Characterising the Dimensional Stability, Checking, and Permeability of Wood Containing Beetle-Transmitted Bluestain

by

Shane McFarling
Wood Preservation Process Technologist
Durability and Protection Group

and

Tony Byrne
Wood Protection Scientist
Durability and Protection Group

Prepared for

2665 East Mall, Vancouver, BC  V6T 1W5

Recipient Agreement Number:  R2003-0133
Forest Research Program

Date:  August 2003
Summary

The major defining characteristic of lumber cut from trees that have been infected with the mountain pine beetle is the extent of fungal bluestain in the sapwood. Forintek Canada Corp. scientists have previously observed that bluestained wood appears to have different dimensional stability characteristics than non-stained wood when subjected to repeated wetting and drying. Bluestained wood has also been reported to show increased permeability, which may make treatment with liquids such as wood preservatives easier. However, no data is available on how bluestained wood resulting from the beetle attack might affect. We therefore identified the need to generate data on the dimensional stability, checking, and permeability characteristics of bluestained wood compared with non-stained wood.

To examine dimensional stability, specimens of bluestained and non-stained 2 x 4 in. lumber were subjected to wetting/drying cycles. After 5 and 10 cycles, the amount of bow, crook, cupping, twist, and checking was measured. The permeability of the wood was also determined by weighing end-matched specimens before and after a 1-, 4-, and 24-hour dip or after a pressure treatment cycle with chromated copper arsenate preservative, and then calculating the uptake and preservative retention.

The results clearly show that when repeatedly wetted and dried, such as occurs in exterior end uses, bluestained beetle-killed wood is more dimensionally stable (less cupping and twist) and checks less than non-stained sapwood, but is more permeable to water. The stresses appear to be relieved by many micro-checks rather than fewer large checks. Overall, the improved dimensional stability should result in the lumber made from stained wood remaining straighter.

Increased permeability of the bluestained wood was confirmed by data showing enhanced chromated copper arsenate (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 overtreated or the non-stained wood undertreated. As anticipated, bluestain in the sapwood had no effect 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.

The increased permeability probably also has implications for ease of air or kiln drying and possibly reduced degrade in the kiln.
Acknowledgements

Fourteen B.C. Interior sawmills kindly provided suitable material for the testing recorded in this series of reports.

Forintek Canada Corp. acknowledges the assistance provided by the Province of British Columbia through the Forestry Innovation Investment Program.

Forintek Canada Corp. would like to thank its industry members, Natural Resources Canada, and the Provinces of British Columbia, Alberta, Saskatchewan, Quebec, Nova Scotia, New Brunswick, and Newfoundland and Labrador for their guidance and financial support for this research.
# Table of Contents

Summary ........................................................................................................................................................................... i
Acknowledgements .................................................................................................................................................................. ii
List of Tables ....................................................................................................................................................................... iv
List of Figures ...................................................................................................................................................................... iv
1 Objective ........................................................................................................................................................................ 1
2 Introduction ..................................................................................................................................................................... 1
3 Materials and Methods ................................................................................................................................................. 1
   3.1 Sample preparation ............................................................................................................................................... 1
   3.2 Dimensional stability/checking .............................................................................................................................. 2
   3.3 Wood permeability ................................................................................................................................................. 2
4 Results and Discussion .................................................................................................................................................. 3
   4.1 Dimensional stability/checking results .................................................................................................................. 3
   4.2 Wood permeability ................................................................................................................................................. 5
      4.2.1 Preservative uptake ......................................................................................................................................... 5
      4.2.2 Preservative penetration ................................................................................................................................. 6
      4.2.3 Heartwood/sapwood ratio ............................................................................................................................... 6
   4.3 General discussion and implications ...................................................................................................................... 7
5 Conclusions ................................................................................................................................................................... 8
6 Recommendations .......................................................................................................................................................... 8
List of Tables

Table 1: Cup and twist: results summary ................................................................. 4
Table 2: Checking of bark faces: summary ............................................................. 4
Table 3: Checking of pith faces: summary ............................................................. 5
Table 4: Average preservative retentions of soaked and pressure-treated stained and non-stained wood ................................................................. 5
Table 5: Penetration data summary .................................................................... 6

