The Colorado Wood Utilization and Marketing Program **presents:**

Beating the Blues: *Frequently Asked Questions about the Mountain Pine Beetle and the Utilization of Blue-Stained Lodgepole Pine Timber in Colorado*

The nature of the problem

1. What is the Mountain Pine Beetle (MPB) and what does it look like?
2. Where can the MPB be found?
3. What effects does the MPB have on overall forest conditions in Colorado?
4. How does the MPB attack tree species such as lodgepole pine (LPP)?

The impact of blue stain

5. What is bluestain?
6. What effect does blue stain have on the timber that remains?

Marketable solutions

7. What products can be produced from trees killed by MPB?
8. How can these products be marketed and who is likely to purchase them?

References

1. What is the Mountain Pine Beetle (MPB) and what does it look like?

The Mountain Pine Beetle, Dendroctonus ponderosae, is a parasite afflicting pine trees in the Rocky Mountain west. Measuring between 1/8th and 1/3rd of an inch (see Figure 1), the MPB is a black bark beetle that differs from other similar species such as the Ips beetle species in that the wing covers for the MPB are smooth while the wing covers for Ips beetles have spines (Leatherman 2005).

Figure 1: Mountain Pine Beetle

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2. Where can the MPB be found?

The MPB can be found throughout Colorado, typically in forested areas below 10,000 feet in elevation. While numbers of the insects have either declined or remained static, natural conditions have encouraged "hotspots" around the state where beetle-related mortality rates remain high. Major outbreaks are currently ongoing in Grand, Summit, Larimer, and Chaffee counties. Areas containing hotspots include the Wet Mountain range, the eastern slope of the Sangre de Cristo mountain range, the I-70 corridor near Vail, and all major National Forests in Colorado (Colorado Division of Forestry 2004: 4-5).

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3. What effects does the MPB have on overall forest conditions in Colorado?

At the end of 2004, the Colorado Division of Forestry (2004: 4) estimated that MPB attacks were responsible for the deaths of over 1.25 million trees, with exponential increases expected as natural conditions favorable to beetle propagation persist (see Figure 2). While normally MPB attacks are endemic (i.e. characterized by low-intensity MPB activity) and center on trees stressed by lightning strikes, affected by age, stricken with pathogen affliction or recurrent attacks from MPB and other insects, or suffering from mechanical injury, prolonged stresses such as the current drought can cause endemics to become epidemics as the natural defenses of large numbers of trees collapse (Chase 2000).

Figure 2: Mortality Due to MPB in Colorado

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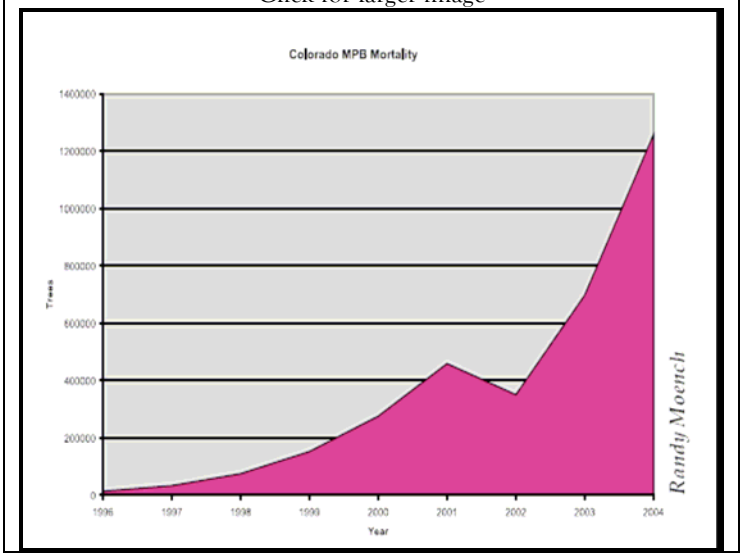

The effects of these attacks are numerous. Outbreaks of the MPB under these conditions can lead to changes in wildlife species composition and distribution by altering available terrain cover and by impeding movement (Amman et al. 1977). Due to the fact that trees are dying throughout this process, water yields may actually increase for several years following an infestation, but these dry, dead trees also pose a fire danger. Not only do MPB attacks affect the timber values of a forest, they also affect other values including recreation, species biodiversity, scenic vistas, cultural heritage, fish, wildlife, and watershed management.

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4. When and how does the MPB attack tree species such as lodgepole pine (LPP)?

