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# OPPORTUNITIES WITH BEETLE-KILLED LODGEPOLE PINE

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## Abstract

This paper is a brief overview of the current mountain pine beetle outbreak found in British Columbia and the implications for how the wood can be processed. An estimated 225-230 million $m^3$ of standing dead lodgepole pine has accumulated to date over a large area in BC's central Interior. The main current and potential uses for the large volume of trees are discussed. Unless substantial capital investments are made the main uses will continue to be manufacture of lumber and veneer, with residues going to pulp, panel products and biofuel. The properties of the bluestained wood resulting from mountain pine beetle attack are similar to those of non-stained wood, with the exception that the sapwood is more permeable. Preservative treated utility poles, decking and framing lumber is proposed as a good use for beetle-killed trees.

## 1 The Mountain Pine Beetle Problem

British Columbia is in the midst of the largest forest insect epidemic ever recorded in the province. The mountain pine beetle (MPB: *Dendroctonus ponderosae*) is native to the forests of western North America. Normally trees that are not growing vigorously are most likely to be attacked. However over the last 20 or so years the populations of this insect have exploded from its endemic level to attack a large area of healthy forest in BC's central Interior. The conditions that have lead to this epidemic are sustained favourable climate for beetle survival, i.e. mild winters and good weather during the dispersal and attack periods, and an abundance of pine of susceptible age and size (Carroll *et al*. 2002). Climate warming has resulted in the natural range of the beetle extending northwards from the south of the province into the area now being devastated (Carroll *et al*. 2004). A century of fire control has lead to the growing inventory of large, mature lodgepole pine trees that the beetle selects to raise its brood. During the mid-summer flight season the beetle attacks these large trees. The mass attack strategy it has evolved attracts large numbers of beetles to the same tree with aggregation pheromones, overwhelming the tree's defenses. As beetles bore through the bark of a healthy tree, copious amounts of resin are produced as a defense mechanism. These "pitch tubes" and the frass or borings at the base of the tree are usually the first visible sign that a tree has been attacked (Leatherman 1999). Resinosis may overcome a few attacking beetles but with mass attack of the same tree, the tree's defense may be overcome and beetles often get through the bark. The beetles carry spores of symbiotic bluestain fungi which germinate and colonize the sapwood. The fungi are thought to block resin production by the tree and clog up the water pathways (Reid *et al.* 1967). The supply of water to the crown is reduced and the tree dies as a result. As this occurs the foliage turns yellowish to reddish throughout the entire tree crown. This usually occurs eight to 10 months after a successful MPB attack and is the first sign visible from the air that the attack has been successful.

Once under the bark the beetles mate and make tunnels in the phloem between the bark and the sapwood. Each beetle pair makes a vertical egg gallery with about 60-80 eggs (Safranyik *et al.* 1974). Following egg hatch, the beetle larvae tunnel away from the egg gallery, producing a characteristic feeding pattern. The MPB larvae spend the winter under the bark. They continue to feed in the spring and transform into pupae in June /July. Emergence of new adults can begin in early July and continue through September. However, the great majority of beetles exit trees during late July.

The current epidemic has been growing exponentially and has resulted in an area attacked that is estimated to be 1150 km long and 550 km long at its widest point, over three-quarters the size of Sweden (COFI MPB Task Force 2003). Over this range there are varying degrees of attack, but overall an estimated cumulative 173.5 million $m^3$ of mature lodgepole pine had been killed by fall of 2003, increasing to 225-230 million $m^3$ by the end of 2004 (official statistics not yet available). The Council of Forest Industries estimates that the value of lumber products that could be produced from the 173.5 million $m^3$ is just under $18 billion, based on average lumber price of $415/Mfbm.

**Table 1. Summary of mountain pine beetle red attack from aerial overview surveys 1999-2001**

| Year | Fresh red attack that year (Ha) |
|---|---|
| 1999 | 164,567 |
| 2000 | 284,041 |
| 2001 | 785,497 |
| 2002 | 1,968,641 |
| 2003 | 4,200,000 |

Source: Pedersen, 2004

The BC Ministry of Forests is predicting that 80% of the volume of mature lodgepole pine in the forest will be killed before the epidemic has run its course (Eng *et. al*. 2004). Control of the beetle has been attempted by harvesting infested trees as soon as the attack has been detected and processing them, mainly through sawmills. However leading edge control of the beetle, while it might have slowed the spread, has been ineffective in stopping the outbreak. Now the forest products industry in the province is focusing its attention on dealing with the consequences and determining how to salvage value from the large volume of dead and dying trees. The standing dead trees continue to deteriorate due to attack from secondary beetles and wood-decaying fungi. However the rate of deterioration of the trees will vary with site and microclimate and little or no data on such rates are available. This lack of data will make prioritization for harvesting the timber difficult over the next few years. Given the magnitude of the area affected the epidemic is changing environmental values and is threatening community and employment stability.

