

Designing with American Hardwoods: A Sustainable, Versatile Material Choice



Haberdasher's Hall, London, uses American white oak to blend traditional materials and building techniques in a 21st century venue. Architect: Michael Hopkins and Partners. Client: Haberdasher's Company.

Versatile, durable and sustainable, American hardwoods have served builders, architects, cabinetmakers and homeowners for centuries. Nontoxic, natural hardwoods bring desirable physical properties, eco-effectiveness and a warm aesthetic to floors, furniture, cabinetry and architectural millwork. Architects and designers often specify American hardwoods because they embody sustainability better than many exotic woods, or newly synthesized materials meant to imitate them.

American hardwoods have long been valued for their warm-toned aesthetics and utility, applicable in residential, commercial, educational, healthcare and institutional settings. Yet, sustainability concerns cause some architects to question traditional assumptions about natural materials. Design professionals recognize that natural materials enrich the built environment and enhance design projects. However, the impulse to protect natural resources may make some architects hesitant to specify them.

As green design evolves into a standard requirement, the process of selecting and specifying materials and products has become increasingly demanding. The meanings of “sustainable” and “environmentally preferable” are not always crystal clear.

Many building products and materials bear “sustainable” labels from across the globe, but this has only clouded the issue. Some products are less green than they claim, while some manufacturers use an “environmentally preferable” label based on only one positive attribute. Exaggerated, misleading or false marketing claims are common hazards when reviewing green products.

Caution is essential in assessing the multitude of low-cost, globally sourced products, synthetic and exotic materials, and related environmental concerns. Available information is often imperfect and incomplete. Trade-offs are inevitable and choices often are not obvious. Selecting and specifying green materials and products requires research and understanding of all product design criteria.

American hardwoods are renewable, sustainable resources that do not introduce toxins or unrecyclable materials into the built environment or the waste stream. Nonetheless, some architects who want to use them still may question their suitability in green buildings. For reassurance, design professionals often turn to product certification systems, because they represent a third-party corroboration of sustainability claims.

However, certification systems have sharp limits. “Certification” and “sustainability” are not necessarily synonymous or interchangeable terms. Decision-making tools such as Leadership in Energy and Environmental Design (LEED) and life cycle analysis (LCA) are evolving, but sustainability can be quantified and standardized only to a limited degree. Green material selection and specification decisions require research and a thorough understanding of materials and processes, rather than reliance on any single resource or reference guide for comparing green materials, products and properties.

Selecting the most environmentally preferable combination of material and application remains a challenge, even given the breadth of knowledge and information that most architects command. Life cycle choices should be based upon a complete understanding of

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LEARNING OBJECTIVES

After reading this article, you should be able to:

- Explore environmentally preferable uses of American hardwoods.
- Specify and use American hardwoods more effectively and sustainably.
- Understand how life cycle thinking facilitates green building products assessment.



materials, rather than on a certification seal or a standards rating alone. Nonetheless, when the unique qualities of American hardwoods make sense for a project, there are practical tactics for specifying and applying them sustainably. Life cycle thinking can logically determine where American hardwoods are environmentally preferable, and how they can be used most eco-effectively.

This article reviews the subtlety and diversity that underline a familiar range of materials, the hardwoods of North America. It explores innovative and sustainable applications of American hardwoods, and offers practical approaches to help architects make aesthetic and environmentally preferable choices.

WHAT “HARDWOOD” MEANS

For effective specifying decisions, design professionals must understand what hardwoods are, and how to compare them with alternative natural and manufactured materials. The term “hardwood” applies to angiosperms, which are trees with leaves, rather than needles. Hardwoods produce fruits or nuts in the summer, shed their leaves in the fall, and go dormant in the winter. The hundreds of hardwoods growing in the continental U.S. all are temperate species. American forests have more diversity of hardwood species than any other temperate forest in the world. They include: Alder, Ash, Aspen, Basswood, Beech, Birch, Cherry, Cottonwood, Elm, Gum, Hackberry, Hard Maple, Hickory/Pecan, Pacific Coast Maple, Poplar, Red Oak, Sassafras, Soft Maple, Sycamore, Walnut, White Oak and Willow.

All of the hardwoods listed are commercially available and can be used for cabinets, furniture, moldings and other architectural millwork, based on aesthetics and supply. For reasons of fashion, regional accessibility, convention, or lack of awareness, many hardwoods, such as gum, poplar and soft maple often are unexplored. Others, including ash, hickory and oak, frequently are underused, despite their widespread commercial availability.