List of Figures

Figure 1: Average cup and twist in test specimens (bars indicate 25th and 75th percentiles) ............ 9
Figure 2: Average total check length, bark vs. pith faces (bars indicate 25th and 75th percentiles) .... 9
Figure 3: Average check width, bark vs. pith faces (bars indicate 25th and 75th percentiles) ........... 10
Figure 4: Average appearance rating, bark vs. pith faces (bars indicate 25th and 75th percentiles) .... 10
Figure 5: Average preservative retention, dip vs. pressure treatments (bars indicate 25th and 75th percentiles) ........................................................................................................ 11
Figure 6: Average percent of heartwood/sapwood area treated in dip and pressure treatments (bars indicate 25th and 75th percentiles) ................................................................. 11
Figure 7: Mean penetration of CCA in dip and pressure treatments (bars indicate 25th and 75th percentiles) ............................................................................................................. 11
Figure 8: Percent CCA penetration ≥ 10 mm on centre sapwood face (CSF) and center heartwood faces(CHF). ........................................................................................................... 12
Figure 9: Non-stained specimens treated with CCA by pressure (top) vs. dip (24-hour soak) .......... 13
Figure 10: Bluestained specimens treated with CCA by pressure (top) vs. dip (24-hour soak) ......... 13
1 Objective

The objective of this work was to determine if commercially available lumber with beetle-transmitted bluestain differs from non-bluestained lodgepole pine sapwood in its dimensional stability, checking, and permeability properties.

2 Introduction

The major defining characteristic of lumber cut from trees that have been infected with the mountain pine beetle is the extent of fungal bluestain in the sapwood. Forintek Canada Corp. scientists have previously observed that bluestained wood appears to have different dimensional stability characteristics than non-stained wood. Additionally, bluestained wood has been reported to show increased permeability, which may make treatment with liquids such as wood preservatives easier (Scheffer, 1969)\(^1\). However, no data was available on the impact on these properties of the specific bluestain vectored by the mountain pine beetle (MPB).

We therefore have identified the immediate need to generate data on the dimensional stability, checking and permeability characteristics of bluestained wood compared with non-stained wood. Such work was undertaken and is reported here, together with some of the implications for the results.

For further background and context to this work please refer to the parallel report (Byrne, A. 2003)\(^2\).

3 Materials and Methods

3.1 Sample preparation

Ten bluestained and ten non-stained 2 x 4 in. lumber pieces from each mill were randomly selected for dimensional stability and preservative uptake studies. For each stain type (stained and non-stained) 20 x 8 ft., 14 x 18 in., and 40 x 34 in. lengths for the various tests were prepared, divided as evenly as possible across the source mills. All test specimens were conditioned at the ambient pilot plant temperature (20°C) and relative humidity (~45%) for five days minimum, achieving a moisture content of about 8%.


\(^2\) Byrne, A. 2003. Characterising the properties of wood containing beetle-transmitted bluestain: background, material collection, and summary of findings. Forintek Canada Corp. report to the Forestry Innovation Investment Program. Vancouver, BC.
3.2 Dimensional stability/checking

There is no standard test for determining the dimensional stability/checking of lumber such as that occurring in some end uses when lumber is repeatedly wetted and dried. Forintek has devised, and uses, an accelerated wetting/drying test to measure such characteristics. Test specimens of full cross-section x approximately 450 mm (18 in.) free of major defects, were cut, numbered, and the ends sealed with three coats of epoxy resin to simulate the middle of a larger piece. Three stained and three non-stained “packages” of 18 stickered pieces were prepared and each package weighed. All packages were subjected to an 8-hr water soak/16-hr dry cycle. The drying was in an oven at 70°C with no humidity control. This cycle was repeated 5 times and, at end of the fifth dry cycle, the dimensional stability characteristics of crook, bow, cup, twist, length, and width of checks were measured for each sample individually on the face closest to the bark (bark face) and the face closest to the pith (pith face). These properties were measured as follows:

Bow: maximum deviation flatwise from a straight line drawn from end to end of a piece (mm)

Crook: maximum deviation edgewise from a straight line drawn from end to end of a piece (mm)

Cup: maximum deviation on the bark face from a straight line drawn from edge to edge of a piece (mm)

Twist: deviation in the form of a curl or spiral, measured as the distance an end of the test specimen is raised above a flat surface when the other end of the test specimen is held firmly flush to the surface (mm)

Check length: the total length of all the checks added together (mm)

Check width: the maximum width of the largest check on the surface of the specimen (mm)

The overall checking appearance was visually rated on a 0 to 4 scale, with 0 (Good) having no checks and 4 (Failure) having many. The wetting/drying cycle was repeated a further 5 times (total 10 cycles), and at end of the 10th dry cycle, the samples were rated once more for the same characteristics. The data were collated and analysed.