## 2 The Effects of Bluestain on Wood Strength and Permeability Properties

The most immediately visible defining characteristic of MPB-killed wood is the bluestained sapwood that carries through to products made from this wood. By the time that MPB attack can be detected from the foliage appearance, close to 100% of the sapwood is stained (Harvey 1979). Although bluestain is not regarded as a defect in lumber grading rules it does make the lumber more difficult to market in some sectors. Japanese customers, particularly, are reluctant to buy bluestained lumber as they associate the bluestain with the onset of decay and have a traditional preference for bright defect-free wood. Recent work at Forintek (Lum 2003) has determined that the bluestain in the sapwood does not significantly alter the strength characteristics, in terms of modulus of rupture or modulus of elasticity, of the lodgepole pine when tests are done on small clear specimens. There was a 5% loss in impact bending strength that was only marginally significant but with no difference at toughness levels below the lowest quartile of the strength distribution, and a 5% increase in mean truss plate connector grip capacity. These small differences are likely to be masked by differences in the mechanical properties of the heartwood and sapwood, and, in the case of full-size lumber, by the presence of strength-reducing growth characteristics such as knots and slope of grain.

Not unexpectedly, recent Forintek research has shown that the bluestain fungi do alter the permeability of the wood, a characteristic previously mentioned in literature (e.g. Lindgren and Scheffer 1939). The permeability of end-matched 2in. x 4 in. lumber with and without heavy bluestain was compared (McFarling and Byrne 2003). The wood was treated with chromated copper arsenate (CCA) in 1-, 4-, and 24-hour dip treatments or using a vacuum-pressure-vacuum treatment. The increase in permeability was confirmed in terms of enhanced CCA uptake and penetration. One implication of the stained sapwood treating more readily than non-stained wood is that in batches of preservative-treated wood the stained wood is liable to be over treated or the non-stained wood under-treated. As anticipated, there was no effect from bluestain in the sapwood on the penetration of preservative into the heartwood, the most refractory part of the wood. Treatment with CCA also masked the bluestain by coloring it green. Given the high volume in the sawmill pipeline for the foreseeable future, it is possible that a significant amount of beetle-killed wood can be diverted into products such as treated decking or termite resistant framing lumber. The market for the latter in the USA south was recently estimated to be a significant one (Vlosky and Gaston 2004). Manufacturers in the US south treat some framing lumber (which may include some imports from Canada) with disodium octaborate, and a blue dye is added to the otherwise clear treating solution to enable the treated wood to be differentiated from non-treated wood. This blue dye could mask the bluestain in lumber made from MPB stands, while the borate would impart durability. Wood for exterior decking is no longer treated with CCA in North America but is treated with copper-containing preservatives. The green colour of the treated wood also masks the blue stain, creating durable products that avoid the marketing problems associated with bluestain.

A potential downside of the increased permeability of sapwood because of the bluestain is the over-absorption of glues and finishes. In a recent study Williams and Mucha (2003) characterized the gluing and finishing properties of bluestained wood killed by the MPB. Laminating tests showed that gluelines in lodgepole pine that contains beetle-transmitted bluestain were not significantly different in strength from gluelines in unstained wood when polyvinyl acetate and phenol resorcinol formaldehyde adhesives are used. The durability and shear strength of the bluestained beetle-killed wood gluelines easily met the requirements specified by the ASTM standards. In finishing tests the appearance of bluestained wood could be enhanced or highlighted by a simple standard clear furniture finish, or masked with standard interior finishes containing blue, red, and charcoal tints in the stain, toner, or glaze coatings. Increased permeability of the bluestain did not affect the adherence of any of the finishes. MPB-killed wood is therefore suitable for appearance grade products so long as a natural finish to highlight the contrast of the blue stain, or a dark finish to mask it, is acceptable to the consumer.

## 3 Utilization Possibilities with Dry MPB-killed Wood

A secondary effect of the bluestain fungi is that the wood dries quickly in the standing tree. Reid (1961) reports that the moisture content of the outer sapwood is normally about 85-165% of oven dry weight with a steep moisture gradient from the outer sapwood to about 30% in the heartwood. In MPB-infested trees the sapwood moisture content can be as low as 16% after one year, though this probably an extreme as most trees have not developed checks and splits after only one year. As standing dead trees dry below the fibre saturation point (about 30% moisture content) the drying stresses are relieved in checks in the stem.