(For detailed profiles of each species, a comparison of physical and working properties, and design values for selected species, see the *Hardwood Species Guide* at www.americanhardwoods.org. Design values for the oaks, maples, beech, birch, hickory, aspen, cottonwood and poplar cover applications such as posts and timbers, beams and stringers, and dimensional lumber two- to four-inches-thick by two- or more -inches-wide.)

Architects and designers have long understood that people respond positively to natural materials in the built environment. Hardwoods add warmth and character, and contribute healthful non-allergenic qualities to homes and workplaces. Since American hardwoods exhibit especially rich diversity in color and grain, they’re most often specified where visual appeal and durability are important. Protective finishes enhance the wood’s color, texture and grain pattern, and are non-toxic and durable. As a result, hardwood products are a sustainable option, even in areas with heavy wear and stringent care, cleaning and maintenance requirements, such as healthcare settings.

Hardwoods contrast with the “softwoods,” or gymnosperms, which are cone-bearing trees with needles, including the fir, pine, hemlock and spruce most often used in construction. Generally, hardwoods are denser and harder than softwoods, although actual resistance to pressure and wear in both groups varies by species.

For this reason, not every American hardwood is suitable for flooring. Those that are hard enough have performed well for centuries. Most applications do not require the extreme hardness exhibited by the tropical woods and grasses, even in heavy traffic areas.

Regarding tropical hardwoods, many of the hardwood species that grow in the world’s tropical forests are subjects of special concern because of illegal, unsustainable harvesting and its effects on wild habitats. In contrast, the U.S. Forest Service documents the sustainability of North American hardwoods, where more has grown than has been harvested annually for more than 50 years. (Figure 1) In addition, hardwood harvesting in U.S. forests is subject to federal, state and local laws and regulations that protect water and wildlife.

In an interview appearing in the 2005 white paper series, *Material Matters*, available at www.americanhardwoods.org under “Green Design and Building,” materials scientist Andrew Dent, director of library and materials research at Material ConneXion, New York, NY, addresses the synthetic substitutes meant to imitate American hardwoods. “The whole point of a composite is putting two dissimilar materials together... basically the perfect composite material is wood. It has the right combination of strengthening fibers and gluey binders to put it all together. So wonderfully reusable and so wonderfully sustainable. Unfortunately the thing they try to replace it with is probably one of the least sustainable materials you’re ever going to come across,” he says.



Floors of locally sourced white oak work sustainably and efficiently with a geothermal radiant heat system at the Girl Scouts' Eberly Family Learning Center in West Virginia.

WORKING WITH NATURE, INNOVATIVELY

Design professionals should know how to judge the sustainability of American hardwoods compared to other materials. When hardwoods are selected for a project, their natural properties and variations distinguish them from predictable, mass-produced materials. Architects who understand these natural processes and manufacturing methods often discover aesthetic and economic opportunities in the choices of species and lumber grades. Three green design principles can be helpful.

- *Work with nature in every respect.*
- *Juxtapose hardwoods with other materials.*
- *Accommodate hardwoods' natural properties during design and specifications.*

Work with nature in every respect. Hardwood-savvy architects understand that some species are more abundant than others. As climate and soil vary, each combination of growing conditions favors a different palette of species. This holds true for various forests and regions across the U.S. Hackberry grows in Louisiana, for example, but not in Vermont; hard maple thrives in Wisconsin, but not in Georgia. This affects the commercial availability and relative affordability of each species. Making the most of this diversity, many architects first consider all the hardwoods native to a region before settling on a solution.

According to Chris Klehm, LEED AP, president of Clearview Construction Services in Pittsburgh, hardwood flooring was used for the 14,200-square-foot Eberly Family Learning Center at the Girl Scouts of Southwestern Pennsylvania's Camp Roy Weller, in Bruceton Mills, WV, where he was the general contractor. "Local West Virginia white oak was selected because it's durable," he says.

This hardwood choice also works effectively with the building's radiant heating system and its heat source, an energy-efficient geothermal system. The client, Denise Fowler of the Girl Scouts, says, "The Girl Scouts are extremely happy with the hardwood flooring over radiant heat. We have three geothermal boilers that make for efficient temperature control. This method significantly lowers our heating costs and promotes sustainability to our youth at the same time."

Klehm adds, "There are two reasons why I select hardwoods. First, they support the sustainable forestry efforts of farmers, as well as the process of creating oxygen for the atmosphere naturally,

and second, they are beautiful. Few other products create value and beauty through the aging process."

