

Value loss in ponderosa pine logs from beetle activity following fire in southern Oregon

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Abstract

Wormholes, stain, and decay in fire-damaged and fire-killed trees are causing rapid loss of value, and, to a lesser extent, volume when processed into wood products. Ponderosa pine trees killed in the Warner Mountain fire (southern Oregon) were found to be infested with wood-boring insects that were causing large amounts of massed wormholes and associated blue stain fungi as soon as 3 months after the fire. A sawmill recovery study was conducted on 44 control logs and 119 "wormy" logs ranging in small-end diameter from 6 to 37 in (15 to 94 cm) to determine if there was any measurable merchantable volume loss in the fire-killed trees as a result of massed wormholes. No lumber volume was lost owing to worm-generated defect. Both the control and wormy logs averaged 78 percent in green cubic volume recovery. There was a significant drop in average value of \$258/MBF lumber tally (2005 prices) from the control to the wormy log sample. In this study, value loss occurred primarily because of the presence of blue stain in lumber that would otherwise have produced the higher value Factory grades (e.g., Shop, Moulding). Almost 80 percent of the lumber volume sawn from the control logs was in the higher value Factory grades whereas only 17 percent of the lumber from wormy logs received these grades. About 52 percent of the lumber produced from wormy logs was graded as lower value Dimension lumber as compared to 18 percent of the control being assigned under that grading system. Value loss increased with log diameter. The primary recommendation from these results is that loss should be handled in the valuation (appraisal) process rather than the measurement (scaling) process.

Land managers are noticing increased beetle activity in some fire-killed stands in the Western United States as compared with a decade ago (Lowell and Cahill 1996, Hadfield and Magelssen 2006). Whether these observations are a result of forest conditions, recent climatic conditions, or fire severity, the influence of this activity has a significant impact on timber-salvage planning and operations and product opportunities for fire-damaged and fire-killed trees. The presence of wormholes (tunnels made by beetle larvae) as a result of attack by wood-boring insects following fire is a common occurrence in recent timber salvage sales. The larvae first produce galleries under the bark before tunneling into the wood, creating holes. The beetles that infest the trees can cause further deterioration by introducing stain and decay fungi carried on their bodies. Their entrance holes also provide an infection court for fungal spores to enter a tree. These holes often provide optimal conditions for fungal growth. Wormholes, stain, and decay in fire-damaged and fire-killed trees are causing rapid loss of value, and to a lesser extent volume, when the trees are processed into wood products.

Not all defects in fire- or beetle-damaged and -killed logs result in a measurable scaling deduction under either the

Scribner or the cubic scaling rules (USDA FS 1985, 1991). Stain and wormholes, although lowering the grade of some types of solid wood products produced from these logs, generally does not affect the volume recovered. Decay (sap rot) and weather check are measurable deduction losses when scaling logs. Increased beetle activity in fire-damaged and fire-killed logs led the National Forest Steering Measurement Committee, Cubic Scaling Measurement Subcommittee, to develop a new log scaling rule that addressed massed wormholes (a large concentration of holes in a small area) as seen in Figure 1.

Literature review

Product value loss studies on fire-killed ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) are few (Fahey et al. 1990). No similar product recovery studies to determine

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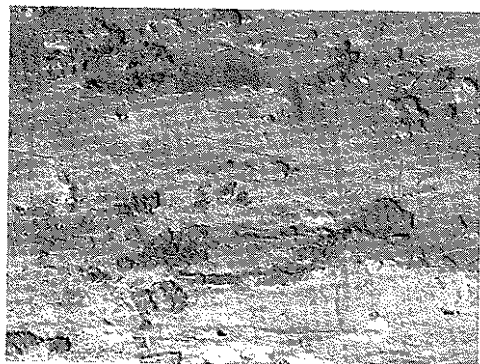


Figure 1. — Massed' wormholes on ponderosa pine salvage logs from the Warner Fire, Lakeview, Oregon.

product value loss have been conducted on other fire-killed species throughout the Western United States. Prior research has focused on volume loss for several species. Volume loss in fire-killed trees was measured in the 3 years following wildfires in southern Oregon and northern California (Lowell and Cahill 1996) for Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), true fir (*Abies* spp.), ponderosa pine, and sugar pine (*Pinus lambertiana* Dougl.). Hadfield and Magelssen (2006) published data on observed changes over 5 years in seven species of fire-killed trees from eastern Washington. A literature review on deterioration rates in fire-killed and fire-damaged timber (Lowell et al. 1992) cites additional studies that address volume loss in logs from dead trees.

