sap stain is a light gray in the sapwood that is apparent after surfacing. Usually, it is the result of oxidation stain, but it also can be caused by mold and fungi. Mineral stain is not limited in the common grades.

For examples of yellow-poplar boards and staining, see Examples of Yellow-poplar Lumber on page 6.

Current and Needed Research and Marketing Efforts

Because yellow-poplar is a relatively soft hardwood, inexpensive, and produces a high percentage of nondurable sapwood, more research is needed to assure its long-term performance for aboveground exterior applications.

The Wood Research Laboratory at Purdue University has undertaken an exploratory research project to study the treatability of yellow-poplar with preservatives. On lumber 15/16 inch thick, the sapwood is completely penetrated, while only the surface of the heartwood is penetrated. Thus, the sapwood can be adequately treated.

Additional work is being conducted to better understand what natural decay resistance the heartwood of today's timber might have. Using a paint adhesion test, our recent research also has shown that wood pressure treated with a preservative and water repellent responds about as well as untreated yellow-poplar with a brushed on water repellent. Thus, the long-term performance of paint on yellow-poplar with a preservative and water repellent treatment does not appear to be jeopardized.

Another possibility to improve decay resistance is called thermal treating or "toasting." Toasting was developed in Europe as traditional wood preservatives were eliminated from the market. The wood is heated to relatively high temperatures in the absence

of oxygen. This darkens the wood and alters its molecular structure. As a result, the wood gains some decay resistance.

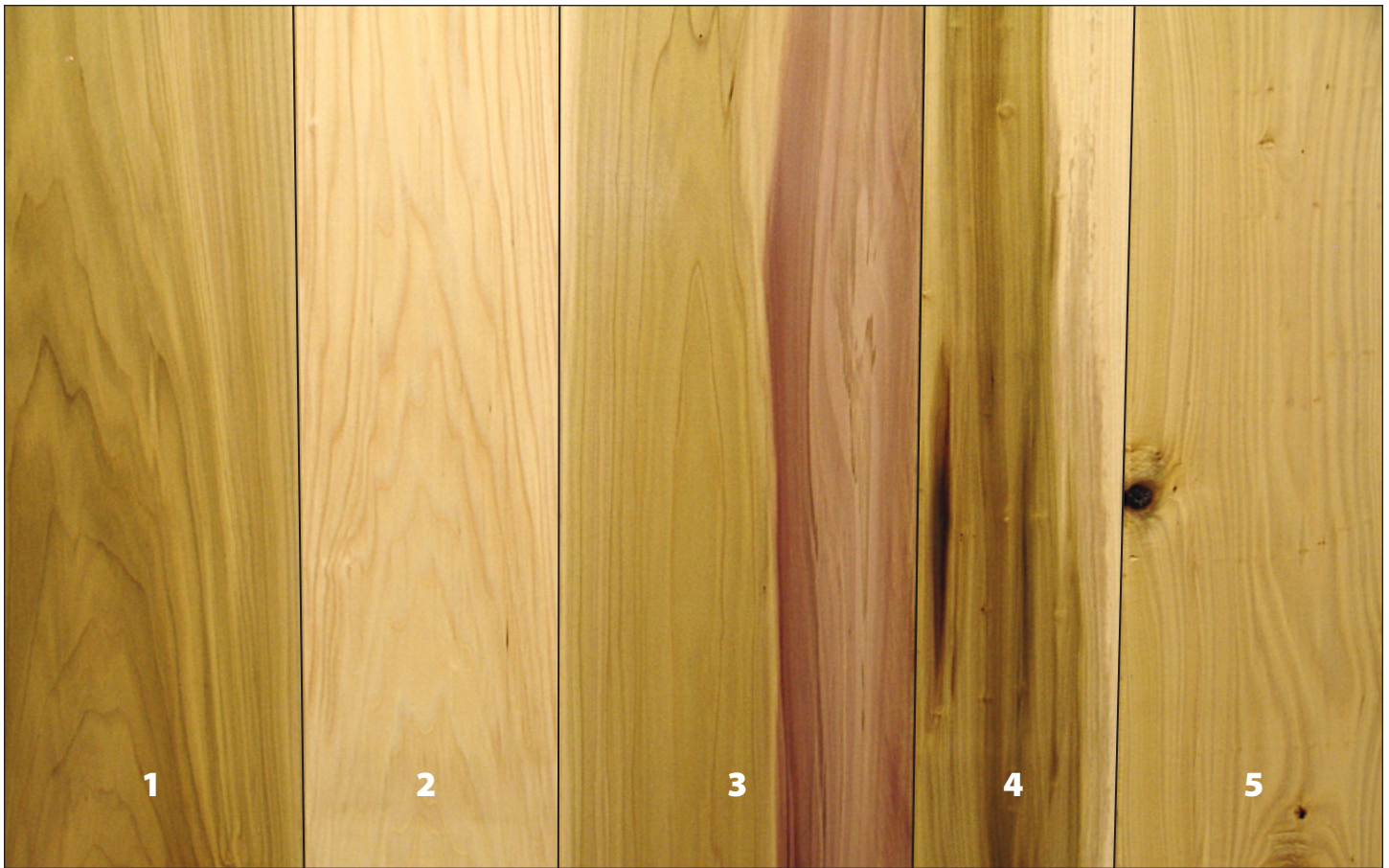
Thermal treatment also helps to stabilize wood. However, at high temperatures, the wood also can experience a loss of mechanical properties. The treatment is a balancing act, which minimizes the reduction of favorable wood properties while enhancing decay resistance. Technical information on North American species is being developed.