MPBs usually serve a beneficial purpose in that they tend to attack the older and least vigorous trees in a forest, especially those, as mentioned previously, under stress from poor site conditions, fire damage, injury, overcrowding, and disease, etc. However, recent attacks on lodgepole pine forests were launched against stands that contained well-distributed, large diameter trees or those stands that are simply dense and overstocked. These attacks typically occur between 20 July and 10 September when the MPB flies from the trees currently inhabited towards green trees. The method of attack for the MPB centers on burrowing through the bark to the phloem layer of the tree, which serves both as a food source and as habitat for breeding. By utilizing this layer, the MPBs essentially girdle infected trees, killing them (Roe and Amman 1970).

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5. What is bluestain?

As the MPBs attack lodgepole pine trees, they concomitantly introduce fungal spores of the species Ophiostoma into the wood that quickly germinate and infect the sapwood. As the fungus grows, the sap flow within the tree becomes hindered. This combination of beetle infestation and fungal growth can lead to massive tree fatalities. The introduction of fungus into the tree and its continued propagation from MPB attacks results in a bluish discoloration in the timber, principally in the sapwood (Byrne et al. 2005: 6). This staining poses a significant problem for the wood products industry. Discoloration leads to a loss in the economic value of the tree due to a loss of marketability as consumers equate this bluish discoloration with some sort of defect.

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6. What effect does blue stain have on the timber that remains?

Several properties of lodgepole timber are impacted by the presence of the bluestain fungus, including physical properties like strength, stiffness, toughness, dimensional stability / checking, permeability, glue joint integrity, and finishing / adhesion capabilities. In 2003, a study was completed by Fornitek Canada Corporation on over 500 pieces of lodgepole pine timber from 14 sawmills in the British Columbia area (4). The results of that study are adapted in Table 1.

Much of the research regarding blue-stained lodgepole pine utilization finds that the sooner the wood is harvested after a MPB attack, the better the chances for quality wood and reduced blue stain. Some of the research also states that high quality wood can be harvested for a number of years following a beetle attack. Preventing and controlling blue stain requires unfavorable conditions for the fungi. Keeping the wood dry and in high temperatures has shown some impacts. Once these spores are on the surface of a nutrient rich environment, they grow rapidly. Blue-stain fungi can survive but grow is stunted in wood with moisture contents (MC) of 20% or less or in high or low temperatures. Temperatures greater than 150 degrees Fahrenheit are lethal to bluestain fungi. This allows for dry kiln operators to use their kiln schedules for the control of fungus growth. It must be taken into account that beetle-killed wood often has a lower MC than normal trees in order to avoid over-drying, splitting, and checking of the wood during the drying process.

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Table 1: Properties of Lumber with Beetle-Transmitted Bluestain

Property Tested	Results	Implications
Stiffness and Breaking Strength	No significant difference.	These are the most important strength properties for structural applications. Bluestained wood is as strong and stiff as non-bluestained wood.
Impact Resistance (Toughness)	Slightly lower (5%) impact resistance for bluestain.[1]	Toughness is not a critical strength property for most end-uses of wood but is one of the first properties affected by biological agents.
Truss Plate Grip Capacity	Measurable (6%) increase in ultimate grip capacity but similar slip for blustained wood as for nonstained wood.	Good plate grip capacity is critical for the design and manufacture of trusses. The measured increase is not of practical significance for truss design
Dimensional Stability and Checking (in Repeated Wetting / Drying)	Bluestained wood was significantly less prone to warping when tested in our simulation of outdoor exposure. Cracks were significantly smaller in bluestained wood.	Bluestained wood seems to develop micro-cracks (hairline cracks). This may have implications for kiln-drying practices, as well as potential benefit for the appearance and performance of wood in outdoor use. True outdoor testing is needed to clarify the implications.
Permeability and Treatability with Preservatives	Bluestained sapwood wets more readily with water. The heartwood resistance to treatment is unchanged.	Bluestained sapwood is more easily treated with wood preservatives and fire retardants.
Glue Joint Integrity	No difference between bluestained and non-bluestained wood.	No changes required for use of either structural or non-structural adhesives with bluestained wood.
Finishes for Masking Bluestain	Best masking of bluestain for furniture-grade products is achieved with stains, toners, or glazes containing blue, red, or charcoal tints.	Furniture manufacturers could use combinations of these tints to reduce stain/non-stain color contrast without making the product too dark.
Finishes for Enhancing Bluestain	Clear finishes are best at enhancing or highlighting the bluestain.	Some people find the bluestain visually appealing (see FAQ #8).
Finish Adhesion	No difference between bluestained and non-bluestained wood.	No changes required for use of stains, toners, and glazes.

Source: Adapted from Fornitek 2003: 2-3.