3.3 Wood permeability

The test described here was designed to measure permeability by determining whether bluestained wood absorbs more liquid than non-stained wood during either simple soaking or pressure treatment. Chromated copper arsenate (CCA) was used as a tracer wood preservative chemical because it reacts with the wood and stops moving at the end of the dip or pressure process. Twin, end-matched (labelled A and B) test specimens of full 2 x 4 in. (nominal) cross-section x approximately 6 in. and free of major defects were cut, numbered by mill source (1–14) and lumber piece (1–5), and the ends sealed with three coats of epoxy resin. All test specimens were conditioned at ambient pilot plant temperature and relative humidity (RH) for five days minimum at 21°C and 45% RH. Each specimen was weighed and, after the
Characterising the Dimensional Stability, Checking, and Permeability of Wood Containing Bee-Tra
transmitted Bluestain

3

heartwood/sapwood boundary was drawn on each end with a fine felt tip pen, the amount of sapwood was
measured using a clear template divided into 20 squares. This enabled an estimate of the
sapwood:heartwood ratio (±5%).

“A” specimens were soaked in a 1.8% CCA wood preservative solution for 1, 4, and 24 hours and
reweighed at each interval. Test specimens were wrapped in a polyethylene sheet to retard drying and, to
promote fixation, placed in an oven at approximately 75°C for 24 hours. Following fixation, the
specimens were unwrapped and oven-dried at 50°C for 24 hours. For preservative penetration
determinations, a 50-mm sample slice was cut from the center of each specimen. Each sample slice was
sprayed with Chrome Azurol S and the penetration of preservative, as revealed by the blue color of the
reagent, was measured at the center of the sapwood and heartwood faces. The percentage of cross-
sectional area penetrated was also measured with the clear template for both sapwood and heartwood.
Chemical retention based on uptake and sapwood content data were entered into a spreadsheet for
analysis.

“B” specimens, both stained and unstained, were treated, in a retort, with the following short pressure
treatment schedule:

- 30 minutes full vacuum 740 mm Hg
- Fill retort under vacuum with 1.8% CCA solution
- 2 minutes to full pressure
- 35 minutes at full pressure - 1035 kPa
- 10 minutes pressure relief
- Empty retort
- 15 minutes final vacuum 740 mm Hg

This schedule had been pre-determined by experimentation to just fully treat the stained portion of the
specimens. Following treatment, each specimen was reweighed. Fixation, drying, and sampling of the
specimens for penetration determinations were done as previously described for the soaked samples.
Uptake, retention, and sapwood content data were entered into a spreadsheet for analysis and reporting.

4 Results and Discussion

4.1 Dimensional stability/checking results

With only two specimens showing a small amount of bow and none showing crook after the
wetting/drying test, these characteristics were not considered to be a significant characteristic of the test
material. However, cup and twist were detectable and good indicators of the innate dimensional stability
of a piece of lumber. The 54 stained specimens had almost no cupping and negligible twist after five or
10 cycles (Table 1; Figure 1). At 0.6 mm, the average twist after 10 cycles was slightly lower than after
five cycles (0.8 mm). There was more cupping and twist in the non-stained wood. Cupping doubled
from 0.2 mm after five cycles to 0.4 mm after 10 cycles, at which point over 11% of the specimens had
1.5 mm or greater cupping. Average twist after 10 cycles was 3 times greater for the non-stained compared to the stained specimens.

### Table 1: Cup and twist: results summary

<table>
<thead>
<tr>
<th>No. of Wet/Dry Cycles</th>
<th>Average Cupping (mm)</th>
<th>Average Twist (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stained</td>
<td>0.0 (0.1)(^1)</td>
<td>0.8 (1.0)</td>
</tr>
<tr>
<td>Stained</td>
<td>0.0 (0.1)</td>
<td>0.6 (0.9)</td>
</tr>
<tr>
<td>Non-stained</td>
<td>0.2 (0.4)</td>
<td>2.0 (1.7)</td>
</tr>
<tr>
<td>Non-stained</td>
<td>0.4 (0.6)</td>
<td>1.8 (2.0)</td>
</tr>
</tbody>
</table>

\(^1\) Numbers in parentheses are standard deviations \((n = 54)\).