Most of the MPB-killed stems that have been harvested to date have not reached this checked dry stage as harvesting has been focused on recently attacked trees. However at some stage decisions will have to be made about how much of the standing dead dry pine will be processed. In theory there is a large range of potential products that can be made from dead lodgepole pine: lumber; veneer and plywood, appearance grade products, utility poles and preservative treated products, house logs, oriented strandboard (OSB), medium density fibreboard (MDF), fuel wood and pellets, pulp, and chemicals. However a large change and investment in the processing infrastructure would have to be made before changes to the current utilization practices for lodgepole pine could be made. Over 90% of the current harvest of lodgepole pine goes to sawmills with about half of the volume of timber coming out of the mill in the form of lumber and about half as residues (pulp chips, hog fuel sawdust and planer shavings). A substantial portion of the sawdust and shavings residues is used to make MDF and fuel pellets. For the foreseeable future, producing lumber will continue to remain the largest use for beetle-killed pine. The solid wood industry has been fortunate recently in that lumber prices, and the US housing market, have been robust, and this industry has been profitable despite punishing duties on lumber sent to the USA and a rapidly appreciating Canadian dollar. However with a downturn in lumber prices and an inevitable decline in the US housing market the volume of lumber shipped to the USA will decline at some point.

The other 10% of lodgepole pine goes into veneer and plywood, preservative-treated roundwood, log homes, OSB and pulp logs. However it is unlikely that these end uses will enable the absorption of significant volumes of dead pine. Veneer and plywood are briefly discussed later in this paper. Dead lodgepole pine has been recognized as suitable for preservative-treated products such as fenceposts and utility poles (Lowery and Hast 1979). Tegethoff *et al*. (1977) suggested that decayed parts of dead pines could be trimmed prior to making poles, but recommended that beetle-killed trees suitable for poles should be harvested soon after death to avoid incipient decay. Lowery and Hast (1979) found that pressure treatment of posts and poles from dead lodgepole pine resulted in retentions exceeding minimum specification requirements. MPB-killed lodgepole pine is also reported to be suitable for log homes (Peckinpaugh 1978). A small amount of lodgepole pine is currently used in OSB plants but the Canadian industry is mainly aspen-based. There is potential for substituting more pine for aspen but in the current plants and with the current OSB manufacturing process this is problematic. Thirty years ago, Maloney *et al* (1976) conducted a study on making composite panel products from standing dead white pine and dead lodgepole pine in the United States. They concluded that the dead material of both white pine and lodgepole pine could be effectively used in making particleboard, MDF and flake board. In light of the modern product standards, product application requirements, manufacture economics and industry practice, the interpretations of those data need to be reconsidered. For example, they showed that lodgepole pine composite panels had relatively poor linear expansion, exceeding commercial standards, except in flakeboards. This would, therefore, raise serious concerns for manufacture of particleboard (PB) or high density fibreboard (HDF) for flooring, applications that are now very important for PB and HDF but were not 30 years ago. In their flake board experiments with dead lodgepole pine, high thickness swell and water absorption was observed. This is similar to the recent findings at Forintek, where research is underway to investigate the phenomena more closely.

In his study of comparative economics of manufacturing composition boards from dead timber, Maloney (1981) concluded that equipment modifications for composite board plants using the dead tree resource would not be major when compared to plants operating conventionally. Furnish preparation using cutting knives would probably be subjected to more wear and maintenance when cutting the dead trees into furnish. Extra strand screening capacity would also be necessary as more fines are generated from dry wood. In addition to these findings, recent Forintek preliminary work has shown that at least 30% more adhesive would be needed to produce commercially acceptable OSB panel products from dead lodgepole pine. It is estimated that even a 10% increase in resin use to manufacture OSB from MPB pine would be uneconomic because it would increase costs by approximately $1.7 million / plant / year.

## 4 Manufacturing Lumber and Veneer from Dry Pine

Problems with handling beetle-killed pine start to be felt right at the harvest site. Salvage logging is usually more expensive than normal orderly harvesting, as the trees may be widely scattered and not close to current forest roads. Salvageability is linked to the time since death and on the severity of deterioration and checking (Neilson and Wright 1984).

Trees with spiral checks are best left in the woods as such checks severely reduce board width and length in a sawmill. However spiral checks are not always visible when the bark is relatively intact. Dry wood is brittle and breakage during harvesting is higher than for green wood. Neilson and Wright (1984) also mentioned that splits and checks open up between the time trees are felled and finally unloaded at the mill. Hence "apparent" light checking can develop into severe checking by the time the logs reach the mill.