References

- American Forest & Paper Assn. 2005. *National Design Specification for Wood Construction*, Supplement, 2005 Edition. Washington D.C.
- Campbell, R.N. and J.W. Clark. 1960. Decay resistance of baldcypress heartwood. *Forest Products Journal*. X(5):250-253.
- Clark, J.W. and T.C. Scheffer. 1983. Natural decay resistance of the heartwood of coast redwood *Sequoia sempervirens* (D.Don) Endl. *Forest Products Journal*. 33(5):15-20.
- Feist, W.C. 1987. Weathering performance of finished yellow-poplar siding. *Forest Products Journal*. 37 (3): 15-22
- Hardwood Review Weekly*. 2008. Vol. 25, Issue 8, Oct. 31, 2008. Box 471307, Charlotte, NC 28247-1307. 5, 9.
- Hunt, M.O., A.J. O'Malley, W.C. Feist, G.P. McCabe, J.W. Evans, D.L. Cassens. 2003. Weathering of painted wood construction: façade restoration. *Forest Products Journal*. 53(4): 51-60.
- MacLean, J. D. 1952. Preservative treatment of wood by pressure methods. Agr. Hbk. No. 40 USDA. 160 pp.
- Random Lengths*. 2008. Vol. 64, Issue 40, Oct. 3, 2008. Box 867, Eugene, OR. 97440-0867.
- Scheffer, T.C. 1957. Decay resistance of western redcedar. *Journal of Forestry*. 33(6): 434-442.
- Smith, Brad W., John S. Vissage, David D. Darr, and Raymond M. Sheffield. 1997. Forest resources of the United States. 1997. U.S. Dept. of Agr., Forest Service. 190 pp.
- Wood Handbook*. 1999. USDA Forest Service Report FPL-GTR-113. www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/fplgtr113.htm.

Acknowledgements

This activity was funded, in part, with a mission-oriented, internal competitive grant from the Purdue University Office of Agricultural Research Programs and Cooperative Extension Service.



Examples of Yellow-poplar Lumber

The yellow-poplar boards shown here provide a range of common characteristics.

Board 1 shows the wide, clear heartwood typical of high-grade yellow-poplar. The growth rings are faintly visible, but there are no discernible pores visible to the naked eye. The color of the heartwood will vary from this relatively dark green to a lighter, almost yellow color in some boards. Small burls are present in the bottom right corner of this piece.

Board 2 is all white sapwood. Heartwood and sapwood are often mixed in the same board, making it difficult to obtain a uniform natural color in a finished product. The sapwood tends to darken to a very light brown, and the greenish heartwood changes to a dark brown over an extended period.

Sapwood also tends to turn gray due to oxidation stain. This piece shows evidence of two very light sticker marks. Stickers are

strips of lumber used to separate the different courses/layers of boards during drying. In white woods, stain can often develop under these stickers. In this case, the contrast appears to be due to weight and crushing of the wood.

Board 3 shows a purplish color, called mineral stain on the right side. In some boards this color will be almost black. With time, the color changes to a dark brown. This stain is probably the result of wounding to the tree.

Board 4 shows mixed heartwood and sapwood and numerous grain swirls. The grain swirls are probably the result of shallow bird peck in the cambium. Some sap stain appears along the right edge.

Board 5 shows both open and tight knots and grain swirls across the width of the board.

PURDUE AGRICULTURE

04/09

It is the policy of the Purdue University Cooperative Extension Service that all persons have equal opportunity and access to its educational programs, services, activities, and facilities without regard to race, religion, color, sex, age, national origin or ancestry, marital status, parental status, sexual orientation, disability or status as a veteran. Purdue University is an Affirmative Action institution. This material may be available in alternative formats.