Checks also represent relief of stresses in the wood. Both the bark and pith faces of the stained specimens had lower average check lengths, narrower check widths, and better average appearance (checking) ratings after both five and 10 cycles compared to the non-stained specimens (Tables 2 & 3; Figures 2, 3 & 4). By all measures, checking was heaviest on the bark faces and became more pronounced as the test progressed. For the bark face after 5 and 10 cycles, the average check width was 3 and 2.5 times, respectively, greater for the non-stained than for the stained wood. There were almost no checks present on the pith side of the stained specimens.

An average appearance rating of 2 (Poor) is our estimate of the level of checking at which the consumer would most likely want to replace the deck. Having the most visual effect, the check width had the greatest influence on the appearance rating. After 10 cycles, the stained samples had an average rating of 1.3 and the non-stained 1.8, the latter being almost at the stage where replacement of the decking would be desirable.

### Table 2: Checking of bark faces: summary

<table>
<thead>
<tr>
<th>No. of Wet/Dry Cycles</th>
<th>Total Average Check Length (mm)</th>
<th>Average Check Width (mm)</th>
<th>Average Overall Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stained</td>
<td>106 (170)(^1)</td>
<td>0.1 (0.2)</td>
<td>0.5 (0.5)</td>
</tr>
<tr>
<td>Stained</td>
<td>229 (188)</td>
<td>0.2 (0.2)</td>
<td>1.3 (0.8)</td>
</tr>
<tr>
<td>Non-stained</td>
<td>128 (121)</td>
<td>0.3 (0.3)</td>
<td>0.8 (0.6)</td>
</tr>
<tr>
<td>Non-stained</td>
<td>324 (207)</td>
<td>0.5 (0.3)</td>
<td>1.8 (0.9)</td>
</tr>
</tbody>
</table>

\(^1\) Numbers in parentheses are standard deviations \((n = 54)\).
Table 3: Checking of pith faces: summary

<table>
<thead>
<tr>
<th>No. of Wet/Dry Cycles</th>
<th>Total Average Check Length (mm)</th>
<th>Average Check Width (mm)</th>
<th>Average Overall Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stained</td>
<td>5</td>
<td>0 (0) (^1)</td>
<td>0.0 (0.0)</td>
</tr>
<tr>
<td>Stained</td>
<td>10</td>
<td>18 (44)</td>
<td>0.0 (0.1)</td>
</tr>
<tr>
<td>Non-stained</td>
<td>5</td>
<td>24 (54)</td>
<td>0.1 (0.1)</td>
</tr>
<tr>
<td>Non-stained</td>
<td>10</td>
<td>65 (105)</td>
<td>0.1 (0.2)</td>
</tr>
</tbody>
</table>

\(^1\) Numbers in parentheses are standard deviations (n = 54).

Close examination showed that the stained specimens had a high incidence of micro-checks (barely visible fine checks) occurring within the stained parts, while the non-stained samples had virtually no micro-checks. Stress relief via many smaller checks rather than fewer larger checks also probably explains why the stained wood was less cupped and less twisted than non-stained wood.

4.2 Wood permeability

4.2.1 Preservative uptake

During the soaking test, the wood showed an initial rapid wetting during the first hour and further increase in uptake was roughly linear up to 24 hours. Stained wood absorbed more liquid than the non-stained specimens, with a 400%, 400% and 300% higher uptake over 1-, 4- and 24-hour soaking periods, respectively (Table 4). A 1-hour soaking of stained specimens resulted in twice the uptake of that from a 24-hour soaking of non-stained specimens. This difference is not accounted for by the higher proportion of sapwood in the stained specimens (see section 4.2.3) and thus shows that the stained wood was significantly more permeable than the non-stained wood. Liquid uptake data were converted to preservative retentions for reporting in Table 4 and Figure 5. The pressure-treated stained specimens had a mean retention of 7.0 kg/m\(^3\), more than twice the 3.2 kg/m\(^3\) retention of the non-stained wood (Table 4).

Table 4: Average preservative retentions of soaked and pressure-treated stained and non-stained wood

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Stained</th>
<th>Non-stained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soak - 1 hour (kg/m(^3))</td>
<td>1.4 (1.1)(^1)</td>
<td>0.3 (0.1)</td>
</tr>
<tr>
<td>Soak - 4 hours (kg/m(^3))</td>
<td>1.6 (1.2)</td>
<td>0.4 (0.1)</td>
</tr>
<tr>
<td>Soak - 24 hours (kg/m(^3))</td>
<td>2.1 (1.3)</td>
<td>0.7 (0.2)</td>
</tr>
<tr>
<td>Pressure – 35 min. (kg/m(^3))</td>
<td>7.0 (3.5)</td>
<td>3.2 (2.4)</td>
</tr>
</tbody>
</table>