[1] The small reduction is much lower than previously reported for other types of wood and staining fungi and is of no practical significance in construction (Fornitek 2003: 2)

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7. What products can be produced from trees killed by MPB?

Bluestain fungi are not mold and do not cause decay or rot problems. They are considered harmless with respect to both wood products and people, and are usually dead by the time they have left the manufacturer (Forintek 2003: 1).

With this in mind, wood that contains the blue stain fungus can be used in all of the same markets as non-stained wood with some qualifiers. The main impediment seems to be consumer related issues involved with the value and performance of this wood. Some of the larger wood retailers and lumber stores are requesting stain-free wood and trying to avoid this issue altogether. Other organizations, like the Denim Pine Marketing Association have established a process to market a variety of blue-stained products such as flooring, paneling, and furniture.

Several different research projects have looked at the feasibility of using bluestained lodgepole pine throughout the Rocky Mountain West. Wood from dead lodgepole pine trees differs very little from live trees for use in composition boards. Some of the internal bond responses differed, but there were few harmful effects and in some respects they were considered to be advantageous for composition board manufacturers (Lemaster et al. 1983). All of the lodgepole pine boards that were tested had relatively poor linear expansion and failed to meet commercial standards, except in flakeboards (Lemaster et al. 1983).

Beetle-killed lodgepole pine can also be used in the fuelwood and biomass markets. Beetle-killed wood inherently has a lower moisture content and thus has a higher BTU content. Bluestain should have no effect on wood set aside for use in biomass and alternative fuel markets, but more research is needed in this field to determine the overall economic feasibility of such projects.

Possibly the most important and widely noticed outlet for bluestain lodgepole pine is the solid wood products field. These products would include but not limited to: house logs, utility poles, dimensional lumber, mine timbers, railroad ties, small posts and poles, fencing, paneling, and pallet stock. Despite the decrease in the level of toughness for bluestained lodgepole pine wood, the overall integrity of the wood is the same. Bluestained wood can be used for any of the aforementioned products without any special technological issues. Some standard lumber grading rules do limit the amount of blue stain permitted on structural lumber if it is exposed. If the wood is concealed, then there should be no downgrading.

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8. **How can these products be marketed and who is likely to purchase them?**

The consumers are the ones that are making the sale of blue-stained wood an issue. Some mill owners are losing money during processing of blue-stained lodgepole pine because of loss in grade and volume, while others are successfully manufacturing and marketing this wood without any problems. This shows that consumer viewpoints are mixed and skewed. The use of blue-stained wood is actually a "green" use of the resource. One approach may involve an aggressive education and marketing plans that could be introduced by sawmills and land management agencies combined with point-of-purchase displays and kiosks at in-state trade shows. Once consumers are educated about blue-stain and realize that bluestain is not indicative of a defect, the magnitude of problems associated with the marketing of blue-stained wood should decrease.

A second approach may be to lean less toward educating consumers and more on marketing the bluish discoloration as an "exotic" product, especially for appearance-grade products. Research from Oregon State University suggests that premiums can be charged for certified wood products that equal or even exceed 2% of a product's monetary value (Anderson

and Hansen 2003a: 1). Bluestained lodgepole pine could be certified through a process in collaboration with the Colorado Forest Products initiative that would allow producers to attach a premium to their products. In this approach, the emphasis relies more on fashionable trends as opposed to enlightening consumers who might simply prefer a product that looks different but more appealing than those goods that are currently and more widely-available.

Previous research suggests the target market segment might consist primarily of consumers who are typically:

- younger,
- politically liberal,
- willing to pay a premium for the certified products,
- more likely to believe environmental information on product packaging, and
- more likely to have engaged in past environmentally-friendly purchase behavior (Anderson and Hansen 2003b: 1).

However, caution is warranted; additional research is needed to verify.

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Images:

Mountain Pine Beetle:
Leatherman, D.A. 2005. Mountain pine beetle. Colorado State University Cooperative Extension Fact Sheet. No. 5.528. Available online at http://www.ext.colostate.edu/pubs/insect/05528.html
Image available on-line at http://www.ext.colostate.edu/pubs/insect/INSIMG/05528f3.jpg

Tree mortality graphic:
Colorado Division of Forestry. 2004. Report on the health of Colorado's forests. Denver, CO: Colorado Department of Natural Resources. 28 p. Image appears on Page 4.
Image available on-line at: http://lamar.colostate.edu/~rmoench/04foresthealth.pdf

Selected References

Amman, G.D., M.D. McGregor, D.B. Cahill, and W.H. Klein. 1977. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. USDA Forest Service Gen. Tech. Rep. INT-36, 19 pp.

