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Stain in Hardwood Logs and Lumber

by
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The problem of stain and its prevention in logs and lumber is receiving increased attention by all lumbermen. Stain is considered a defect in the upper grades of all hardwood species. Log prices have increased to the point where the devaluation or loss of even a small proportion of each log that produces high grade lumber causes considerable economic loss. Hardwood lumber exports have increased substantially. This market is particularly quality conscious and demands bright lumber.

Even after stain-free logs are turned into lumber, the problem does not end. Lumber, especially sapwood, can be discolored by molds, stains, and chemical reactions before it is dried.

Then, too, capital investments in sawmills and their producing capacities have increased. High overhead costs require these mills to operate throughout the year. In turn, these operating requirements and increased mill capacities require that large log inventories be maintained. Large inventories during warm weather increase the likelihood of stain.

Types of Stain

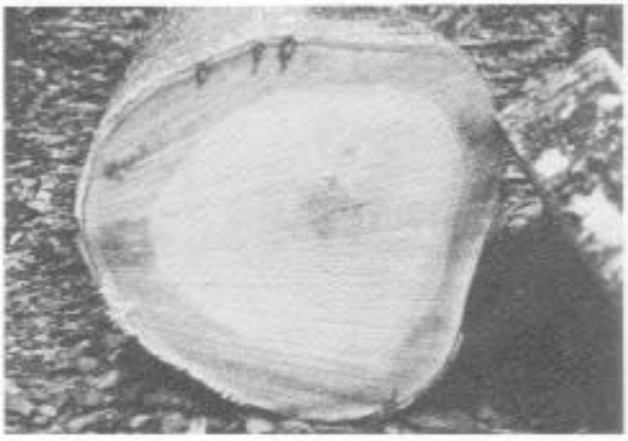
Fungal Stain

Log and lumber stain is a general term that refers to the discoloration of wood by fungi. Fungi are minute, thread-like organisms which dissolve wood or food substances in wood by action of enzymes. The wood is a food source to the fungi. Besides food, fungi also require the presence of air (oxygen), water, and warm temperatures to live and grow.

Wood may suffer from three general types of fungal damage. The most prevalent fungi in stored logs and lumber are those which affect mainly the sapwood, and the resulting damage is called "sap stain." Blue stain is probably the most common of these, and it causes objectionable discoloration and darkening of the wood, as the name indicates. In most cases, the strength of the wood is not affected. However, where heavy sap stain is prevalent, the toughness of the wood or its ability to withstand shock may be reduced.

A second type of fungi, decay fungi, usually takes longer to develop and is more serious than the sap stain fungi. Decay fungi may attack the heartwood as well as the sapwood and will cause serious strength loss and discoloration. When logs have been left unprotected and fruiting bodies or "mushrooms" begin to appear, serious decay has occurred. Sap stains may be accompanied by decay fungi, since both require the same conditions for growth and for destruction of wood.

Molds are a third type of fungi which damage wood. They are a surface growth of a fungus. Molds do not discolor wood as deeply as sap stains, but occasionally their presence will be visible after the lumber is surfaced. Molds are an indication that conditions are correct for sap stain and wood decay to develop, and molds often occur together with stain and decay.



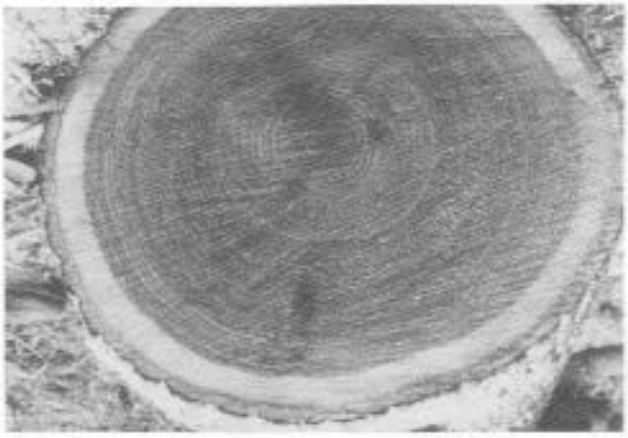


Figure 1. Large sapwood band on southern oak log (A) as compared to narrow band on northern oak log (B).