\(^1\) Numbers in parentheses are standard deviations (n = 70).
4.2.2 Preservative penetration

Penetration data are shown in Table 5 as the mean percentage of sapwood or heartwood penetrated by the preservative, as well as the mean penetration and percent over 10 mm on the sapwood and heartwood faces (see also Figures 6–8). Following a 24-hour soak, the stained specimens had 61% of the available sapwood treated compared to only 8% for the non-stained. As might be expected, heartwood was basically unpenetrated; both stained and non-stained specimens had only 1% of the heartwood treated, with a 24-hour soaking treatment. Almost all of the sapwood (99%) in the pressure-treated stained specimens was penetrated, compared to 81% for the non-stained specimens. As indicated by penetration data, stained material therefore had greater sapwood permeability in both treatments and the adjacent heartwood permeability was slightly improved with the pressure treatment. The higher permeability of the stained wood is well illustrated in Figures 9 and 10.

Table 5: Penetration data summary

<table>
<thead>
<tr>
<th></th>
<th>Dip Treatment</th>
<th></th>
<th>Pressure Treatment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stained</td>
<td>Non-stained</td>
<td>Stained</td>
<td>Non-stained</td>
</tr>
<tr>
<td>Avg. sapwood area treated (%)</td>
<td>61 (27)</td>
<td>8 (15)</td>
<td>99 (3)</td>
<td>81 (25)</td>
</tr>
<tr>
<td>Avg. heartwood area treated (%)</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>25 (25)</td>
<td>14 (16)</td>
</tr>
<tr>
<td>Centre sapwood face avg. penetration (mm)</td>
<td>6.6 (5.5)</td>
<td>0.5 (0.7)</td>
<td>12.1 (5.0)</td>
<td>4.6 (4.9)</td>
</tr>
<tr>
<td>Centre heartwood face avg. penetration (mm)</td>
<td>1.2 (4.0)</td>
<td>0.0 (0.1)</td>
<td>2.9 (4.6)</td>
<td>2.3 (2.9)</td>
</tr>
<tr>
<td>Centre sapwood face % ≥ 10 mm</td>
<td>24</td>
<td>0</td>
<td>71</td>
<td>20</td>
</tr>
<tr>
<td>Centre heartwood face % ≥ 10 mm</td>
<td>7</td>
<td>0</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

1 Numbers in parentheses are standard deviations (n = 70).
2 Max. penetration measured = 16 mm, as per AWPA standards.

To highlight any differences for this study, penetration measurements were taken from the center of both sapwood and heartwood faces. (Industry core borings to determine conformity to standards are taken randomly from the lumber edges.) The mean penetration into the sapwood face was over 12 times higher for the soaked stained specimens (mean = 6.6 mm) than for the non-stained specimens (mean = 0.5 mm). The pressure-treated stained specimens had a 160% higher mean sapwood penetration than non-stained specimens. Following soaking or pressure treatment, the center heartwood penetration measurements showed virtually no difference between stained and non-stained wood.

4.2.3 Heartwood/sapwood ratio

The data collected allowed us to determine the relative amount of sapwood and heartwood for the wood in test. Although we had attempted to collect unstained control pieces with a similar amount of sapwood, we were not entirely successful. The summary data show an average of 50% sapwood (standard deviation 29.2) in the bluestained pieces and 31% sapwood (standard deviation 30.5) in the non-bluestained pieces. We believe the 250 cross-sections measured (to the nearest 5%) in collecting these data were a representative sample of the whole of the material tested for all wood properties.
4.3 General discussion and implications

The results clearly show that when beetle-vectored bluestained wood is repeatedly wetted and dried, such as occurs in some exterior end uses, the wood is more dimensionally stable (less cupping and twist) and checks less but is more permeable to water than non-stained sapwood. The stresses appear to be relieved by many micro-checks rather than fewer large checks. The improved dimensional stability of the stained wood might be reflected in the lumber remaining straighter during weathering, but this remains to be investigated in the field.

The increased permeability probably also has implications for ease of air or kiln drying and possibly reduced degrade in the kiln. The fact that the moisture transfer mechanism for bluestained wood is enhanced could produce faster drying of the bluestained part of the wood and might be part of the reason for the reduced cupping. In the kiln, cupping commonly results from a steep gradient in shell/core moisture content caused by overdrying of the sapwood shell. Micro-checking of the sapwood may provide channels for moisture loss, affording less opportunity for moisture gradient and core moisture content to be reduced. We selected pieces that were as heavily stained as we could find for this work, but for pieces that have more erratically distributed bluestain, unevenness in the drying may result. Given that it is often drier to begin with, bluestained wood might be overdried if in the same kiln load as non-stained material. Data on the subject of lumber drying and degrade in stained vs. non-stained wood remain to be generated.