Juxtapose with other materials. Peter Bohlin, FAIA, president of Bohlin Cywinski Jackson, Wilkes-Barre, PA, frequently juxtaposes multiple hardwood species, staining techniques, and contrasting materials. In a 2004 interview appearing in *Material Matters*, Bohlin says, "We've been using hardwoods for windows, particularly where we're wrapping [window frames] with copper." For the design and construction of a Utah mountain residence, he notes, "We've used maple or cherry for the basic wood frame that's visible on the inside, and a copper sheathing on the outside. Where we're at high altitudes... that is quite a sustainable strategy. Obviously, there's interplay between [the materials], but also it is really taking the same attitude to all of them, of going after those almost inevitable extensions of those materials and their natures... sort of expressing the spirit of the particular material."

London's Haberdashers' Hall, completed in 2002 and designed by Sir Michael Hopkins, of London-based Michael Hopkins and Partners, combines modern architecture with traditional materials and building skills to form a 21st century high-quality venue. Hopkins, who with his wife and partner, Patty Hopkins, won the 1994 Royal Institute of British Architects Royal Gold Medal, is known for his innovative approaches to construction and energy-efficient design. For Haberdasher's Hall, he chose stainless steel ties, rather than timber trusses, as bracing elements for the roof clad in American white oak. At each intersection of the lattice, four stainless steel shoes are glued to the wood, and bolted to a stainless steel node connecting to steel ties that brace the structure. The result is a light, open, elegant and unobstructed wood pattern.

Accommodate natural properties. Even when applications are innovative, hardwoods are far from experimental materials. They exhibit characteristic and predictable behavior in any application. All wood will reach equilibrium with its surroundings, as the internal moisture content, usually ranging from six to eight percent, adapts to the ambient relative humidity. Traditional techniques address this slight expansion and contraction when installing trim, molding, millwork, flooring or built-ins. On the job site, materials should be kept dry and indoors several days before installation, after the space is climate-controlled. This allows the wood to adjust to relative humidity levels.

Aldo Leopold was a powerful 20th century advocate for conservation and "intelligent consumption." In an article in *American Forest* magazine, "The Home Builder Conserves," he questioned "our universal insistence on clear hardwoods for furniture and interior woodwork.... Consider that the greater part of our enormous hardwood waste occurs in the process of trimming out knots. Is it too much to hope that fashion may some day lift the ban against them?"

Little has changed since Leopold made his plea in 1928. Hardwoods with character markings usually are seen only in rustic settings. The clear high-grade wood that makes up only a small part of the tree is the norm for flooring and architectural millwork in commercial or residential applications. Sustainable use of more of each tree remains a design challenge.

Few design professionals take advantage of the full range of natural visual effects possible with hardwoods.

LEED AND CERTIFICATION SYSTEMS

Even with a strong grounding in the properties and origins of materials, architects may refer to certification systems, rating standards and assessment techniques in evaluating products and materials. However, these tools may be incomplete.

The U.S. Green Building Council's LEED guidelines are an evolving effort to set common standards of green measurement in areas as diverse as water efficiency, energy and atmosphere impact, material and resource use, and indoor environmental quality.

Although not intended as a product evaluation tool, LEED standards favor Forest Stewardship Council (FSC) certification for wood products despite the extremely limited availability of FSC-approved hardwoods anywhere in the world, including the U.S.

Ideally, certification offers reassurance that a product has some level of sustainable merit. However, certifications can become outdated as forest products, conditions and practices change, and not all that's sustainable is certified. Conversely, many forests and forest products meet certification standards even though they have not gone through the formal process.

American hardwood sources are a case in point. Private individuals and families own three quarters of U.S. hardwood forests. According to the U.S. Forest Service, their record of sustainable management spans more than 50 years. However, most do not participate in the fee-based, third-party certification programs established in the 1990s. In fact, less than five percent of the hardwood forestland in the U.S. is certified under any system, including FSC, the Sustainable Forestry Initiative (SFI), and the American Tree Farm program.

As a result, although architects will find sustainable locally-sourced hardwoods, most of the material will not be certified. While all LEED guidelines are being revisited, the FSC preference is unlikely to change soon. Similarly, without a realistic approach to complex hardwood supply chain and chain-of-custody issues, the U.S. hardwood certification situation is unlikely to change dramatically.