Postfire mortality in ponderosa pine can result from beetle attacks (Fowler and Sieg 2004). Some of the scaling defect (sap rot and wormholes) in fire-killed trees can be a result of beetle infestation and thus similar or identical to the defect found in beetle-killed trees. Type and amount of defect may differ between fire-killed and beetle-killed trees. For example, weather checks may occur more frequently in fire-killed trees as a result of the drying effect of fire, especially in smaller, thin barked trees or upper logs of larger trees (Kimmey 1955).

More studies have been conducted on deterioration of beetle-killed trees than fire-killed trees. Results of beetle-kill effect on volume and value recovery for solid wood products are available for lodgepole pine (*Pinus contorta* Dougl. ex Loud.) (Snellgrove and Fahey 1977, Plank 1979, Fahey 1980, Snellgrove and Ernst 1983, Plank 1984, Fahey et al. 1986), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) (Cahill 1980), western white pine (*Pinus monticola* Dougl. Ex D. Don) (Snellgrove and Cahill 1980), ponderosa pine

(Willits et al. 1990), Douglas-fir and grand fir (*Abies grandis* Dougl. ex D. Don) Lindl.) (Parry et al. 1996), and spruce (*Picea* spp.) (Lowell and Willits 1998, Lowell 2001).

A study examining effect of beetle attack on product volume and value was conducted by Parry et al. (1996) in eastern Oregon on Douglas-fir and grand fir. The tree sample consisted of live, 1-, 2-, 3-, and 4-year dead trees. Logs were processed into dimension lumber and a small quantity of 4/4 boards. Up to and including 4-year dead trees, there was no value loss that could be attributed to stain or insect activity (wormholes). This is because stain and wormholes are not considered grade-reducing defects in dimension lumber (Western Wood Products Association 1998). Volume loss started with the 2-year dead material. Weather checking and sap rot were the cause of lumber grade fall-down.

Objectives

The Ecologically Sustainable Production of Forest Resources team of the Pacific Northwest Research Station (Portland, Oregon) conducted a sawmill recovery study in January 2003 on a sample of ponderosa pine logs to test the validity of the new scaling rule developed by the Forest Service National Measurement Committee by (1) determining if there was any measurable merchantable volume loss in the fire-killed trees as a result of massed worm holes and (2) determining if there was product value loss in lumber produced from logs from fire-killed trees when compared to a control sample.

Methods

Site selection

The Warner Fire on the Fremont-Winema National Forest, Lakeview Ranger District, was the origin of trees used in the study. Ponderosa pine trees from the Warner Mountain Timber Sale were found to be infested with the type of wood-boring insects that were causing large amounts of massed wormholes and associated blue stain fungi. The timber sale was located in an area that had burned in July 2001. A site visit to the stand verified that worm activity was already underway 3 months after the fire. The Fremont Sawmill (a division of The Collins Companies) in Lakeview, Oregon, purchased this timber sale and cooperated in the lumber recovery study.

Log selection

In fall 2002, log scalers and measurement specialists from USDA Forest Service Regions 6 and 5 (Pacific Northwest and Pacific Southwest Regions), industry, and third-party scaling bureaus, joined with representatives of the National Forest Steering Measurement Committee, Cubic Scaling Rules Subcommittee, to select wormy and control logs to be used in the product recovery test from incoming truckloads of logs salvaged from the Warner Fire. Logs were selected at the mill logyard based on small-end diameter inside bark and condition. No logs with pre-existing defect (e.g., butt or heart rot) were selected. The proposed log diameter range was 7 to 30 inches inside bark on the small end stratified by 2-in diameter classes, with an additional class for logs 30 or more inches in diameter. Logs with a small-end diameter of 12 inches or less contained a large amount of weather checking. The weather checking was so extensive that it caused the logs to be culled according to standard scaling practices. Therefore they could not be included in the sample. Wood-boring insect attacks generally occur first in the mid to lower bole of the tree. Consequently, there were a small number of butt logs (three) in the control sample as compared to the wormy sample (Table 1).

Because deterioration (insect, decay fungi, and weather checking) had taken place so rapidly, it was difficult to achieve a full sample of wormy logs in the smaller diameter classes.

Control logs

As no green trees were allowed in the timber sale, the control logs had to be selected from the fire-damaged or fire-killed tree population yet be free of worm activity and blue stain. Each control log was carefully examined to ensure it had no signs of beetle activity. Consequently, it was not possible to fill the complete sample of control logs. Ideally, control logs should come from similar but undisturbed stands. Although our control logs allow for a comparison between damaged and undamaged logs, they do not allow direct comparison with undamaged material from green stands.

Log measurements

Scaling was done according to the National Forest Log Scaling Handbook (USDA FS 1985) and the National Forest Cubic Scaling Handbook (USDA FS 1991) and using the proposed massed wormhole deduction rule developed by the National Cubic Measurements subcommittee. Scaling defects were recorded by cause for deduction (type of defect) for both the control and wormy log samples.