Although the solid wood sector has handled a small proportion of dead timber in its operations for many years the sawmills and veneer plants are set up to handle green wood. The consequences of shifting to a diet of dead logs of variable moisture content, but getting proportionately drier with time, are not fully known as there are no modern data on what proportions of dry wood can be handled, and what the impact would be on manufacturing costs. Neilson and Wright (1984) reviewed existing literature as well as visiting 15 operations processing dead timber. Bluestain, the dryness of the wood, and splits and checks were the main characteristics of this wood that negatively affected production operations and/or product value. The effect of these varied by product. For lumber the dryness and the splitting of tree stems reduced product yield and value. Kiln drying mixtures of green and dry lumber resulted in overdrying and high degrade levels in the already dry wood. In lumber and plywood operations dead timber must be salvaged quickly. For kraft pulp production, decay in dead timber is the primary concern, and the effect of bluestain on brightness is also a consideration. Table 2 is a summary of the problems cited in processing beetle-killed pine at B.C. Interior sawmills. All of these problems add costs to production while reducing overall volume outturn and grade value. Few attempts have been made to quantify lumber grade yields and recovery losses resulting from MPB attacks and these studies are so old as to be hardly relevant to the modern sawmill. The only Canadian study that has attempted this (Dobie and Wright 1978) confirmed that lodgepole pine lumber values drop once the foliage is lost from the dead trees and again after the bark has loosened and begun to fall.

In terms of veneer production, the dryness of the logs and checking results in more partsheets. Fortunately before bolts are rotary peeled they are conditioned and during this process the checks at least partially close up. Snellgrove and Ernst (1983) compared veneer recover from live trees and from trees that had been dead one or three years. Volume recovery of veneer from one-year dead trees was not significantly different from that of live trees, but recovery from three-year dead trees was about 30% less. Veneer grade recovery was not affected by time since death, but a higher percentage of random-width strip was produced from the older dead logs. Bluestain does not appear to be a problem in marketing most plywood and usually some of the bluestain is lost as the log is rounded off in the lathe.

As Neilson and Wright (1984) pointed out the main questions that need to be addressed are "Can the problems associated with processing beetle-killed pine to lumber be reduced?" and "What can be done to reduce the impact of problems associated with producing plywood from beetle-killed pine?" With the huge volume of wood affected in the current MPB outbreak, Forintek Canada Corp. has put in place a research program that is examining various aspects of utilization of dry wood:  conditioning and rotary peeling of veneer from logs with checks, the manufacture of OSB from dry beetle-killed pine, sorting and drying lumber of mixed moisture content, machine stress rated lumber, and optimization of sawing checked logs.

**Table 2. Problems cited in processing beetle-killed pine at B.C. interior sawmill operations**

| Problem Area | Description |
|---|---|
| Log handling | Higher log breakage in yard, log infeed decks<br>Debarkers remove excess wood and cause breakage |
| Cutting tools | Dry wood dulls cutting tools more quickly than green wood<br>When set up to cut frozen wood in winter, dry wood causes saws to heat up and lose stability |
| Pulp chips | Dry wood results in more chip fines<br>Chip volumes increase significantly when processing a high proportion of infected pine |
| Lumber Recovery | Spiral checking is a major factor contributing to reduced recovery |
| Grade yields | A higher percentage of low grade dimension lumber is produced and a lower percentage of #2 and better results |
| Markets | Bluestain and wormholes not accepted in export markets |
| Drying | Uneven final moisture content distribution due to mix of green and partly dry stock; some lumber overdried, some may still be green |
| Planing | More breakage and jam-ups at planer with overdried wood reduces planer productivity<br>Increased trim loss at planer |
| Small-log salvage | Higher than normal proportion of small logs results in lower lumber recovery factor, lower mill productivity, higher unit costs |

Source: Neilson and Wright (1984)

## 5 Conclusions

There is a huge standing inventory of dead lodgepole pine resulting from the MPB. Extracting value from this resource will pose major utilization problems over the foreseeable future. The lumber manufacturing industry is the main current user of beetle-killed pine and this is likely to remain the case for the foreseeable future. So long as trees are harvested and used soon after they have been attacked, processing of the logs into lumber and plywood can proceed as for live green logs. However once trees become dry, and splits and checks occur, there are severe limitations on processing the material. Processing of dry logs adds costs and reduces volume and grade of lumber and veneer. Although it is always possible to make products such as OSB and lumber from standing dead trees, the current economics of processing remain to be determined. Some of the best potential uses for bluestained lodgepole pine are pressure treated utility poles or decking or termite resistant framing lumber.

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