Anderson, R.C. and E.N. Hansen. 2003a. Do forest certification ecolabels impact consumer behavior? Results from an experiment. Wood Science & Engineering, Oregon State University, Corvallis, OR. Available on-line at http://www.cof.orst.edu/cof/fp/faculty/hansen/Home%20Depot%20Experiment%20one%20pager.pdf. 2 p.

Anderson, R.C. and E.N. Hansen. 2003b. Segmenting Consumers of Ecolabeled Forest Products. Wood Science & Engineering, Oregon State University, Corvallis, OR. Available on-line at http://www.cof.orst.edu/cof/fp/faculty/hansen/SegmentingEcolabeledConsumersonepager.pdf. 2 p.

Bowyer, J.L., R. Shmulsky, and J.G. Haygreen. 2003. Forest products and wood science: an introduction. Ames, IA: Iowa State University Press.

Byrne, T., K.L. Woo, A. Uzunovic, P.A. Watson. 2005. An annotated bibliography on the effect of bluestain on wood utilization with emphasis on mountain pine beetle vectored bluestain. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC. Mountain Pine Beetle Initiative Working Paper 2005-4. 58 p.

Chase, J. 2000. Mountain pine beetle frequently asked questions. Colorado State Forest Service, Boulder District. Available online at http://lamar.colostate.edu/~jchase/faqs.htm.

Colorado Division of Forestry. 2004. Report on the health of Colorado's forests. Denver, CO: Colorado Department of Natural Resources. 28 p.

Forintek Canada Corp. 2003. Properties of lumber with beetle-transmitted bluestain. Forintek Canada Corp., Western Division, Vancouver, B.C. Wood Protection Bulletin. 4pp.

Leatherman, D.A. 2005. Mountain pine beetle. Colorado State University Cooperative Extension Fact Sheet. No. 5.528. Available on-line at http://www.ext.colostate.edu/pubs/insect/05528.html.

Lemaster, R.L., H.E. Troxell, G.R. Samson. 1983. Wood utilization potential of beetle-killed lodgepole pine for solid wood products. Forest Products Journal 33(9): 64-68.

Roe, A.L. and G.D. Amman. 1970. The mountain pine beetle in lodgepole pine forests. USDA Forest Service Research Paper INT-71. 21 p.**Selected Additional References**

Amman, G.D.; McGregor, M.D.; Cahill, D.B.; Klein, W.H. 1977. Guidelines for reducing losses of lodgepole pine to the mountain pine beetle in unmanaged stands in the Rocky Mountains. USDA Forest Service Gen. Tech. Rep. INT-36, 19 pp.

Ballard, R.G. 1982. The pathogenicity of blue-stain fungi on lodgepole pines attacked by mountain pine beetle. PhD diss., Utah State University, Logan, UT. 89pp.

Ballard, R.G.; Walsh, M.A.; Cole, W.E. 1982. Blue-stain fungi in xylem of lodgepole pine: a

light microscope study on the extent of hyphae distribution. Canadian Journal of Botany 60: 2324-2341.

Ballard, R.G.; Walsh, M.A.; Cole, W.E. 1984. The penetration and growth of blue-stain fungi in the sapwood of lodgepole pine attacked by mountain pine beetle. Canadian Journal of Botany 62: 1724-1729.

Barron, E.H. 1970. Utilization of beetle-killed southern pine trees. Paper Trade Journal. 154 (42, Oct. 19): 62.

_____. 1971. Deterioration of southern pine beetle-killed trees. Forest Products Journal 21(3): 57-59.

Byrne, A.; Uzunovic, A. 2000. Does beetle-killed lodgepole pine lack strength? Forintek Canada Corp., Western Division, Vancouver, B.C. Internal Report, 9pp.

Byrne, A. 2003. Characterizing the Properties of Wood Containing Beetle-Transmitted Bluestain: Background, Material Collection, and Summary of Findings. Report to Forest Innovation Investment. Forintek Canada Corp., Western Division, Vancouver, B.C. [W-1974]. 9pp.

Byrne, T.; Woo, K.L.; Uzunovic, A.; Watson, P. 2005. An Annotated Bibliography on the Effect of Bluestain on Wood Utilization with Emphasis on Mountain Pine Beetle-Vectored Bluestain. Mountain Pine Beetle Initiative Working Paper 2005-4. Report from Pulp and Paper Research Institute of Canada and Forintek Canada Corp. Vancouver, B.C. 58 pp. Available at: http://warehouse.pfc.forestry.ca/pfc/25333.pdf.

Carr, W.R. 1978. Comparison of lodgepole pine lumber recovery from live and dead timber. USDA Forest Service, Missoula, MT. Office Report. 19pp.