Log processing and product data

The log sample was sawn into products according to the normal practice used by the sawmill at that time for the species and size of log. The production included 2-in dimension lumber (a structural product), 6/4 Shop lumber (an appearance product), and a small amount of 4/4 boards. Tallying of lumber volume and lumber grade was done in the green condition. Western Wood Products Association (WWPA) grading inspectors performed the lumber grading at the sawmill grading presort station located between the trim saw and the sort bins. The mill chose to saw all dimension and Shop lumber to a uniform green thickness. This provided the lumber graders with a choice of grading systems, based on the quality of each piece. This allowed them the opportunity to assign the higher value grade to individual pieces of lumber from within a log.

Grading lumber in the green condition does not always provide the final lumber grade (value) because there can be about a 5 to 10 percent grade fall-down following kiln-drying and surfacing of products (Center for Advanced Wood Processing 2004). Defects associated with shrinkage (e.g., warp, checks, splits, and shake) and fungi can occur in lumber as a result of

kiln-drying. Surfacing can further expose defects not seen in the green condition and can create machining defects such as planer skip, raised grain, or machine burn that would lower the grade of the lumber.

Results

Log measurements

Gross and net cubic log scaling volumes are displayed in **Table 2**. The control sample cubic scale volume loss was less than 2 percent. About 34 percent of cubic volume was deducted for the wormy logs when using the proposed massed wormhole rule. Other deductions accounted for about 4 percent cubic volume loss in the wormy logs.

Lumber volume

Comparing the lumber volume recovery results for the control to those of the wormy sample showed that no lumber volume was lost owing to worm-generated defect. Cubic recovery percentage of green lumber volume was the same in the wormy logs as in the control logs (**Table 3**). Therefore, application of the proposed mass wormhole deduction rule resulted in a much lower net log scale for the wormy logs (**Table 2**) than the actual lumber volume measured in the recovery study. Thus, the proposed scaling rule is not appropriate because no loss of volume is occurring.

Figure 2 illustrates the results of the option afforded the graders by producing lumber that can be graded under either the Dimension or Selects and Factory Lumber (e.g., Shop and Moulding) grading rules. Almost 80 percent of the lumber volume sawn from the control logs was in the higher value Factory lumber grades whereas only 17 percent of the lumber from wormy logs received these grades. Wormy logs did produce 27 percent Stained Shop, a much lower value product. About 52 percent of the lumber produced from wormy logs was graded as lower value Dimension lumber as compared to 18 percent of the control being assigned under that grading system.

Lumber value

Ponderosa pine is used for three major types of products: 4/4 (1-inch) boards, dimension (2-inch) lumber, and appearance-grade Selects and Factory lumber. Damage by beetles (worms and wormholes) and stain (e.g., blue and brown) have no effect on the grading of dimension lumber and little effect on Common boards. Conversely, appearance-grade Selects and Factory lumber do not permit the presence of worms, wormholes, and stain, so flitches that contain these defects should not be used to manufacture appearance-grade products. The presence of these defects results in a very substantial decrease in selling price. Larger logs tend to produce a higher percentage of clear wood than smaller logs. As a result, value loss changes with log diameter.

A linear regression analysis was conducted using log small-end diameter as the independent variable and value (expressed in dollars per thousand board feet (MBF) lumber tally,

\$/MLT) as the dependent variable. The relationship was found to be highly significant ($p = 0.0001$). **Figure 3** (Eqs. [1] and [2]) shows predicted values in \$/MLT by log small-end diameter (SED) for lumber produced from the control logs and logs that contained stain and wormholes.

Table 1. — Log sample data by log condition.

| Log condition | Logs | Butt logs | Diameter range | Average diameter |
|---------------|------------------|-----------|-----------------|------------------|
| | ------(No.)----- | | ------(in)----- | |
| Control | 44 | 3 | 6 to 35 | 18 |
| Wormy | 119 | 63 | 7 to 37 | 19 |

Table 2. — Cubic scaling volumes by deduction types.

| Log condition | Gross volume | Net volume | Sound | Worm deduction (proposed rule) | Other deductions |
|---------------|-------------------------------|------------|-------|--------------------------------|------------------|
| | ------(ft ³)----- | | (%) | ------(ft ³)----- | |
| Control | 1580.7 | 1558.6 | 98.6 | 0 | 22.1 |
| Wormy | 4577.5 | 2826.7 | 61.7 | 1556.8 | 194.0 |

Table 3. — Lumber tally volume, cubic recovery, and value recovered from the study by log condition.

| Log condition | Lumber tally (BF) | Green cubic recovery (%) | Average lumber value ^a (\$/MBF) |
|---------------|----------------------|-----------------------------|---|
| Control | 18,020 | 77.8 | 611 |
| Wormy | 51,002 | 77.5 | 353 |

^aWWPA 2005.