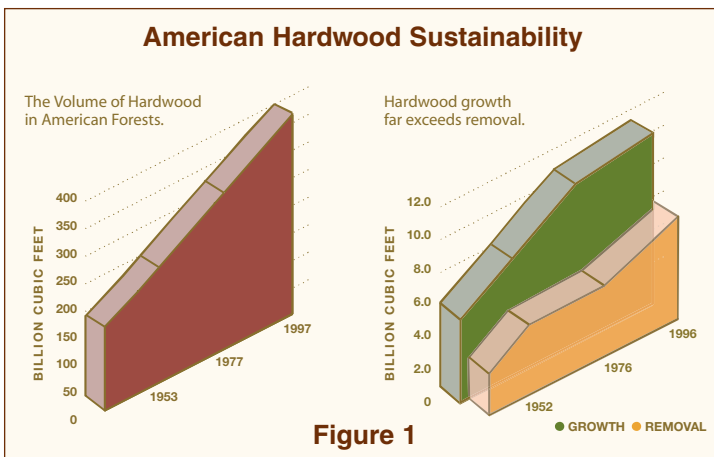


Figure 1

As products proliferate and China and South Asia dominate manufacturing, the variables in assessment detail become increasingly cumbersome. An increasing number of products and materials will be difficult to handle with traditional evaluation tools.

According to Dent, "We're still lacking the fundamental knowledge. We're lacking the terms, and also the 'realistics.' There are some great ideas about using recycled and sustainable materials, but you've got to get a healthy dose of realism there as well."

Jill Kowalski, AIA, LEED AP, director of sustainable design at Philadelphia-based EwingCole, says there's a problem when worldwide product sourcing meets the detailed demands of life cycle analysis. In a 2005 *Material Matters* interview, she observes, "When you're comparing systems, it's more straight-forward. But when you start applying it to products and materials, where there are parts and pieces from all over the globe, it's complicated. The question becomes, 'How far back do I take it?'" In most cases, taking it all the way back is impossible.

THE PRACTICALITIES OF LIFE CYCLE THINKING

Comparing two potential material alternatives, and defending the choice, means evaluating widely different characteristics. Sustainability concerns range from energy conservation, recycling and indoor air quality, to impact on indigenous peoples and wildlife habitats. Simple formulas are no help in weighing the positive impact of high-recycled content against the negative impact of high-embodied energy, for example.

New products are not always better when evaluating hardwoods and green building products. In a 2004 *Material Matters* interview, Huston Eubank, AIA, vice president of the World Green Building Council observes, "How about looking at old materials and finding new ways to use them? Let's look at some old solutions before we feel the need to invent some piece of rocket science that takes the entire power output of the Columbia River to manufacture."

Many forests and forest products meet certification standards even though they have not gone through the formal process.

Clearly, life cycle questions have no simple answers. There's no substitute for product and material research, professional judgment, critical thinking and common sense.

Rules of thumb, however, can produce defensibly sustainable decisions. Although full-scale life cycle analyses and assessments may be unrealistic, life cycle thinking is a practical route to materials selection—a common-sense framework for evaluating alternatives that can be tailored to each project.

Design professionals often use LEED as a quick checklist, and can be tempted to focus on amassing LEED points, rather than on integrated design. Kowalski notes, "If you get too hung up in the credits, you don't take advantage of the whole system. That's how LEED is meant to be used. If you're not used to integrated design, you may work line-by-line instead of big-picture. You have to put the LEED checklist aside for a minute. Do integrated design, and LEED will be automatic."

Advancing technology will continue to strengthen the need for human connections to the natural world. Projects reflecting integrated sustainable design will foster these connections and protect the environment. Smart use of renewable materials, such as North American hardwoods, in attractive, well-designed, environmentally preferable buildings, will contribute to sustainability and enhance the built environment.

SMART AND SUSTAINABLE SPECIFYING TECHNIQUES

"One of the remarkable things about wood is its self-expression ... a kindred spirit to live with and to know."

Eric Sloane (1910-1985), artist and author, *A Reverence for Wood* (Dover, 2004)

Every hardwood surface has a unique personality, like a signed original artwork, inscribed by climate, soil and sun. Two planks in the same floor, two arms on the same chair, two doors on the same cabinet all harmonize, while displaying subtle differences.

As a tree grows, successive seasons trace concentric rings that are visible in the trunk's cross-section, in patterns that vary among species and individual trees. The cell structure and density determine how hard each type of hardwood will be and thus how it can be used.

As the tree grows, knots mark the points where branches joined the trunk. Over time, they disappear under fresh layers of wood. Other natural processes and conditions leave traces that, like knots, reappear only when the tree is harvested and milled into lumber.

When converted to lumber, much of a tree's wood will show knots, mineral streaks or other character marks that reduce the conventional lumber grade, but that do not compromise its visual appeal or integrity. By insisting on clear lumber only, that is, wood that is free of knots and other visible marks, a design professional can miss opportunities to extend budgets or to integrate materials with rich visual qualities. The renowned American master woodworker George Nakashima (1905-1990) excelled at turning lumber with dramatic character marks and irregular contours into furniture of great individuality and beauty.

