BLUE STAIN GROWTH REQUIREMENTS AND SOME RELATED CONTROL PROCEDURES

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Characteristics and Spread of Blue Stain

Blue stain, found in lumber producing areas throughout the world, occurs in both hardwoods and softwoods. In the United States, pines and sweetgum seem most susceptible. Staining essentially is confined to sapwood. The stain is caused by a number of particular fungi that preferentially invade moist sapwood and discolor it as they grow and mature. Like all fungi, they lack chlorophyl, need no sunlight, and cannot synthesize their own food. The staining fungi feed mostly on the starch and sugar contents of certain wood cells, particularly ray tissue, but otherwise do little damage to the wood. Consequently, the strength of blue-stained wood is not reduced significantly except in toughness (1), nor are other wood properties including decay resistance, permeability to preservative solutions, equilibrium moisture content, gluability, or paintability much affected (12). The extent and rapidity of staining increase as conditions for fungal growth improve. Under optimum conditions, as during warm, humid weather, staining fungi may penetrate within 48 hours beyond the depth in wood reached by anti-stain chemical dip treatments (3).

The spread of staining fungi through log and lumber storage yards may occur in several ways. Contact of bright lumber with infected wood allows the fungus to grow directly from board to board and spread locally within a stack of close-piled green lumber. Wider distribution of the fungus occurs through infection of green lumber and logs by bits of the fungi or their spores. The microscopic fragments and spores are easily airborne and carried about by air currents or, to some extent, by insects.

The spores of staining fungi are sensitive to dessication but will germinate if moisture and temperature are adequate. High humidity and temperatures near 70°F at moist wood surfaces not exposed to sunlight and rapid drying are favorable for germination. Spores of a common blue-stain fungus Ceratocystis pilifera attained 80 percent germination after 25 hours at 68° to 77°F (2). Fungal spores do not infect air-dry wood surfaces; they require high humidity or, in some cases, a film of water (1). There is evidence that even small differences in relative humidity may affect both amount and rate of germination of fungal spores (7).

Germinated spores produce microscopically fine, root-like, colorless "hyphae" that move deep into the sapwood and spread rapidly along the grain. As the hyphae mature, they enlarge and darken. It is the mature, brown-colored hyphae that impart the typically bluish-grey color to blue-stained wood.

In addition to food obtained from the wood and favorable levels of temperature and moisture, the invading fungus also needs oxygen in order to grow and cause serious staining. If we examine these requirements in detail it will become apparent how familiar log and lumber handling practices may control, or in some cases promote, fungal stains.

Moisture and Oxygen Requirements

Sapwood of freshly-cut, living trees of most western coniferous species, particularly sugar pine and western hemlock, may be temporarily too wet for optimal fungal growth. The reduced air space and lack of oxygen in saturated wood inhibits growth of common wood-inhabiting fungi. Most western softwoods are saturated when the sapwood moisture content is in a range of about 150 to 220 percent, depending on the density of the wood (4). Low-density woods with greater void space, like pines and spruces, need higher moisture contents to attain saturation.

As saturated sapwood dries, air spaces in cell cavities enlarge and the amount of oxygen eventually becomes adequate for fungal growth. Moist sapwood continues to remain vulnerable to infection and staining during drying, if other conditions are favorable, until it reaches fiber saturation point. At that time, the moisture content limits fungal growth. Growth ceases when moisture content falls to about 24 percent. Further drying to 20 percent allows a safe margin beyond what is generally regarded as a no-growth condition.

Rapid drying of wood surfaces, or prompt treatment with an antiseptic dip or spray, may prevent new infections, but these superficial treatments will not prevent interior staining if the fungus has penetrated below the surface into damp corewood.

Temperature Requirements

Blue-stain fungi generally grow best when wood temperature is at about 75° to 85°F. Growth is slow and may cease, for practical purposes, when the temperature falls below 40°F or rises to 95°F or higher. Geographical strains within a species may differ in their temperature requirements. Some species adjust immediately to change in the thermal environment and continue to grow at the rate normal for the temperature (3). Their quick response allows them to take full advantage of temporarily favorable conditions.

Growth and staining are much reduced as temperatures approach freezing, but the fungus may withstand periods below freezing. A common species, Ceratocystis pilifera, which is tolerant of low temperatures (2), produced viable spores and stained wood slowly at 38°F (5).

Staining fungi are more sensitive to heat than to cold. Lindgren's work (3) showed that an increase of 9° to 15°F above optimum temperature inhibited growth, whereas a decrease of 36°F or more was required to inhibit growth. Growth slows rapidly as temperature rises above optimum and then practically ceases at ~95°F. However, an air temperature of 95°F is not likely to slow fungal growth within the cooler confines of a pile of sappy, green lumber where both temperature and moisture conditions would appear to be favorable for staining. Artificially high temperatures used in dry kilns can be lethal, especially under moist conditions. Some blue-stain fungi may withstand 150°F for at least an hour, but a dry-bulb temperature of 150°F held for 24 hours should kill both stain and decay fungi (8).