Chemical Stain

Stains caused by fungi should not be confused with a gray to brown chemical or oxidation stain which develops in logs and lumber during prolonged warm, wet seasons, especially in the southern United States. Species which are predominately sapwood, such as hackberry, sycamore, and ash, are particularly susceptible. In the sapwood of maple and hickory, a reddish or brown color can result. "Pinking" is the industry term often applied to discoloration in these species. Concern about chemical stain in southern oak has also been expressed. Figure 1A shows the cross section of a southern oak log, and Figure 1B shows a northern log. The southern log has a much wider sapwood which has already begun to discolor. On the southern log the sapwood represents a substantial percentage of the total lumber volume. In the northern log, most of the sapwood will be removed in the milling process.

Sometimes chemical stain can discolor the surface of lumber. However, it usually develops just beneath the wood surface, where adequate drying has not occurred (Figure 2).

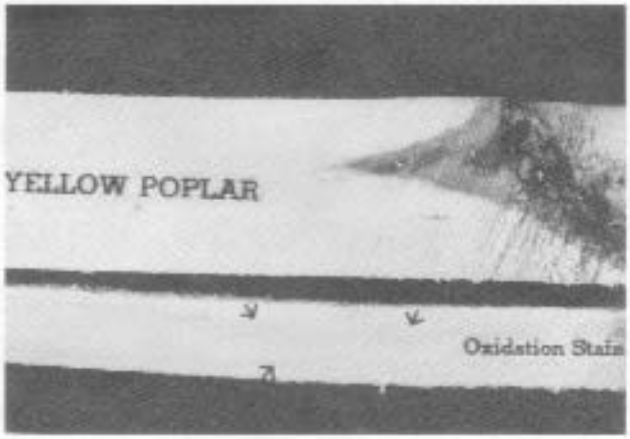


Figure 2. Interior oxidation stain on yellow poplar.

Chemical stains are thought to be the result of oxidation and enzymatic action on certain materials stored in the wood cells. These stains are especially troublesome, since they may not show up until the lumber is surfaced, and they may occur even when biocides and good air drying techniques are used to prevent the fungal type sap stains.

Chemical stain can be differentiated from the fungus type. A concentrated solution of oxalic acid will bleach out the chemical stain but not those caused by fungi. On the other hand, a bleach solution (1 part household bleach and 3 parts water) will remove the surface discoloration caused by molds and mildew fungi.

Mineral Stain

Logs and lumber may also contain mineral stain, which should not be confused with the discoloration problems caused by fungi or chemical reactions in cut timber. Mineral stain occurs in standing trees and takes the form of dark lines or streaks in oak, green to brown zones in sugar maple, or purple to black areas in yellow poplar, for example. Such discoloration can often be traced to a wound in the tree. It is generally objectionable to the end user of fine hardwoods, and it is limited in some grades, depending on species. No effective controls or corrective measures are known.

Damage from Stain

Most lumbermen have no idea how much economic loss they may suffer from sap stains. Portions of boards with stain are sim-

ply "cut back," or the grade is lowered so that losses are hidden. Then, too, stain may be extensive one time, but, at another time, it may not present a serious problem. Warm conditions favor stain development. Therefore, the problem can come and go, depending on the season of the year.

It is difficult to accurately assess the amount of damage which occurs due to stain. An Indiana study on yellow poplar showed that 25 to 39 percent of the sapwood area was stained in logs stored for 10 weeks during the summer. In Texas, 23 to 62 percent of the lumber from logs was stained after 6 months.[1] In a Wisconsin and Michigan study of maple and birch veneer bolts, average sap stain penetration ranged from 21 to 42 inches from each end for winter-cut material held until October.[2] A Mississippi study on hackberry showed that nearly all lumber cut from untreated logs had stain penetration of 15.5 inches on each end.[3] The logs were held for 4 weeks during the summer. Another Mississippi study showed that the value of lumber cut from unprotected hackberry logs was reduced by 56 percent due to stain.[4]

Indiana Study of Stain Development

To determine the significance of stain development, a study was conducted on 32 yellow poplar logs at (1) a central Indiana sawmill and (2) at the Southern Indiana Purdue Agricultural Center (SIPAC) in Dubois County. At each location, one set of logs was used as a control, one set was treated with a chemical spray, and another set was held under water spray. The objectives were to determine the amount of sapwood stained in control logs and the effectiveness of water and chemical sprays in preventing the development of stain.