- *Grain Pattern.* The angle at which each board is sawn from the log determines the grain figure it will display. Flat-sawn lumber is more plentiful and thus more economical than the vertical-grained pattern of quarter-sawn or rift-sawn lumber. Dimensional stability is directly related to proper jobsite handling and acclimation, not sawing direction (see map below).



- *Component Sizes.* After specifying especially long or wide elements (complicated crown moldings, for instance), design professionals sometimes realize that the long, wide, clear boards from which they can be shaped are high in cost or unavailable. Two proven solutions to the molding challenge, either of which may suggest applications in other situations,

are to use material economically finger-jointed from readily available shorter lengths, or to build up a long, complex shape from a series of narrower profiles assembled on-site. (Figure 2) Hundreds of standard profiles exist, usually making it unnecessary to invest in costly custom milling. The results are more economical, and make environmentally responsible use of readily available material, thereby minimizing waste.

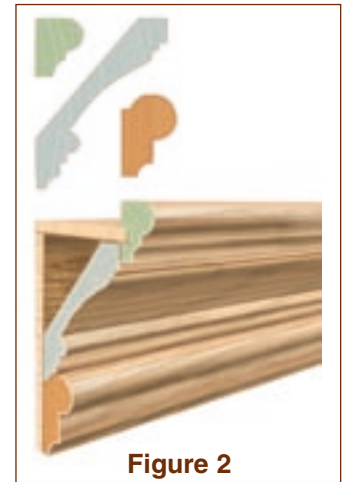


Figure 2

SOURCES OF U.S. HARDWOOD SUSTAINABILITY

According to the U.S. Forest Service, the hardwood volume in American forests increases by 10.2 billion cubic feet each year, while annual removals total only 6 billion cubic feet. As a result, over the last 50 years, the inventory of hardwoods in U.S. forests has grown by more than 90 percent.

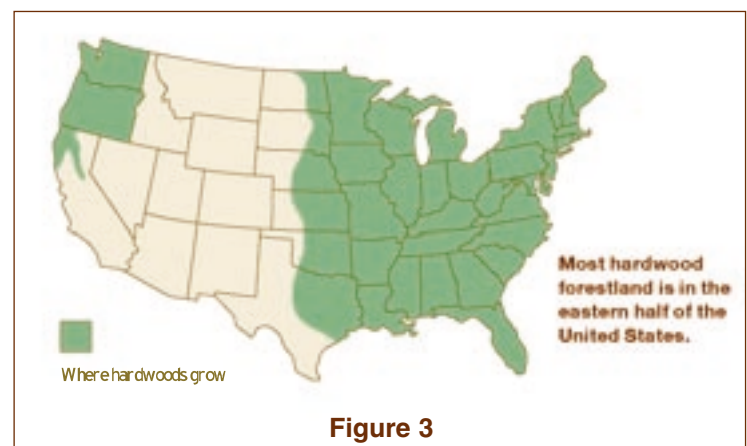


Figure 3

U.S. hardwood forests cover 269 million acres, (Figure 3) land equal to all of Georgia, Illinois, Indiana, New York, North and South Carolina, Ohio, Pennsylvania, West Virginia, and half of Virginia. Most hardwood forests are in the eastern U.S., and they are home to more hardwood tree species than any other temperate-zone hardwood forests on Earth. The reason is that each species thrives under a unique set of regional climate and soil conditions. As a result, each species has a unique set of physical and working properties, (Table 1) and some species are far more widely distributed and naturally plentiful than others. (Figure 4)

Hardwood trees in American forests have a natural life span of 60 to 80 years. Hardwood forestry emulates natural forces by employing single- or small-group tree harvesting. Selection harvesting promotes growth by giving younger trees a greater share of sunlight, water and nutrients.

Domestic hardwood forests replenish themselves on their own natural timetable, and without human intervention. Hardwood forest renewal happens without the post-harvest replanting required for softwoods, as "volunteer" hardwood trees sprout naturally from seeds, tree stumps and roots.