Sprinkling stored logs with water helps to maintain high moisture content and thereby retard entrance of fungus-supporting oxygen into the log. Slime growth over log ends is encouraged by sprinkling; it does no harm and may help slow oxygen entry (11). Thorough coverage with water sprays of log surfaces, especially the ends, is important. Mist nozzles on risers between log decks are more effective than drenching sprays from atop decks for wetting the unevenly projecting log ends (9). Water temperature is less important than thorough wetting. Volkmann (13) found no serious damage to pine pulpwood stored for a year under sprinkled warm water (100° to 102°F) from evaporator hot wells. Intermittent spray cycles (6 minutes on, <10 minutes off) were as effective as continuous sprays on pine logs (6). Sprinkling also controls checking and insect attack and can facilitate debarking.

Hot logging and milling procedures race against time to reduce exposure during which stain might develop and spread after felling and throughout milling and drying. During that sequence the wood may become infected, but the fungus may not mature enough to produce serious staining.

Drying and Chemical Treatments

Once logs have been sawed into lumber and the wood is in a form convenient for drying, prompt drying to a safe low moisture content, rather than wetting by sprinkling, is a practical means for controlling stain. Otherwise, chemicals may be used to protect lumber that will not be dried soon.

Air drying of lumber surfaces quickly below fiber saturation point reduces the wood moisture content to levels that do not support spore germination or favor fungal growth. Fast surface drying lessens the chance of infection, but when drying conditions are poor, the fungus may move inward ahead of the inhibiting fiber-saturation level and cause interior staining. Stacking green lumber in solid piles for a day or two during warm weather could produce interior staining later during air drying.

Kiln drying imposes stresses of both low moisture and high temperature on fungi unlucky enough to undergo the process. Resident wood-staining fungi will probably be killed by dry-bulb temperatures of 150°F held for 24 hours. The Dry Kiln Operator's Manual (8) suggests schedules for sterilizing lumber to kill fungi and insects. Kiln-dried lumber is only temporarily sterile, but, like any dry wood, it will remain safe from blue stain as long as its moisture content does not exceed 20 percent. Chemical treatment is recommended if insect damage is a danger during later storage or use (8).

Anti-stain chemicals provide a superficial antiseptic treatment that inhibits fungal infection of lumber surfaces. Chemicals often are applied by dipping or spraying and are useful for protecting green lumber during temporary storage or export (10). They should be applied soon after sawing to avoid possible internal staining. Some species of blue stain fungi may be resistant to particular treatments (2). Your vendor should be able to recommend the formulation and concentration appropriate for your conditions.

Summary

Blue stain fungi have specific requirements for oxygen, moisture, warmth, and food--all of which must be satisfied if the fungi are to thrive and mature sufficiently to cause serious wood staining. Most stain control procedures used during logging, storage, and milling operations attempt to deprive the fungus of one or more needs. Hot logging and milling may outstrip the development of stain. Stored logs that are kept wet maintain high moisture contents and thus limit oxygen in the sapwood. Lumber may be quickly dried to deny adequate moisture, or may be treated with antiseptic chemicals if drying must be delayed.

Literature Cited

1. Boyce, John Shaw. 1948. Forest Pathology. 2nd Ed. McGraw-Hill Book Co., Inc., New York.

2. Käärik, Aino. 1980. Fungi causing sap stain in wood. Sveriges Lantbruksuniversitet, Institutionen för virkeslära, Rapport nr R 114. Upssala, Sweden.

3. Lindgren, R. M. 1942. Temperature, moisture, and penetration studies of wood-staining Ceratostomellae in relation to their control. U.S.D.A. Tech. Bull. No. 807.

4. MacLean, J. D. 1952. Effect of moisture changes on the shrinkage, swelling, specific gravity, air or void space, weight and similar properties of wood. U.S. For. Prod. Lab. Mimeo No. 1448.

5. Miller, D. J. and B. Goodell. 1980. Blue staining in ponderosa pine sapwood at moderate and low temperatures. Manuscript submitted for publication, For. Prod. J.

6. Miller, D. J. and Sam Swan. 1980. Blue stain in sprinkled log decks and lumber piles of ponderosa pine. For. Prod. J. 30(2):42-48.

7. Morton, H. L. and D. W. French. 1966. Factors affecting germination of spores of wood-rotting fungi on wood. For. Prod. J. 16(3):25-30.

8. Rasmussen, E. F. 1961. Dry kiln operator's manual. U.S.D.A. Agriculture Handbook No. 188.

9. Richmond, H. A. and W. W. Nijholt. 1972. Water misting for log protection. Pacific Forest Research Centre, 506 W. Burnside Rd., Victoria, B. C.

10. Roff, J. W., A. J. Cserjesi, and G. W. Swann. 1980. Prevention of sap stain and mold in packaged lumber. Tech. Rep. No. 14R. Forintek Canada Corp., Western Forest Products Lab., Vancouver, B. C. V6T 1X2.

11. Scheffer, T. C. 1969. Protecting stored logs and pulpwood in North America. Material and Organismen 4. Bd. Heft 3. Verlag: Duncker & Humblot, Berlin 41.

12. Scheffer, T. C. and R. M. Lindgren. 1940. Stains of sapwood and sapwood products and their control. U.S.D.A. Tech. Bull. No. 714.

13. Volkmann, D. 1966. Water spray storage of southern pine pulpwood. Tappi 49(7):48A-53A.