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Selecting Lumber and Lumber Substitutes for Outdoor Exposures

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In California, naturally durable woods such as redwood and other lumber that has been chemically treated to improve durability have long been used in landscape, garden, and structural applications that require increased resistance to wood-eating insects (termites and beetles) and decay fungi. Until the wood-treating industry voluntarily halted its residential use in January, 2004, the arsenical preservative chromated copper arsenate (CCA) was the most common for residential applications. Health concerns regarding human contact with arsenic leached from the lumber resulted in this voluntary withdrawal. The U.S. Environmental Protection Agency accepted the withdrawal, but does not recommend the replacement of existing structures made with the lumber or any removal of soil surrounding CCA-treated lumber [US EPA 2002].

Alternative products have always been available for many exterior applications, but growing consumer interest in lower-maintenance products, combined with a certain degree of concern over the use of old-growth redwood, has increased the demand for other products such as plastic-lumber composites. Slower-growing (old-growth) redwood and other naturally durable species are still available, but faster-growing (young-growth) redwood is more common. The production of all-plastic lumber and fiber-plastic lumber composites has been a growth industry in recent years, and a number of brands are now available to consumers.

Wood cannot rot if its moisture content remains low enough, so keeping wood dry is one way to increase its useful service life. Keeping wood dry, however, can sometimes be difficult. Treated woods have been used where untreated wood would not last long: an increase in useful service life and safety was balanced against any potential environmental impacts that could result from the use of chemically treated wood. Typical uses include structures in direct contact with the ground or water (decks, retaining walls, raised-bed gardens, piers for boat docks) and other applications where wetted lumber could only dry very slowly.

With the growing use of new lumber treatments and lumber substitutes, a number of questions arise: How long can the newer non-arsenically treated lumber last in severe exposure situations? Are there any performance and durability issues associated with lumber substitutes used in common applications where treated lumber would otherwise be used? This publication is a guide to the options available to do-it-yourselfers and contractors who use building materials in more severe exterior exposures.

MATERIALS AVAILABLE

Depending on the application, you have a variety of alternatives to CCA and other non-arsenical preservative treated lumber (*pressure-treated lumber*) (Table 1). These include untreated lumber and fiber-plastic composite lumber. For certain applications, particularly raised-bed gardens, concrete blocks are an appropriate alternative material. Additionally, certain design features can reduce the potential for rot, such as the use of plastic sheeting laid between treated lumber and soil. This also minimizes the contact between any chemicals that might leach from treated lumber and the soil that contains garden plants.

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Table 1. Summary of suitability information for common alternative materials used in specific applications.

Application	Material			
	Untreated wood	Treated wood (non-arsenical)	Plastic composite lumber	Stone, concrete, concrete blocks (CMUs)
Deck boards	Acceptable; best results with a durable species. If stained appearance is desired, re-staining is required every 12–18 months.	Acceptable, but other materials (untreated wood or plastic composite lumber) may be more desirable.	Acceptable; fire susceptibility of some products may limit use in some areas.	Not applicable
Deck support joists and beams	Not the best choice, but untreated Douglas-fir joists are currently used in many decks. Special precautions to protect joists from moisture would extend service life.	Acceptable, and required (by building code) in many locations.	Not acceptable due to structural limitations, however it is commonly used for post and railing applications on decks.	Not applicable
Marine environments	Not acceptable	Acceptable with appropriate chemical loading. Some preservative treatments are not allowed due to environmental concerns.	Acceptable for non-structural applications (e.g., fender piles).	Yes, concrete piles or wraps.
Playground structures	Acceptable; potential service life limitations if non-durable species is used or if sapwood is included in lumber, particularly for ground-contact members. Ground contact portion may be treated to extend useful service life.	Non-arsenical pressure-treated members are available. Would be used in conjunction with other materials.	Acceptable; structural components typically are reinforced. Metal components are also commonly used in these applications.	Not applicable
Raised-bed gardens	Acceptable, potential service life limitations if a non-durable species is used or if sapwood is included in lumber.	Acceptable, especially from service life perspective. Some leaching of copper is possible, which may be of concern to some builders or owners.	Acceptable	Acceptable
Retaining walls	Not the best choice due to potential service life limitations if non-durable species is used or if sapwood is included in lumber.	Acceptable, especially from service life perspective.	Depending on height of wall and loading from behind, structural limitations are likely.	Acceptable
Sill plates	Only selected species and grades are allowed by building codes.	Acceptable, and required by building code.	Not a currently accepted use.	Not applicable