Strength and Mechanical Properties (inch - pound)^a

COMMON SPECIES NAMES	MOISTURE CONTENT	SPECIFIC GRAVITY (G)	STATIC BENDING			IMPACT BENDING TO GRAIN (ft-lb)	COMPRESSION PARALLEL TO GRAIN (lb/ft ²)	COMPRESSION PERPENDICULAR TO GRAIN (lb/ft ²)	SHEAR PARALLEL TO GRAIN (lb/ft ²)	TENSION PERPENDICULAR TO GRAIN (lb/ft ²)	SIDE HARDNESS (lb/ft)
			MODULUS OF RUPTURE (lb/ft ²)	MODULUS OF ELASTICITY (G) (10 ³ lb/ft ²)	WORK TO MAXIMUM LOAD (in-lb/ft ²)						
Alder	Green - 12%	0.37 - 0.41	6,500 - 9,800	1.17 - 1.38	8.0 - 8.4	22 - 20	2,960 - 5,820	250 - 440	770 - 1,080	390 - 420	440 - 590
Ash	Green - 12%	0.45 - 0.60	6,000 - 15,000	1.04 - 1.74	11.8 - 16.6	-- 43	2,300 - 7,410	350 - 1,420	860 - 2,030	-- 940	-- 1,320
Aspen	Green - 12%	0.35 - 0.39	5,300 - 9,300	0.86 - 1.43	5.7 - 7.7	-- 22	2,140 - 5,300	180 - 450	660 - 1,080	-- 260	-- 350
Basswood	Green - 12%	0.32 - 0.37	5,000 - 8,700	1.04 - 1.46	5.3 - 7.2	16	2,220 - 4,730	170 - 370	600 - 990	280 - 350	250 - 410
Birch	Green - 12%	0.48 - 0.65	6,400 - 16,900	1.17 - 2.17	15.7 - 20.8	29 - 33	3,540 - 7,110	360 - 690	1,130 - 1,700	560 - 570	660 - 950
Cherry	Green - 12%	0.47 - 0.50	8,000 - 12,300	1.31 - 1.49	11.4 - 12.8	34 - 55	2,360 - 8,540	270 - 1,080	840 - 2,240	-- 950	560 - 1,470
Cottonwood	Green - 12%	0.31 - 0.40	3,900 - 8,500	0.75 - 1.37	4.2 - 7.4	-- 22	1,690 - 4,910	140 - 380	500 - 1,040	-- 580	-- 430
Cypress	Green - 12%	0.42 - 0.46	6,600 - 10,600	1.18 - 1.44	6.6 - 8.2	24 - 25	3,580 - 6,360	400 - 730	810 - 1,000	270 - 300	390 - 510
Elm	Green - 12%	0.46 - 0.63	7,200 - 14,800	1.11 - 1.54	11.8 - 19.8	38 - 56	2,910 - 7,050	360 - 1,230	1,000 - 1,920	-- 660	620 - 1,320
Gum	Green - 12%	0.46 - 0.52	7,300 - 12,500	1.20 - 1.64	10.1 - 11.9	32 - 36	3,040 - 6,320	370 - 620	990 - 1,600	540 - 760	600 - 850
Hackberry	Green - 12%	0.49 - 0.53	6,500 - 11,000	0.95 - 1.19	12.8 - 14.5	43 - 48	2,650 - 5,440	400 - 890	1,070 - 1,590	580 - 630	700 - 880
Hickory/Pecan	Green - 12%	0.56 - 0.75	9,300 - 20,200	1.29 - 2.26	13.8 - 31.7	-- 104	3,920 - 9,210	760 - 1,980	-- 2,430	-- 2,680	-- 1,820
Hard Maple	Green - 12%	0.52 - 0.63	7,900 - 15,800	1.33 - 1.83	12.5 - 16.5	39 - 48	3,270 - 7,830	600 - 1,470	1,130 - 2,330	-- 720	840 - 1,450
Pacific Coast Maple	Green - 12%	0.44 - 0.48	7,400 - 10,700	1.10 - 1.45	7.8 - 8.7	23 - 28	3,240 - 5,950	450 - 750	1,110 - 1,730	540 - 600	620 - 850
Soft Maple	Green - 12%	0.44 - 0.54	5,800 - 13,400	0.94 - 1.64	7.8 - 12.5	23 - 32	2,490 - 6,540	370 - 1,000	1,050 - 1,850	-- 600	590 - 950
Red Oak	Green - 12%	0.52 - 0.69	7,400 - 18,100	1.14 - 2.28	8.0 - 21.5	26 - 54	3,000 - 8,740	550 - 1,250	930 - 2,080	-- 1,050	860 - 1,510
White Oak	Green - 12%	0.57 - 0.88	7,200 - 18,400	0.88 - 2.05	9.4 - 19.2	-- 50	3,290 - 8,900	530 - 2,840	1,210 - 2,660	-- 940	-- 1,620
Poplar	Green - 12%	0.40 - 0.42	6,000 - 10,100	1.22 - 1.58	7.5 - 8.8	24 - 26	2,660 - 5,540	270 - 500	790 - 1,190	510 - 540	440 - 540
Sycamore	Green - 12%	0.46 - 0.49	6,500 - 10,000	1.06 - 1.42	7.5 - 8.5	26	2,920 - 5,380	360 - 700	1,000 - 1,470	630 - 720	610 - 770
Walnut	Green - 12%	0.51 - 0.55	9,500 - 14,600	1.42 - 1.68	10.7 - 14.6	34 - 37	4,300 - 7,580	490 - 1,010	1,220 - 1,370	570 - 690	900 - 1,010

^a Results of tests on small clear specimens in the green and air-dried conditions. Definition of properties: impact bending is height of drop that causes complete failure, using 0.71 kg (150-lb) hammer; compression parallel to grain is also called maximum crushing strength; compression perpendicular to grain is fiber stress at proportional limit; shear is maximum shearing strength; tension is maximum tensile strength; and side hardness is hardness measured when load is perpendicular to grain.