Chapman, A.D.; Scheffer, T.C. 1940. Effect of bluestain on specific gravity and strength of southern pine. Journal of Agricultural Research 61(2): 125-133.

Dobie, J. 1978. An overview of dead timber potential in Canada. Pages 1-10 in The dead softwood lumber resource: proceedings of the symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Dobie, J.; Wright, D.M. 1978. Lumber values from beetle-killed lodgepole pine. Forest Products Journal 28(6): 44-47.

Encinas, O.; Henningson, B.; Daniel, G. 1998. Changes in toughness and fracture characteristics of wood attacked by the blue stain fungus Lasiodiplodia theobromae. Holzforschung 52(1): 82-88.

Fahey, T.D. 1980. Evaluating dead lodgepole pine for products. Forest Products Journal 30(12): 34-39.

Fahey, T.D.; Snellgrove, T.A.; Plank, M.E. 1986. Changes in product recovery between live and dead lodgepole pine: a compendium. Pacific Northwest Research Station, USDA Forest Service, Portland, OR, USA. Research Paper PNW-353. 25pp.

Fell, D. 2002. Consumer visual evaluation of Canadian woods. Forintek Canada Corp. Report to Natural Resources Canada, Vancouver. 110pp.

Findlay, W.P.K. 1939. Effect of sap-stain on the properties of timber II. Effect of sap-stain on the decay resistance of Pine sapwood. Forestry 13: 59-67.

Findlay, W.P.K. 1959. Sap-stain of timber. Forestry Abstracts 20(1 and 2): 1-14.

Findlay, W.K.; Pettifor, C.B. 1937. The effect of sap-stain on the properties of timber I. Effect of sap-stain on the strength of Scots pine sapwood. Forestry 11: 40-52.

Forintek Canada Corp. 2003. Properties of lumber with beetle-transmitted bluestain. Forintek Canada Corp., Western Division, Vancouver, B.C. Wood Protection Bulletin. 4pp.

Gee, W.; Johal, S.; Hussein, A.; Yuen, B.; Watson, P. 2003. The pulping properties of mountain pine beetle-killed lodgepole pine. Paprican Research Report (available upon request).

Giles, D. 1986. Salvage and storage of beetle-killed timber. Pages 10-14 in R.W. Neilson, ed. Harvesting and Processing of Beetle-Killed Timber: proceedings of a seminar sponsored by Forintek Canada Corp. and COFI, Northern Interior Lumber Sector held May, 10, 1985 in Prince George, B.C. Forintek Canada Corp., Western Division, Vancouver, B.C. Special Publication 26.

Giles, D. 1986. Harvesting and processing of beetle-killed pine. Pages 15-17 in R.W. Neilson, ed. Harvesting and Processing of Beetle-Killed Timber: proceedings of a seminar sponsored by Forintek Canada Corp. and COFI, Northern Interior Lumber Sector held May, 10, 1985 in Prince George, B.C. Forintek Canada Corp., Western Division, Vancouver, B.C. Special Publication 26.

Glos, P. 1989. Strength of spruce structural timber with insect and fungus attack: compressive and tensile strength. Hols als Roh und Werkstoff 4(9): 365-371.

Grantham, J.B. 1978. How can dead softwood timber contribute to the nation's energy needs? Pages 53-59 in The dead softwood lumber resource: proceedings of symposium held May 22-24 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Harvey, R.D., Jr. 1979. Rate of increase of blue stained volume in mountain pine beetle killed lodgepole pine in northeastern Oregon, USA. Canadian Journal of Forest Research 9(3): 323-326.

Holtam, B.W. 1966. Blue Stain—a note on its effect on the wood of homegrown conifers and suggested methods of control. Great Britain Forest Commission, London, England. Leaflet 53. 4pp.

Howard, A.F.; Gasson, R. 1989. A recursive multiple regression model for predicting yields of

grade lumber from lodgepole pine sawlogs. Forest Products Journal 39(4): 51-56.

Howe, J.P. 1978. Uses of dead timber in specialty products. Pages 61-66 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Ince, P.J. 1982. Economic perspective on harvesting and physical constraints on utilizing small dead lodgepole pine. Forest Products Journal 32(9): 65-68.

Ince, P.J. 1982. Economic perspective on harvesting and physical constraints on utilizing small, dead lodgepole pine. Forest Products Journal 32(11-12): 61-66.

Ince, P.J.; Henley, J.W.; Grantham, J.B.; Hunt, D.L. 1984. Costs of harvesting beetle-killed lodgepole pine in eastern Oregon. Pacific Northwest Forest and range Experiment Station, USDA Forest Service, Portland, OR, USA. General Technical Report PNW-165. 26 pp.