Untreated Lumber

The durability of untreated lumber depends on the type of wood used: some species are very durable and others are not. It is important to understand that the sapwood of any species has a very low natural resistance to the organisms that can destroy lumber. For example, the white part of redwood (the sapwood) is not naturally resistant to decay, but the red part of redwood (the heartwood) is (Figure 1). The natural decay resistance of the heartwood of common commercial lumber species in the western United States and some of the more popular imported tropical hardwoods is given in Table 2.

Natural resistance to decay is caused by the extractives (nonstructural organic components found in wood) found in the heartwood. Because the amount and types of the extractives vary from species to species, so does decay resistance. These extractives also give the heartwood its color. Unfortunately, heartwood decay resistance varies within a species, and depends on the original location of the piece of lumber within the tree. This means that with the same exposure to soil or water, two pieces of lumber from the same tree could perform differently. Given our increased use of second-growth timber, many of our naturally decay-resistant species are in fact less resistant to decay than old-growth lumber. (Note, for example, that Table 2 gives old-growth redwood the highest decay-resistance rating, but gives only a moderate rating for second-growth [or *young-growth*] redwood.)

The advantage of pressure-treated wood over naturally durable species is its greater potential for uniformity in its useful service life. From a performance perspective, the disadvantage of pressure-treated lumber, particularly species such as Douglas-fir and the Hem-fir species group (hemlock and the true firs) that are commonly used in California and the West, is that the lumber is only treated at and near its outer surface. The lumber's core usually cannot be treated (Figure 2). If the treated lumber is cut to length or if it is drilled, the user must either apply a field treatment or rely on the wood's natural

Figure 1. The sapwood of any species is not very durable. Color can often help distinguish the heartwood and sapwood of a species. In this redwood (*Sequoia sempervirens*) board, the reddish wood on top is the heartwood and the white portion is sapwood.

Figure 2. ACQ-treated lumber used in a retaining wall. The end-cut boards reveal a cross-section showing that only the outer shell of the lumber, where discoloration is apparent, contains the preservative chemicals.

Table 2. Domestic and selected imported tropical woods, listed according to average heartwood resistance to decay (Wood Handbook, 1999). These terms *(very resistant, resistant, moderately resistant, slightly resistant,* and *nonresistant)* are intended to provide a relative measure of decay resistance and are based on standard tests where resistance to decay fungi is evaluated in a laboratory.

Resistant or very resistant	Moderately resistant	Slightly resistant or nonresistant
American mahogany (true or Honduras mahogany)	African mahogany	Alder, red
Black walnut	Douglas-fir	Ashes
Cedars (western red cedar, incense cedar, Alaskan yellow cedar)	Larch, western	Aspens
Ipe	Redwood, young growth	Firs, true
Junipers	Southern yellow pines	Hemlocks
Oaks, white	Teak, young growth	Meranti or Luan (Philippine mahogany)
Pacific yew		Oaks, red
Redwood, old growth		Pines (sugar pine, ponderosa pine, lodgepole pine)
Teak, old growth		Tanoak
		Yellow-poplar

Table 3. Estimated service life of representative treated and non-treated lumber.* For this table, it is assumed that non-treated lumber contains no sapwood.

Product	Service life	
	Not in contact with the ground	In contact with the ground
Untreated:		
Douglas-fir	10–15 years	3–6 years
Ponderosa pine	5–10 years	1–3 years
Redwood (old growth)	50+ years	20+ years
Redwood (young growth)	15–25 years	10–15 years
Treated:		
ACQ-treated Douglas-fir (0.4 pounds per ft^3 retention)	30+ years	30+ years
CCA-treated[†] Hem-fir (0.4 pounds per ft^3 retention)	25+ years	25+ years

*Publications by Wilcox (1984) and Miller and Graham (1977) were used in developing this table. A questionnaire completed by regional wood performance experts and the senior author of this publication was also used.

[†]CCA-treated lumber is no longer available for residential use; service life information is given here for historical reference.