^b Specific gravity is based on weight when oven-dry and volume when green or at 12% moisture content.

^c Modulus of elasticity measured from a simply supported, center-loaded beam, on a span length ratio of 14/1. To correct for shear deflection, the modulus can be increased by 10%.

Source: Wood Handbook, Wood as an Engineering Material, USDA Forest Service

Table 1

The U.S. Forest Service estimates that 73 percent of these hardwood forest acres are privately owned; the forest industry owns 11 percent, and 16 percent is held by federal, state and local governments. Private owners number around seven million individuals and families, with many holding an average of 50 acres. Often, hardwood forestland ownership goes back several generations, as does the practice of sustainable forestry.

Life cycle analysis is an exhaustive technique, tracing every input and output of each step in the production, use and disposal of a product: extraction and processing of raw materials, manufacturing, transportation and distribution, use or reuse, recycling, waste management and disposal.

Detailed LCA data for products ranging from concrete to roofing are useful only when they are specific. That's why typical building material LCA uses a methodology to study each product from a specific manufacturing process in a given application. Changes in a manufacturing process can invalidate the LCA. Thus, it's unlikely that LCA based on exactly the same terms, statistical tools and applications would have been performed for two materials being compared, leading to an "apples to oranges" dilemma.

For example, the Canada-based Athena Sustainable Materials Institute produced LCA data for softwood construction lumber in residential buildings. The Consortium for Research on Renewable Industrial Materials (CORRIM) also has issued life cycle studies of softwood as a green building material. While somewhat similar, these data aren't directly transferable to hardwoods for appearance applications.

Hardwoods present even greater challenges for life cycle analysis, inventorying and costing. A hardwood product LCA would have to apply a specific methodology to each product made from each different species, such as four-inch red oak plank flooring. These values could not be transferred and assigned with any scientific validity to eight-inch poplar moldings or ten-inch hickory beams, or even to four-inch hickory flooring.

However, when assessing green building products and materials, the following life cycle criteria can aid decision making:

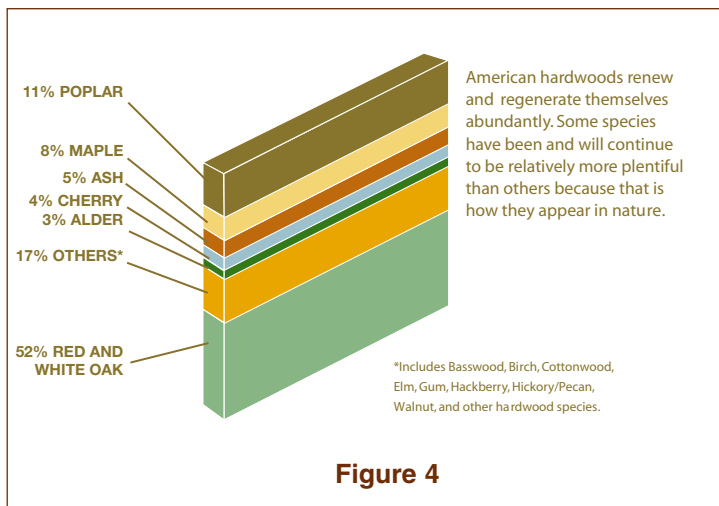


Figure 4

CRITERIA AND CONSIDERATIONS

American hardwoods' diversity—in species and their product applications—presents challenges for certain types of life cycle assessment.

Dennis Gilbert/VIEW



Ninety-eight percent of the materials in this European Commission building outside Dublin are re-useable or recyclable. Opened in 2002, it has won numerous sustainable building awards. Ceiling slats are American ash. Architect: Ciaran O'Connor, Office of Public Works.