The chemical was applied to the point of run-off over the entire log at the rate of 1 gallon per 50 gallons of water (active ingredients, sodium pentachlorophenate 21.91% and sodium tetrachlorophenate 3.12%). As suggested by the manufacturer, this is twice the recommended rate for use as a lumber dip. End coatings were not applied. To prevent insect attack, lindane was also incorporated in the spray. However, no insect damage was evident in the control logs.

A commercial water spray system was used at one location, while a perforated garden hose was used at the other. At both locations, the logs were kept consistently wet.

At each location, the three sets of logs were held for about 10 weeks and then sawn into 4/4 lumber. The area of heartwood, sapwood, and sapwood containing stain was measured from the poorest side (usually the heart side) of each board.

The results are presented in Table 1. Percentages of stained sapwood area averaged 25 and 39 percent in the untreated or control logs. On the chemically treated logs, 3 and 7 percent of the sapwood were stained. On water-sprayed logs, 4 and 1 percent were stained. The control logs had a considerably larger percentage of stained area as compared to the treated ones. There appeared to be little difference in the amount of stain which occurred in the chemically and water-treated logs.

Table 1. Surface area of heartwood, sapwood, and stained sapwood, for control, chemically treated, and water sprayed logs from two locations in Indiana.

Treatment	Location	Surface area (Sq. ft.) Total	Heartwood	Sapwood Total	Sapwood Stained	Sapwood area stained (%)
Control	1*	274	153	121	47	39
	2**	270	59	219	54	25
Chemical	1	232	123	109	3	3
	2	227	74	153	10	7
Water	1	378	301	77	3	4
	2	448	273	175	2	1

*Central Indiana sawmill.

**Southern Indiana Purdue Agricultural Center, Dubois County.

Lumber cut from the water-sprayed logs appeared to contain an excessive amount of moisture. As a result, lumber cut from logs held under water spray may take longer to air dry, thus increasing susceptibility to stain. Dip treating freshly cut lumber, as described later, is recommended.

Logs held under water spray lost most of their bark and became slippery. Other species may respond differently. Extra effort to remove bark from the log yard will be required, and some handling problems, due to the logs becoming wet and slippery, may be encountered. After being held under water spray, the logs take on a dark-colored appearance but are bright and clean when opened up.

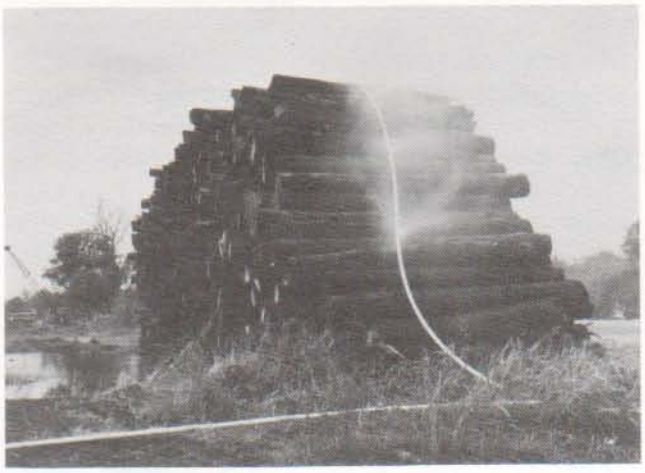


Figure 3. Water sprinkler system used to prevent log stain.

Preventing Log Stain

Since fungi require moderately warm conditions to grow, few fungi-related problems are experienced when temperatures are below 50°F. In northern areas, trouble from log stain seldom occurs during late fall, winter, or the early spring months. In the Deep South, however, stain can develop throughout the year.

Inventory Control

During the warm summer months, stain can be controlled by a rapid turnover of logs. A system should be devised where the first logs decked are the first to be milled. Logs can be decked from one side of the alley and removed from the back side. This prevents any logs from remaining in the yard longer than necessary. Limiting inventory will also help prevent stain of untreated logs during the summer months and will cut inventory costs, as well. It is also common practice to cut those species with wide sapwood first. These species include yellow poplar, hard maple, soft maple, gum, sycamore, and hackberry.

Water Spray Systems

Stain can also be avoided by preventing contact of air (oxygen) with the logs. When ponding logs was common practice, stain seldom developed in those log parts which were consistently submerged because air was excluded.