Figure 3. Plastic-lumber composite material is used for deck boards. These boards feature a channeled construction, large grooves on the underside of the boards that reduce each board's weight without reducing its strength.

durability. Over-the-counter preservatives used for field treatments will be discussed later.

To help you better understand the trade-offs between treated and untreated lumber, Table 3 gives an estimate of useful service life for treated and untreated lumber based on published information and an informal survey of regional wood experts. A limited survey of local lumberyards indicated that Construction Heart grade redwood would cost about 50% more than pressure-treated lumber. An all-heartwood grade of redwood would cost almost four times as much as pressure-treated lumber.

Plastic-Lumber / Composites

A number of plastic-lumber and fiber-plastic composite products have been introduced in recent years (Figure 3). Some of these products are 100% plastic, but many others contain wood fibers as filler and reinforcement. When present, wood fiber typically accounts for about 50% of the weight of the board. Other reinforcement fibers such as fiberglass or rice hulls are sometimes used. Many but not all of these products contain recycled plastic and wood fiber. Plastic-lumber composites have the advantage of relative resistance to biological organisms, particularly as compared to untreated wood. This is one property that gives them low maintenance requirements. Recently published research and field observations have shown that some wood-fiber–plastic lumber composite products are susceptible to at least limited fungal decay (Mankowski and Morrell 2000; Pendleton et al. 2002; Manning and Ascherl 2004). In these studies, the extent of decay was dependent on the amount of wood in the plastic composite, wood particle size, and other processing variables that affected the composite's water resistance.

According to information obtained in the limited survey of lumberyards mentioned earlier, the cost of 2 × 6 plastic composite decking material was roughly twice that of 2 × 6 Construction Heart grade redwood, and was comparable to a "B" grade. A "B" grade of redwood is more of an appearance grade, meaning that it would contain fewer knots. The price of plastic composite lumber varied according to color, with the reddish products being more expensive. Plastic composite lumber products typically are not as stiff as solid wood or other structural materials, so they are not used as support joists in decks. In raised-bed gardens, though, this material should perform well.

A potential disadvantage for some of these products is their vulnerability to fire (Quarles, Cool, and Beall 2004). This is an important consideration for homes located in the wildland-urban interface when these materials are used as deck boards. Finally, some plastic and plastic composite materials will expand and contract with changes in temperature, so builders might have to provide gaps between boards during construction. Information on the need for and suggested size of the between-board gap should be available from the product manufacturer.

TREATED LUMBER OPTIONS

Field Treatments ("Over-the-Counter Preservatives")

Lumberyards and hardware stores stock a number of wood preservatives and treated-lumber products. The wood preservatives stocked by these stores are generically referred to as *over-the-counter* preservatives because they are readily available to individuals who have not received any special training in chemical use or handling. Over-the-counter preservatives are applied to wood products by either spraying, brushing, or dipping. They are also used on the ends of pressure-treated lumber that has been cut to length or on untreated surfaces that have been exposed by drilling. Preservatives applied in this way do not penetrate very deep, and so should only be thought of as a surface treatment. Greater penetration can be expected when the chemicals are applied to the end grain than when applied to side grain. Also, you can expect a five-minute dip to provide greater penetration that a spray-on or brush-on application (Figure 4).

A number of fungicides are used commercially in paints and stains to minimize the growth of mold fungi (*mildew*), but only a few are used commonly in over-the-counter preservatives for lumber. The most common are copper naphthenate (typically a green solution) and zinc naphthenate (typically a clear solution). Borate-based preservatives, very effective insecticides and fungicides with low toxicity to humans and animals, are also available. The disadvantage of most borate preservatives is that they are easily leached from wood. In exposures where borate-treated lumber could be repeatedly wetted, this preservative would eventually leach away, leaving the wood unprotected.