Keepf, C.J. 1978. Industry recovery experience in operating a sawmill on dead timber. Pages 11-18 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Kelly, M.W.; Barefoot, J.E.; Swint, W.H.; Levi, M.P. 1982. Properties of particle- and hardboard made from healthy and beetle-killed southern pine. Forest Products Journal 32(3): 33-39.

Koch, P.; Keegan, C.E. III; Burke, E.J.; Brown, D.L. 1989. Proposed wood products plant to utilize sub-sawlog size and dead lodgepole pine in northwestern Montana—a technical and economic feasibility analysis. Intermountain Research Station, USDA Forest Service, Missoula, MT, USA. General Technical Report INT-258. 145pp.

Lemaster, R.L.; Troxell, H.E.; Samson, G.R. 1983. Wood utilization potential of beetle-killed lodgepole pine for solid wood products. Forest Products Journal 33(9): 64-68.

Levi, M.P.; Dietrich, R.L. 1976. Utilization of Southern Pine beetle-killed timber. Forest

Products Journal 26(4): 42-48.

Levi, M.P. 1981. Southern pine beetle handbook. A guide for using beetle-killed southern pine based on tree appearance. U.S. Department of Agriculture, Washington D.C., USA. Agriculture Handbook 572. 19pp.

Levi, M. 1978. Blue-flecked paneling: a new market for southern pine beetle-killed trees. Southern Lumberman 237(2994): 70-71.

Lieu, P.J.; Kelsey, R.G.; Shafizadeh, F. 1979. Some chemical characteristics of green and dead lodgepole pine and western white pine. Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, MT, USA. Forest Research Note INT 256. 7pp.

Lindgren, R.M.; Scheffer, T.C. 1939. Effect of blue stain on the penetration of liquids into air-dry southern pine wood. American Wood Preservation Association 35: 325-336.

Lowery, D.P. 1978. Using dead softwood timber: kiln drying procedures for lumber and preservative treatments for fenceposts. Pages 99-111 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Lowery, D.P. 1982. Dead softwood timber resource and its utilization in the west. Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, MT, USA. General Technical Report INT-125. 18pp.

Lowery, D.P.; Hillstrom, H.A.; Elert, E.E. 1977. Chipping and pulping dead trees of four rocky mountain timber species. Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, MT, USA. Research Paper INT-193. 12 pp.

Lowery, D.P.; Pellerin, R.F. 1982. Evaluation of dimension lumber made from dead-tree logs.

Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, MT, USA. Research Paper INT-286. 7pp.

Lowery, D.P.; Hast, J.R. 1979. Preservation of dead lodgepole pine posts and poles. Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, MT, USA. Research Paper INT-241. 12 pp.

Lowery, D.P.; Hearst, A.L. 1978. Moisture content of lumber produced from dead western pine and lodgepole pine trees. Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, MT, USA. Research Paper INT-212. 11pp.

Lum, C. 2003. Characterizing the mechanical properties of wood containing beetle-transmitted bluestain. Report to Forest Innovation Investment. Forintek Canada Corp., Western Division, Vancouver, B.C. [W-1984]. 17pp.

Maloney, T.M. 1984. Utilization of lodgepole pine forest products residuals for composition board. In: Proceedings of the Lodgepole Pine and Its Management. May 1984; Spokane, WA. Washington State Univ., Pullman, WA. p. 325-330.

Maloney, T.M.; Talbott, J.W.; Strickler, J.W.; Lenz, M.D.; Martin, T. 1978. Composition board from standing dead white pine and lodgepole. Pages 19-51 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Mancini, A.J. 1978. Manufacturing and marketing older dead lodgepole pine. Pages 193-196 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

McFarling, S.; Byrne, A. 2003. Characterizing the dimensional stability, checking, and permeability of wood containing beetle-transmitted bluestain. Report to Forest Innovation Investment. Forintek Canada Corp., Western Division, Vancouver, B.C. 13pp. [W-1985]

McGovern, J.N. 1951. Pulping of lodgepole pine. Forest Products Laboratory, USDA Forest Service, Madison, WI. Report R1792. 11 pp.

McLain, T.E.; Ifju, G. 1982. Strength properties of blue-stained wood from beetle-killed southern pine timber. Pages 55-67 in How the environment affects lumber design: assessments and recommendations: proceedings of a workshop held May 28-30, 1980 in Madison, WI, USA. Forest Products Laboratory, Madison, WI, USA.