Today, the most common method of preventing log stain is by using water sprinkler systems (Figure 3). Southern log yard managers have indicated that logs can be stored under water for six months to 1 1/2 years without appreciable damage. Any type of sprinkler system may be used as long as the logs are kept consistently wet. Strong winds, which blow the spray to one side, and hot, dry days must be considered in designing the system. Common crop irrigation equipment is used by some mills. Makeshift operations using fire hose perforated with a leather punch and draped across log decks have been incorporated by others and have given excellent results.

The cost of setting up an irrigation-type sprinkler system to cover a log deck area measuring 120 by 150 feet has been estimated at about $1,800 by one commercial company. This would include 350 feet of 2-inch line, 16 sprinkler heads, a pump, and a 2-horse power motor. It is assumed that the water supply is available at ground level near the log yard. Installation is possible by regular mill employees or maintenance people. The amount of water required varies with temperature and wind conditions. However, 60 gallons per minute should be adequate. The life expectancy of the pipe is about 15 years.

In a Maryland study, it was estimated that it would cost $4,000 (1974 prices) to install a water spray system in a yard capable of storing 1 1/4 million board feet of pine logs. Operating costs would be about $200 per month, most of which would be spent for electricity to run the pump.[5]

The use of water spray systems in log yards may cause excessive accumulation of moisture and water soluble extractives from the bark in the yard, and some of it will "run

off," especially during periods of heavy natural precipitation. In those cases where water is discharged from a point source (log yard), each state has authority granted from the Federal Water Pollution Control Act to require the operator to obtain a National Pollutant Discharge Elimination System (NPDES) permit. This permit will require that the company, at its expense, periodically sample and analyze the discharged water for flow, pH, biochemical oxygen demand (BOD), and total suspended solids.

Past experience has indicated that, without special treatment facilities, it is impossible for state and federal requirements to be met. If this discharged water reaches a stream and the contaminants are still above state or federal requirements, companies will be in violation of the law. If the water from the log yard does not reach a stream or can be contained on the premises, the law is not violated. If a dike or holding pond is constructed to prevent any wastewater discharge, the NPDES permit is not required, but other state permits may be required, especially if any such facilities would constitute a "wastewater treatment system."

Chemical Spray

Chemical sprays have also been used to prevent log staining, although environmental considerations may restrict some chemicals. Pentachlorophenol dissolved in oil or its salt, sodium pentachlorophenate, dissolved in water, has proven effective. Sodium pentachlorophenate mixed with borax has also been effective. Sodium pentachlorophenate was commonly used as a green lumber dip to prevent blue stain. It is now a restricted-use pesticide.

All log species have not been tested. Good results have been obtained on sweetgum, oak, yellow-poplar, magnolia, elm, hickory, sycamore, and black locust in the Deep South, and on white and yellow birch and hard and soft maple in the Lake States and New England. Black oak, beech, and pine species have not responded to the treatment.

It has been reported that only the log ends require treatment. It is assumed that the bark protects the rest of the log. However, openings in the bark, due to cut branches or bark sloughing off, will allow infection to occur. Therefore, it is probably better to treat the entire log.

In treating logs, the chemical should be applied within 24 hours of cutting. An ordinary hand sprayer or larger equipment, as required, may be used. Solution should be applied until it runs freely from the log. If the logs are held long enough to allow end checks to develop, stain can penetrate past the chemical barrier, and an end coating may be required.

Logs subject to insect damage may be infected by stain inoculum carried on the insects. In these cases, all log surfaces should also be sprayed with a compatible insecticide. Lindane and sodium pentachlorophenate are traditionally used and may be mixed together and applied at one time.

Sodium pentachlorophenate, lindane, and the newer pesticides are poisonous compounds. When sprayed on logs, the chemicals will become mixed with sawmill or veneer plant residues such as sawdust and bark. Subsequent uses of the residues may be limited because of the poisonous nature of these chemicals.

Chemical sprays appear to be feasible when small quantities of high-value logs are stored for short time periods. Due to limited commercial application and inconsistent research findings, chemical sprays should be used only when rapid turnover or water spray systems are not practical.

Wax emulsion end coatings are sometimes applied to high-value veneer logs. The coatings should be applied as soon as the logs are bucked. The objective of the coating is to prevent end checking on the log. If the coatings are applied at the time of harvesting, however, they will also serve as a physical barrier to the entry of stain and insects.