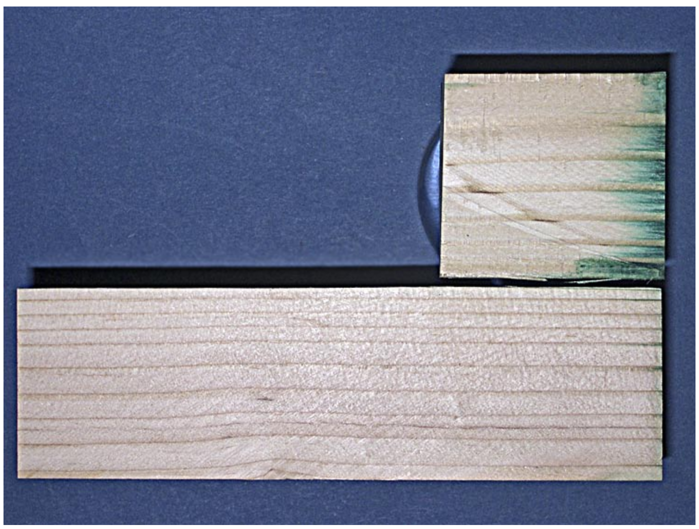

Figure 4. Penetration of copper naphthenate into the end grain of Douglas-fir. A five-minute dip treatment (upper) provided greater penetration than a brush-on application. Typical penetration for the dip treatment was a little more than ¼".

Preservative-Treated (Pressure-Treated) Lumber

The preservative-treated lumber found in lumberyards has been subjected to a pressure treatment process using chemicals that cannot be purchased by the typical consumer. With pressure treatment, the chemicals penetrate deeper into the wood, and the result is improved durability with an associated longer service life. Narrow knife marks that are cut into the lumber surface at regular intervals also aid in penetration of the preservative. Lumber bearing these marks is said to be *incised* (Figure 5). Pressure-treated Douglas-fir and Hem-fir lumber more than one inch thick *must* be incised. Because of its large sapwood zone (which is more permeable than its heartwood), southern yellow pine is not incised. For the same reason, round members (poles) from western species usually are not incised: the more-permeable sapwood is on the outside of the tree underlying the bark, which is removed prior to treatment. Small-diameter round members called *peeler cores* (the part of a log remaining after veneer has been peeled off) often are pressure treated and are available for use in landscaping applications. Peeler cores are not incised, and because they only contain heartwood the preservative does not penetrate very deep.

Figure 5. Incised lumber shows visible marks where knives have cut into the lumber surface. Lumber is incised before treatment with preservatives so the chemicals will be able to penetrate deeper into the wood.

For a number of years now, CCA-treated lumber from the Hem-fir species group (hemlock and white fir) has been widely available in lumberyards. Because Douglas-fir is a common construction material in the West and is hard to treat with CCA, it has commonly been treated with other preservatives. These include ammoniacal zinc copper arsenate (ACZA) and ammoniacal copper quaternary (ACQ). ACZA, like CCA, is an arsenic-containing preservative, but it will continue to be available. Most Douglas-fir lumber treated with ACZA has been used in commercial applications, so it is not available in all lumberyards.

Since the voluntary withdrawal of CCA, new non-arsenic-containing wood preservatives have become available. These include ACQ (with brand names such as Preserve and Nature Wood) and Copper Azole (CBA or CA, depending on whether boron is included in the formulation). Copper Azole is sold under the name "Natural Select." Other non-arsenical formulations will become available over time. In the newer non-arsenical preservatives, copper is the primary preservative, with additional co-biocides added to provide additional anti-fungal activity (Laks 1997). The treatment stamp or tag applied to each piece of treated lumber provides information on the type and amount of preservative chemical contained in the lumber (Figure 6).

Unpublished results of performance assessment for these new preservatives show that the degree of decay and insect resistance of lumber treated with the new non-arsenicals, with appropriate retention and penetration levels, can be similar to that of CCA-treated lumber. This general result is reflected in the expected service lives given in Table 2. In order to prevent premature corrosion of fasteners (nails, bolts, etc.) that can occur when they are used with pressure-treated lumber, the treating industry has always recommended the use of hot-dipped galvanized or stainless steel fasteners. This recommendation will still apply to the new preservatives. Tests conducted by Simpson Strong-Tie, a manufacturer of fasteners and connectors, have shown that many of the new-generation preservatives are more corrosive to steel fasteners than CCA (Simpson Strong-Tie 2004), making the use of stainless steel or hot-dipped galvanized fasteners even more important (Morrison 2004).