The anticipated increase in permeability was confirmed in our research in terms of preservative 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 overtreated or the non-stained wood undertreated. As anticipated, there was virtually no effect of bluestain in the sapwood on the penetration of preservative into the heartwood, the most refractory part of the wood. The micro-checking biologically mimics incising, a mechanical process used on refractory wood to increase preservative penetration and enable standards to be met. Unfortunately, the micro-checking is in the “wrong place”, in that the sapwood is already treatable. Because pieces of lodgepole pine lumber are hardly ever pure sapwood, it is hard to take advantage of the increased permeability. Attempting to do so by shorter press time would exacerbate the sapwood:heartwood preservative retention ratio even more heavily towards the sapwood. From the standpoint of the treater, more preservative would be used, at higher cost, to achieve the same level of protection of the non-durable heartwood. CSA standards require treatment of both heartwood and sapwood, and the heartwood is the limiting factor in achieving compliance with CSA standards. Consequently, improved sapwood permeability is not a great advantage to the pressure-treating industry.

Treatment with CCA masked the bluestain by coloring it green, thereby disguising the stained wood. Preservatives now commercialized as replacements for CCA in the domestic market have a similar color and the results obtained here with CCA are likely applicable also to those preservatives. Given the high volume in the sawmill pipeline for the foreseeable future, it is possible that a significant amount of beetle-killed wood could be diverted into products such as treated decking. The fine micro-checking on the stained wood gave a superior appearance over non-stained sapwood. This would be an advantage for pressure-treated decking when the sapwood is face up.
Increased permeability also means that dried bluestained wood will wet more readily in the presence of liquid water. We have previously observed this in bluestained lumber left unprotected in the weather. Preservative-treated bluestained wood would also wet up more under similar circumstances. End uses such as decking will be subjected to wetting/drying cycles, simulated in this testing. This may increase the leachability of less fixed preservatives, such as the ones being commercialized to replace CCA. Reducing the wetting of preservative-treated wood by water repellents or sealants might be a useful strategy.

5 Conclusions

- Wood with beetle-transmitted bluestain is more dimensionally stable (i.e., shows less twist and cupping) if repeatedly wetted and dried than is non-stained wood.

- In tests stimulatory outdoor wetting and drying, wood with beetle-transmitted bluestain checks differently than non-stained sapwood: fine micro-checking on the bluestained wood had a superior appearance over preservative-treated non-stained wood.

- Bluestained lodgepole pine sapwood is more permeable than non-stained sapwood and absorbs water-based wood preservative and water more readily.

6 Recommendations

- The drying properties of bluestained vs. non-stained wood should be determined to help industry optimize drying processes for beetle-killed wood.

- Treatability of bluestained wood with preservatives being introduced as alternatives to CCA should be determined.

- Field studies of the performance of preservative-treated bluestained pine are merited.

- Methods of reducing wetting characteristics of preservative-treated bluestained wood should be investigated.
Figure 1: Average cup and twist in test specimens (bars indicate 25th and 75th percentiles)

Figure 2: Average total check length, bark vs. pith faces (bars indicate 25th and 75th percentiles)
Figure 3: Average check width, bark vs. pith faces (bars indicate 25th and 75th percentiles)

Figure 4: Average appearance rating, bark vs. pith faces (bars indicate 25th and 75th percentiles)
Characterising the Dimensional Stability, Checking, and Permeability of Wood Containing Beetle-Transmitted Bluestain

Figure 5: Average preservative retention, dip vs. pressure treatments (bars indicate 25th and 75th percentiles)

Figure 6: Average percent of heartwood/sapwood area treated in dip and pressure treatments (bars indicate 25th and 75th percentiles)
Figure 7: Mean penetration of CCA in dip and pressure treatments (bars indicate 25th and 75th percentiles)

Figure 8: Percent CCA penetration ≥ 10 mm on centre sapwood face (CSF) and center heartwood faces (CHF).
Figure 9: Non-stained specimens treated with CCA by pressure (top) vs. dip (24-hour soak)

Figure 10: Bluestained specimens treated with CCA by pressure (top) vs. dip (24-hour soak)