In applying chemicals, care should be taken to avoid contact with the skin. Protective clothing, including rubber gloves and rubber rain suits, must be worn by those applying the chemicals. All label warnings must be read, and all directions must be followed.

Preventing Lumber Stains

Fungal Stain

Lumber, like logs, will stain rapidly under appropriate conditions. Figure 4 illustrates sap stain and surface mold on yellow poplar. During summer months in the north, stain can be minimized or eliminated in freshly sawed lumber by following recommended handling and drying practices. The lumber should be put on sticks and placed in a kiln

Figure 4. Sap stain and surface mold on yellow poplar.

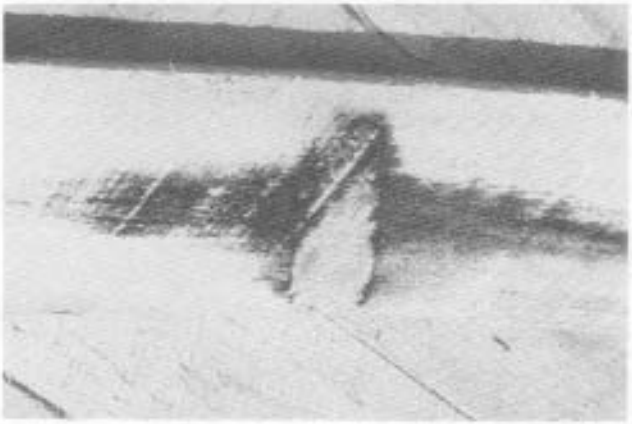


Figure 5. Sticker stain on yellow poplar.

or in a well-located and well-designed air-drying yard as soon as it is cut. This practice allows for rapid drying of the wood surface and thus reduces stain development. (Caution: Excessive checking may occur in thick stock of refactory species such as oak if drying proceeds too rapidly.)

Although proper air drying will generally produce an acceptable product in the north, the use of fungicides will likely result in brighter lumber, particularly for long exposure periods on the air-drying yard. A study conducted in Indiana on yellow poplar which was stickered for 16 weeks during the summer provides some interesting results.[6] Only 27 percent of the untreated boards were rated stain free, compared to 90 percent of those treated with fungicides.

Sticker stain may also develop in untreated lumber while air drying (Figure 5). With good drying conditions, sticker stain is usually not a problem. Stain may develop, however, when poor drying conditions exist and/or when wet stickers are used to stack the lumber. Treatment with an effective fungicide will prevent the problem.

In many cases, it is desirable to bulk-pile green lumber for shipment without prior drying. During warm summer months, stain can develop in a few days. In these cases, stain

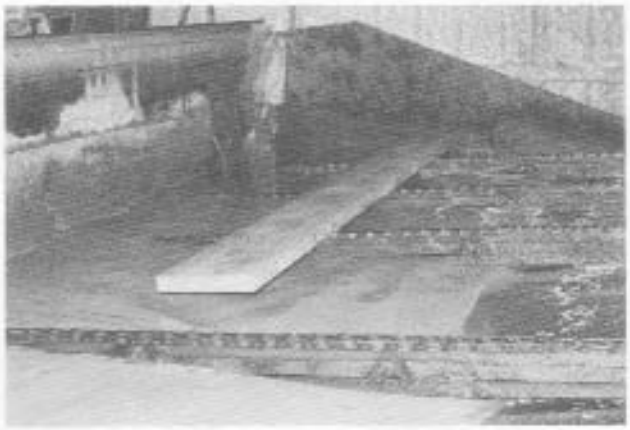


Figure 6. Dip tank with anti-stain chemical.

Figure 7. Dip tank for bulk piled bundles of lumber.

can be controlled by surface treatment of lumber with fungicides. Several fungicides are now available. Treatment can take the form of a dip, where the boards are submerged in a chemical tank installed in the line with the "green chain" (Figure 6). When only a portion of a mill's production is to be treated, large dip tanks located adjacent to the production line are sometimes used (Figure 7). Entire bundles of bulk-piled lumber are lowered in the tank until all surfaces are wetted. Some operators report that a quicker treatment, which also gave better coverage, is obtained by raising one end of the package. This allows air bubbles to escape. In another method, the lumber passes through a spray. In both cases, the objective is to completely coat the wood surface and thus provide temporary protection until the wood is dried.