1. **Natural product from a sustainable, renewable resource.** If the material is a composite designed to replace a natural product, review the sustainability of components and resins holding them together.
2. **Supply:** Determine abundance, accessibility and availability.
3. **Durability and life cycle:** Review the service life in years, decades or more.
4. **Maintenance requirements:** Assess overall building life cycle, and disposal during future demolition.
5. **Recycled content:** Determine how much energy will be needed to convert the original material to another product.
6. **Recyclability:** Review energy needed to separate components at the end of a material's useful life, and a plan for credible collection and disassembly of infrastructure.
7. **Habitats:** For exotic or tropical crops, determine if increased demand disturbs wild habitats.
8. **Harvesting and production:** For exotic or tropical crops, ascertain applicable regulations, and adequate enforcement and punishment of violators.
9. **Environmental costs:** Review energy requirements for transportation, and find out if toxins involved in production negate advantages of recycled content.
10. **Renewal rates for sustainable resources:** Consider the relative merits of a fast-growing monoculture crop vs. a forest product from a diverse habitat that thrives steadily as individual trees come and go.

Additional reading:

Web site: www.americanhardwoods.org
 "Materials and Methods" – Professional Specifying and Professional Finishing
 "Green Design and Building" – *Material Matters* white papers

About the Hardwood Council

The Hardwood Council serves architects, designers and builders by providing useful information about American hardwoods in sustainable design and building. As an independent, nonprofit organization, the Council advances better understanding of hardwood flooring, furniture, cabinetry and millwork, without bias toward specific products or manufacturers.

The Council's Web site, www.americanhardwoods.org, offers basic information about dozens of American hardwood species, background on sustainable forestry, and overviews of sustainable specifying, design, installation and finishing practices.

In addition to online information resources, The Hardwood Council provides:

- Sustainable Solutions, a handy kit containing 20 American hardwood species samples, a detailed brochure on hardwood



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sustainability and materials properties, and a CD that enables you to try out finishing alternatives on your computer's desktop;

- *Material Matters*, a series of white papers devoted to "conversations about sustainability and our surroundings" that document discussions with leading architects, designers, authors and architects;
- Tips & Techniques, a library of practical briefings on topics such as hardwood products selection, installation, finishing and care.

For more information about The Hardwood Council, and American hardwoods, please visit www.americanhardwoods.org



LEARNING OBJECTIVES

- Explore environmentally preferable uses of American hardwoods.
- Specify and use American hardwoods more effectively and sustainably.
- Understand how life cycle thinking facilitates green building products assessment

QUESTIONS

- The amount of hardwood growing in U.S. forests today is how much greater than it was 50 years ago?
 - 10 percent
 - 20 percent
 - 45 percent
 - 90 percent
- What percentage of trees in U.S. hardwood forests are cherry and oak, respectively?
 - Cherry 45%; Oak 26%
 - Cherry 22%; Oak 37%
 - Cherry 14%; Oak 45%
 - Cherry 4%; Oak 52%
- Which of the following are not American hardwoods?
 - Ash, birch, cherry, elm
 - Fir, pine, hemlock, spruce
 - Hackberry, hard maple, poplar, red oak
 - Sycamore, walnut, white oak, willow
- Which of the following is not an environmentally preferable tactic when using hardwoods?
 - Using only rift-sawn lumber
 - Using a wide variety of species
 - Building up long, wide moldings from narrower, shorter elements
 - Selecting the grade of the wood for the application
- Which of these is not an environmentally important attribute of American hardwoods?
 - Self-renewing
 - Locally available
 - Plantation grown
 - Non-toxic

INSTRUCTIONS

Refer to the learning objectives at left. Complete the questions below. Go to the self-report form below. Follow the reporting instructions, answer the test questions and submit the form. Or use the Continuing Education self-report form on *Record's* web site—archrecord.construction.com—to receive one AIA/CES Learning Unit including one hour of health, safety, welfare credit.

- All of the following are smart specifying strategies for hardwood except which?
 - Design to accommodate natural expansion and contraction
 - Specify only clear, highest grade wood
 - Juxtapose with other materials
 - Give priority to local materials
- Approximately how much American hardwood is certified under any system?
 - Less than 5 percent
 - About 10 percent
 - About 25 percent
 - About half
- All of the following apply to American hardwoods except which?
 - Durable
 - Re-usable
 - Non-allergenic
 - Non-sustainable
- Non-toxic, durable, low-maintenance wood finishes make it possible to use hardwood products in healthcare settings.
 - True
 - False
- Hardwood floors can be used with geothermal radiant heat systems.
 - True
 - False

Program title: **“Designing with American Hardwoods: A Sustainable, Versatile Material Choice,” (10/05)**

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AIA/CES Credit: This article will earn you one AIA/CES LU hour of health, safety, and welfare credit. (Valid for credit through October 2007.)

Directions: Select one answer for each question in the exam and completely circle appropriate letter. A minimum score of 70% is required to earn credit.

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Material resources used: Article: This article addresses issues concerning health and safety.

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