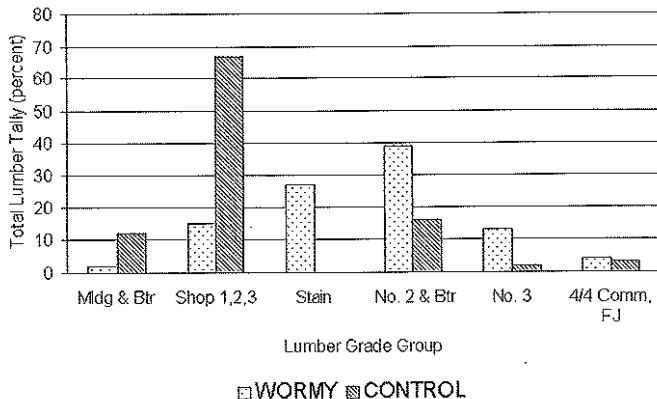


Figure 2. — Lumber grade recovery by log condition and grade group.

These predicted values shown are based on the mix of products sawn from these logs and the average prices for those products in 2005. As prices do not always change proportionately, the loss in value from wormy logs will depend on current market prices at the time of processing.

Table 3 illustrates that without considering scaling deductions, there is a significant drop in average value of \$258.00 per MBF lumber tally from the control to the wormy log sample. In this study, value loss occurred because of the presence of blue stain in lumber that would otherwise have produced the higher value Factory (Shop) and Moulding and Better grades. When cutting a piece of lumber to 6/4-inch thickness, the sawmill has the option of grading this piece under Factory or Dimension grading rules. The price of Dimension lumber is currently much less than Shop prices. Fifty-two percent of the lumber produced from the wormy logs was graded under the Dimension rules, whereas only 18 percent of the control logs were sawn for Dimension lumber.

Conclusion

Results of this research show that no cubic volume is lost when ponderosa pine fire-killed logs are processed 1-1/2 years after a fire. However, significant value loss does occur and increases significantly with log diameter. The primary recommendation from these results is that this loss should be handled in the valuation (appraisal) process rather than the measurement (scaling) process. For ponderosa pine, it may be more effective to treat massed wormholes and the associated blue stain by using a value deduction based on log diameter classes in the appraisal process rather than classifying it as a volume deduction defect in the measurement (scaling) system.

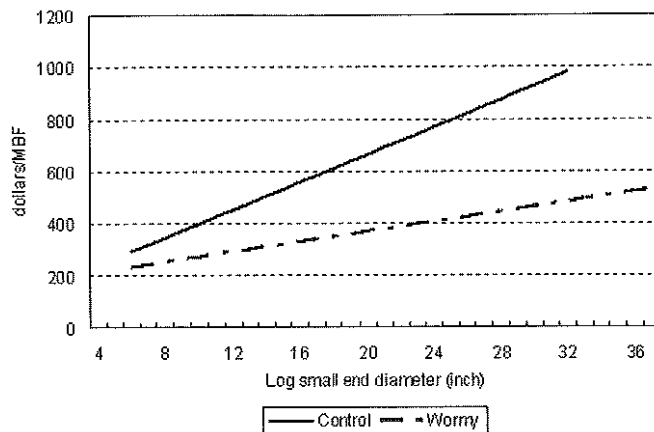


Figure 3. — Value (dollars per MBF lumber tally) of control and wormy logs. Prices used were from WWPA 2005.

$$\text{Control sample: } y = 133.11 + (26.47 \times \text{SED}) \quad r^2 = 0.82 \quad [1]$$

$$\text{Wormy sample: } y = 174.73 + (9.59 \times \text{SED}) \quad r^2 = 0.65 \quad [2]$$

Both dimension and Factory lumber were produced in this study. Dimension lumber sawn from logs that came from a fire salvage area does not experience grade fall-down because of wormholes or stain. Although stain and wormholes change the appearance of dimension lumber, they are not a cause of downgrade under the structural grading rules. However, they do affect grade when graded under Factory lumber (e.g., Shop) grades. Recently, it has become clear that some end users are judging the appearance of structural lumber to make their purchasing decisions (Hart 2003, Forestry Innovation Investment Ltd. 2005), thus creating a *de facto* appearance grade of dimension lumber and making it more difficult to market dimension lumber from fire- and beetle-damaged logs.

Forest stand conditions differ throughout the Western United States and there are many factors that influence deterioration rates of fire- and beetle-killed trees. The data presented above may be used as a guideline. However, visual inspection of stands can reveal a wide range of variation in defect. Differences will exist based on species, age, elevation, stand density, and climatic conditions, to name but a few (Lowell et al. 1992). Each sale presents a unique set of conditions and should be evaluated case by case.

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