Costs to treat lumber vary. Significant costs include the chemical equipment, such as tanks or spray lines; construction costs of pads or other confinement work which the state may require to collect drippings and

accidental spills; storage equipment; safety equipment; and permits.

Chemical Stain

The most effective, practical means of control is to rapidly dry the wood. Fan air drying of hackberry is effective in reducing discolorations but may cause excessive checking in refactory species. Drying freshly cut lumber below 50°F or pre-steaming at 200°F prior to kiln drying also has merit, but it is not always practical.

Recent research has shown that red oak boards from freshly cut logs can be protected by dipping them for five minutes in 5% sodium bisulfate (wt/wt basis) and a compatible biocide, followed by 14 days of bulk-piled diffusion storage.[7] The same treatment was effective on hackberry and ash lumber. Unfortunately, this preliminary work was not as effective on lumber cut from logs which had been under water spray. The lumber should be treated as soon as possible after being cut.

Chemical stains can also cause sticker discoloration in two different forms. The first is a faint-to-moderate, gray-to-brown discoloration in the area where the stickers make good contact with the lumber. With the second form, most areas between the sticks usually show a grayish or slightly reddish color after drying, but the areas beneath stickers have nearly the color of fresh cut wood. Both stains may be visible only at or near the surface, or they may occur deep in the wood. Sticker stain occurs mostly in sapwood.

Staining can continue well into the drying program, mainly because the areas under the sticker remain wetter than adjacent areas of the board. On previously air-dried wood, moisture from an outside source (rain or condensation) can be trapped under the sticker, resulting in potential discoloration problems.

This discoloration can be prevented by purchasing fresh cut lumber during the winter months and kiln drying as soon as possible. The kiln dry bulb temperature should be kept low until the core gets below 30% moisture content. Low humidities should be used in the kiln, and caution should be exercised on those refractory species that are prone to surface check. Dry, narrow stickers placed at closer intervals, or grooved sticks, can be helpful. Yard inventories should be limited to avoid extended periods of wetting - drying - rewetting cycles. Yard time should be minimized, especially in warm, very humid periods. And extremely high humidities for extended periods in predriers should be avoided.[8]

Figure 8. Iron stain on oak lumber.

Metal Stain

When iron contacts wet oak lumber or the lumber becomes wet in the presence of iron, a blue-black discoloration or iron tannate stain can result. The tannin in the oak reacts with the iron to form the discoloration. The discoloration can result as the lumber lies for a few hours on iron supports or from iron strapping (Figure 8). The markings are relatively distinct. A slight uniform discoloration can result from blackened water from an iron dip tank. Fortunately, the discoloration is only surface deep and will be removed in machining. If lumber appearance is critical, however, the wood can be treated with a commercially available aqueous solution of an effective metal ion sequestrant.

Summary

Stain, or the objectionable discoloration of wood, is generally caused by fungi and occurs during warm weather. It can affect both logs and lumber. If the proper conditions are allowed to develop, stain is a costly problem. Fortunately, it can be controlled in logs by rapid processing, water spray systems, or by fungicides. It can also be controlled by treating freshly cut lumber with a fungicide. Lumber treatment will not be effective if the logs being processed are already seriously damaged. Unfortunately, treatments do not eliminate damage that has already occurred.

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Precautionary Statement

For some applications, pesticides are required to prevent stain and discoloration of both logs and lumber. When using pesticides, be sure to read and follow label directions and practice proper safety precautions.

In addition, certain state and federal regulations may apply when a water spray system is used for logs, when dip tanks or spray booths are used for lumber treatment, where chemicals are stored or disposed of, and in other situations. Permits may be required. Because the regulatory process is constantly changing, be certain to check with the appropriate state official before proceeding.

Numerous pesticides have been used in the past on wood products. Sodium pentachlorophenate was the most common fungicide, and lindane was the most common insecticide. Both are now restricted-use pesticides and available only to certified applicators. A number of other unrestricted fungicides and at least one insecticide registered for use on wood are now, or soon will be, on the market. Manufacturers can supply information about the effectiveness of these products. Little public domain research or experience is available. As a result, this publication cites results which were generated in the past with sodium pentachlorophenate and lindane. The newer pesticides may be just as effective and not as toxic to people or the environment.

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