Neilson, R.W. 1986. Beetle-killed pine processing problems and opportunities: a British Columbia perspective. Pages 6-9 in R.W. Neilson, ed. Harvesting and Processing of Beetle-Killed Timber: proceedings of a seminar sponsored by Forintek Canada Corp. and COFI, Northern Interior Lumber Sector held May 10, 1985 in Prince George, B.C. Forintek Canada Corp., Western Division, Vancouver, B.C. Special Publication 26.

Neilson, R.W.; Mackay, J.F.G. 1986. Sorting of dry and green lodgepole pine before kiln drying. Pages 31-34 in R.W. Neilson, ed. Harvesting and Processing of Beetle-Killed Timber: proceedings of a seminar sponsored by Forintek Canada Corp. and COFI, Northern Interior Lumber Sector held May 10, 1985 in Prince George, B.C. Forintek Canada Corp., Western Division, Vancouver, B.C. Special Publication 26.

Neilson, R.W.; Wright, D. 1984. Utilization of beetle-killed lodgepole pine. Report for Forintek Canada Corp., Western Division, Vancouver, B.C.

Nelson, R.M. 1934. Effect of blue-stain fungi on southern pine attacked by bark beetles. Phytopathology 7: 327-353.

Parry, D.L.; Filip, G.M.; Willits, S.A.; Parks, C.G. 1996. Lumber recovery and deterioration of beetle-killed Douglas-fir and grand fir in the Blue Mountains of eastern Oregon. Gen. Tech. Rep. PNW-GTR-376. USDA Forest Service, Pacific Northwest Research Station. Portland, OR. 24 pp.

Peckinpaugh, S. 1978. The log home market for dead timber. Pages 67-70 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Plank, M.E. 1979. Lumber recovery from live and dead lodgepole pine in the northern Rocky Mountains. Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, Portland, OR. Research Paper PNW-344. 15pp.

Plank, M.E. 1984. Lumber recovery from insect-killed lodgepole pine in the northern Rocky Mountains. Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, Portland, OR. Research Paper PNW-320. 12pp.

Plank, M.E.; Snellgrove, T.A.; Fahey, T.D. 1986. Volume and value recovery from live and dead lodgepole pine. Pages 27-30 in R.W. Neilson, ed. Harvesting and Processing of Beetle-Killed Timber: proceedings of a seminar sponsored by Forintek Canada Corp. and COFI, Northern Interior Lumber Sector held May 10, 1985 in Prince George, B.C. Forintek Canada Corp., Western Division, Vancouver, B.C. Special Publication 26.

Reid, R.W. 1961. Moisture changes in lodgepole pine before and after attack by the mountain pine beetle. Forestry Chronicle 37(4): 368-375.

Reid, R.W.; Whitney, H.S.; Watson, J.A. 1967. Reactions of lodgepole pine to attack by the Dendroctonus ponderosae Hopkins and the blue stain fungi. Canadian Journal of Botany 45: 1115-1125.

Robinson, R.C. 1962. Blue stain fungi in lodgepole pine (Pinus contorta Dougl. Var. latifolia Engelm.) infested by the mountain pine beetle (Dendroctonus monticolae Hopk.). Canadian Journal of Botany 40: 609-614.

Roe, A.L.; Amman, G.D. 1970. The mountain pine beetle in lodgepole pine forests. USDA Forest Service Research Paper INT-71. 21 pp.

Safranyik, L.; Shrimpton, D.M.; Whitney, H.S. 1974. Management of lodgepole pine to reduce losses from the mountain pine beetle. Pacific Forest Research Centre, Victoria, B.C. Forestry technical report (Canadian Forest Service) 1. 24pp.

Saling, W.M. 1930. The effect of bluestain on the penetration and absorption of preservatives. Pages 183-187 in proceedings of the 26th Annual Meeting of American Wood Preservers' Association held January 28-30, 1930 in Seattle, WA, USA.

Sampson, G.R.; Betters, D.R.; and Brenner, R.N. 1980. Mountain pine beetle, timber management, and timber industry in Colorado's Front Range: production and marketing alternatives. Rocky Mountain Forest and Range Experiment Station. USDA Forest Service. Fort Collins, CO. Resource Bulletin RM-3. 10 pp.

Scheffer, T.C.; Lindgren, R.M. 1940. Stains of sapwood and sapwood products and their control. US Department of Agriculture, Washington D.C. Technical Bulletin 714. 124pp.

Shrimpton, D.M.; Whitney, H.S. 1968. Inhibition of growth of blue stain fungi by wood extractives. Canadian Journal of Botany 46: 757-761.

Sinclair, S.A. 1979. A mill operator's guide to profit on beetle-killed southern pine. US Department of Agriculture, Washington D.C., USA. Agriculture Handbook 555. 15pp.