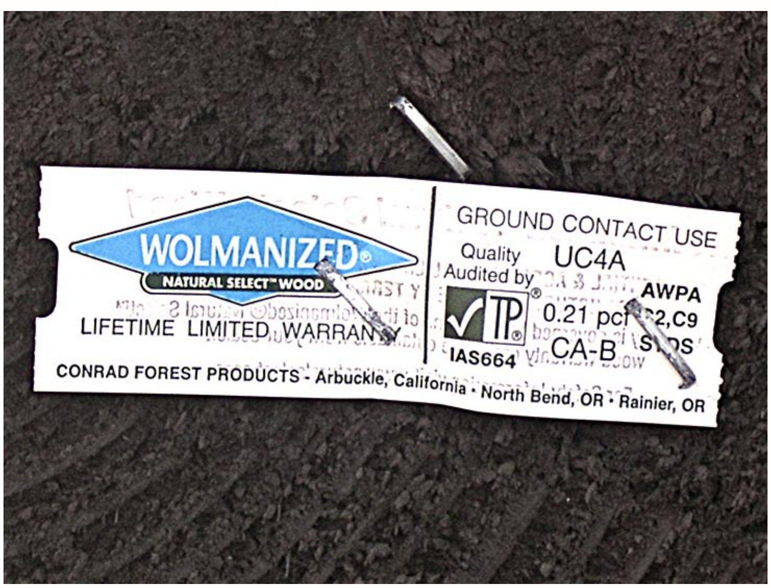

Figure 6. Typical tag on pressure treated lumber, in this case indicating the preservative chemical is Copper Azole, and that the lumber has been treated for a ground contact application. "TP" is a quality control indicator; "UC4A" refers to the lumber's application ("use category"), and is in this case is somewhat redundant with the "ground contact use" statement.

Borate-treated products, either in the form of zinc borate (typically used in oriented strand board [OSB] sheathing panels and cellulose insulation) or sodium borate (used in lumber and plywood products), are also available. Zinc borate is much less soluble than are sodium borate products, so leaching is less of an issue. Some advances have also been made in reducing the leaching tendency of other borate products, but they still are not recommended for use in freshwater- and ground-contact applications.

Preservative-treated timbers (round and square members) that contain pentachlorophenol (*penta*) and creosote are still produced, but are not typically available to the general public. Penta is used to treat utility poles. Creosote is commonly used to treat railroad ties and utility poles. Homeowners can sometimes find used railroad ties at a lumberyard for use in landscaping applications (Figure 7). Used utility poles are harder to find.

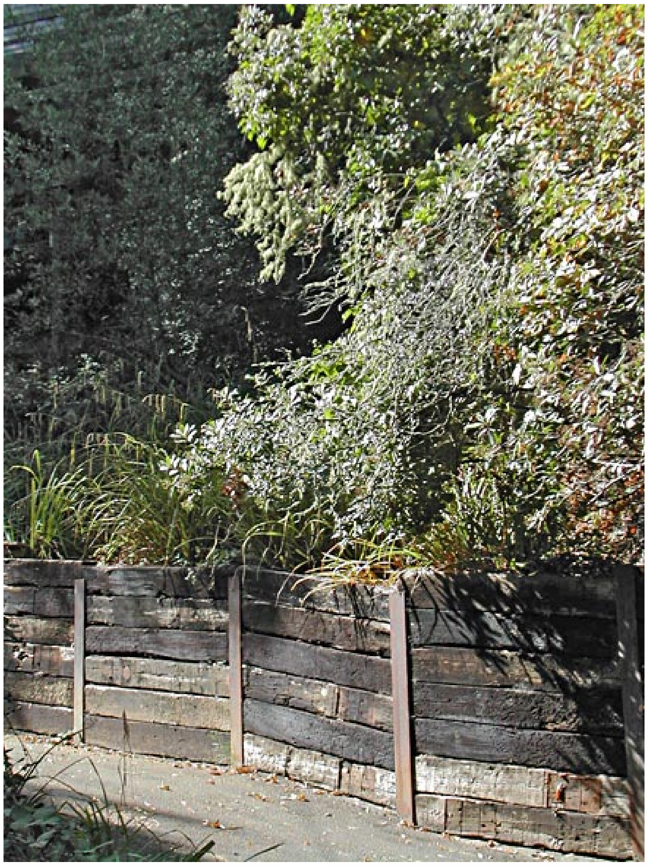

Figure 7. Salvaged creosote-treated railroad ties, now being used in a residential retaining wall.

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