Sinclair, S.A. 1980. SAWMOD: a tool for optimizing profit from beetle-killed southern pine sawtimber. Wood and Fiber 12: 29-39.

Sinclair, S.A.; Ifju, G.; Heikkenen, H.J. 1977. Bud boards: lumber yield and grade recovery from timber harvested from southern pine beetle-infested forests. Southern Lumberman 234(2900): 9-11.

Sinclair, S.A.; Ifju, G. 1977. Processing beetle-killed southern pine—an opinion survey in Virginia. Southern Lumberman 235(2916): 11-14.

Sinclair, S.A.; Ifju, G. 1979. Lumber quality of beetle-killed southern pine in Virginia. Forest Products Journal 29(4): 18-22.

Sinclair, S.A.; Ifju, G.; Johnson, J.A. 1978. Changes in toughness of wood from beetle-killed shortleaf pine. Forest Products Journal 28(7): 44-47.

Sinclair, S.A.; McLain, T.E.; Ifju, G. 1979. Toughness of sap-stained southern pine salvaged after beetle attack. Wood and Fiber 11(1): 66-72.

Snellgrove, T.A.; Cahill, J.M. 1980. Dead western white pine (Pinus monticola): characteristics, product recovery, and problems associated with utilization. Pacific Northwest Forest and Range Experiment Station, USDA Forest Service, Portland, OR. Research Paper PNW-270. 63pp.

Snellgrove, T.A.; Ernst, S. 1983. Veneer recovery from live and dead lodgepole pine. Forest Products Journal 33(6): 21-26.

Solheim, H. 1995. Early stages of blue-stain fungus invasion of lodgepole pine (Pinus contorta)

sapwood following mountain pine beetle attack. Canadian Journal of Botany 73(1): 70-74.

Solheim, H.; Krokene, P. 1998. Growth and virulence of mountain pine beetle associated blue-stain fungi. Ophiostoma clavigerum and Ophiostoma mantium. Canadian Journal of Botany 76(4): 561-566.

Tang, J.L. 1983. Wood properties affected by mold, blue0staining, and wood destroying fungi. [In English]. Quarterly Journal of Chinese Forestry 16(4): 412-425.

Tang, J.L.; Troxell, H.E. 1977. Suitability of beetle-killed pine in Colorado's Front Range for wood and fiber products. Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, CO. 53 pp.

Tegethoff, A.C.; Hinds, T.E.; Eslyn, W.E. 1977. Beetle-killed lodgepole pine are suitable for powerpoles. Forest Products Journal 27(9): 21-23.

Troxell, H.E.; Tang J.L.; Sampson, G.R.; Worth, H.E. 1980. Suitability of beetle-killed pine in Colorado's front range for wood and fiber products. Rocky Mountain Forest and Range Experiment Station. USDA Forest Service. Fort Collins, CO. Resource Bulletin RM-2. 10 pp.

Tsukiji, R. 1952. Decay durability of blue-stained timber. [In English]. Wood Industry Tokyo 7: 16-18.

Wallace, D.E. 1978. The challenges of marketing products from dead timber. Pages 95-97 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Walters, E.O.; Weldon, D. 1982. Utilization of southern pine beetle killed timber for lumber in East Texas. Texas Forest Service. College Station, TX, USA. Circular 256. 4pp.

Walter, E.O. 1982. Bending strength loss for southern pine beetle (SPB)-killed timber. Texas Forest Service. College Station, TX, USA. Circular 260. 4pp.

Williams, D.; Mucha, E. 2003. Characterizing the gluing and finishing properties of wood containing beetle-transmitted bluestain. 19 pp. Report to Forest Innovation Investment. Forintek Canada Corp., Western Division, Vancouver, B.C. [W-1986]

Willits, S.; Woodfin, R.O.; Snellgrove, T.A. 1990. Lumber recovery from dead ponderosa pine in the Colorado Front Range. Res. Paper PNW-RP-428. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, OR. 63 pp.

Woo, K.L.; Watson, P.; Mansfield, S.D. 2004. The effects of mountain pine beetle attack on lodgepole pine wood morphology and chemistry: implications for wood and fiber quality. Wood and Fiber Science 37(1): 112-126.

Woodson, G. 1985. Utilization of beetle-killed southern pine. USDA Forest Service. Washington, D.C. General technical report WO 47. 27 pp.

Work, L.M. 1978. Dead timber evaluation and purchase—firewood or lumber. Pages 179-185 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

Worth, H.E. 1978. Marketing considerations for products from dead timber. Pages 87-94 in The dead softwood lumber resource: proceedings of symposium held May 22-24, 1978 in Spokane, WA, USA. Washington State Univ., Pullman, WA, USA.

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