TECHNOLOGY TRANSFER NOTES
Forestry Research Applications Pacific Forestry Centre No.7 October, 1997

Decay Associated with Logging Injuries in Western Larch, *Larix occidentalis*, and in Lodgepole Pine, *Pinus contorta*

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Strategic Importance

Entries into stands of lodgepole pine or western larch by large mechanical equipment generally cause serious injuries on about 10% of crop stems, usually in the most valuable portion of the trees. Changes in harvesting and stand management techniques are resulting in more frequent entries into stands. Each entry results in some level of injury to stems and roots. These injuries can provide entry courts for fungal decay organisms, increase susceptibility to insects and diseases, decrease vigor, reduce growth and yield, and seriously degrade wood quality.

The British Columbia Forest Practices Code regulations require that forest managers understand the implications of wounding and are able to predict damage losses through time. In many situations, wounding and associated decay can be reduced. Training and techniques to avoid injury will significantly improve the future value of stands.

Prior to this study, little research had been done on wound-related decay in lodgepole pine and western larch. However, studies of wound-related decay in true firs and western hemlock have shown that decay is commonly associated with up to 90% of injured trees and that losses can be as high as 10% of the merchantable volume.

Study Methods and Results

Injured western larch and lodgepole pine trees near Cranbrook, British Columbia, were sampled destructively and assessed for decay. Samples were taken in the MSdk, IDFdm, ESSFdk, ICHmw biogeoclimatic zones. The relationships between decay and: scar size and age, location, cause, intensity and depth of wound were assessed.

Western Larch

More than 100 injured western larch trees were examined at 10 sites throughout the Cranbrook Forest District. Of these, 88% had decay associated with injuries (Figs. 1 and 2). Injury characteristics such as scar size, height from ground, and injury intensity had some effect on the incidence of decay but little or no effect on decay volume (Table 1). The average volume of decay associated with larch injuries was 0.028 m³, or 7.2% of merchantable volume. The median decay volume, more representative of most decay events, was 3.5% of merchantable volume.

Injured wood provided a favorable substrate for colonization by decay fungi and there was little evidence of host response to infection. Most scars became colonized soon after injuries occurred. These fungi continued to grow in the wood adjoining scars without being blocked from further development by resinosis or other host responses.

Wounds that exposed the phloem but did not penetrate the wood had a lower incidence of decay than those in which the wood was gouged. There was no significant difference in the incidence of decay between scars with gouges less than or greater than 1 cm deep. There was no significant difference in incidence of decay among scars attributed to damage associated with skidders, falling injuries, or rub trees.

There were significant differences in decay volume between large (> 400 cm²) and small (< 400 cm²) scars that were less than 10 years old.

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Wood boring insects were associated with significantly higher volumes of decay in western larch. The insects may have acted as vectors of decay organisms. Without vectors, decay fungi can only infect injured trees while injuries are fresh and moisture levels are favorable for fungal growth. Once injuries have dried, penetration by decay fungi is much less successful. Insect vectors, however, can carry fungal spores inside the tree where moisture levels are more favorable, bypassing the dry surface of an old injury. In lodgepole pine, insect activity was only found in scars that had decay associated with them.

Figure 1. 8-year-old injury that occurred when this 116-year-old western larch was 108 years old.

Figure 2. Decay associated with the scar in Fig. 1 resulting in a 6% loss of merchantable volume.

Figure 3. 16-year-old injury on an 82-year-old lodgepole pine.

Figure 4. Cross-section of the injury shown in Fig. 3. The resin-soaked surface of the injury prevented fungal colonization and subsequent development of decay.

Lodgepole Pine

Lodgepole pine trees with injury scars were examined at 10 sites throughout the Cranbrook Forest District. A relatively small percentage (7.8%) of the injuries on lodgepole pine had associated decay. The average volume of decay associated with these injuries was 5.6 % (median = 4.3%) of merchantable tree volume.

There was no relationship between the incidence of decay and any of the other factors measured (scar size class, scar height from ground, injury intensity, cause of damage, or tree age at time of injury). Profuse resinosis was associated with the pine injuries. This is thought to form a "barrier" to fungal colonization (Figs. 3 and 4).

Figure 5. 76-year-old injury that occurred when this 106-year-old western larch was 30 years old.

Figure 6. Decay associated with the scar in Fig. 5 resulting in a 3.5% loss of merchantable volume. If the same injury had occurred at the age of 50, the volume loss would have been 14% of the merchantible volume.

	Incidence of Decay	Volume of decay
Scar Age Classes	76% to 100%*	0.018 to 0.066 m^3*
Scar Size Classes	<400 cm² = 74%** >400 cm² = 92%	<400 cm² = 0.008 m^3** >400 cm² = 0.023 m^3
Scar height class from ground	<30 cm = 95% of injuries >30 cm = 76% of injuries**	No significant differences
Injury Intensity	Gouged wood had 94%-100% incidence of decay. Exposed phloem with no gouge had 80%.**	No significant differences
Crown Class	No apparent relationship	No significant differences
Cause of damage	No significant differences	No significant differences
Age at time of injury	<40 years = 88%* >100 years = 100%	No significant differences

* not statistically different ** p < .05

Table 1. Incidence and volume of Decay Associated with Injuries in Western Larch

Comparison of Volume of Decay Losses for Coniferous Tree Species

The volume of decay losses in western larch and lodgepole pine is consistent with studies carried out on other tree species (Table 2). These studies indicate that significant wood volume losses to decay can be prevented if tree injuries are avoided.

Decay Progression Model

The tree age at which injuries occur and the subsequent development of infection have significant impacts on the lumber recovery value. Through a process known as "compartmentalization", fungal growth is restricted and cannot colonize new wood laid down after an injury occurs. Consequently, decay initiated when a tree has a small diameter will occupy a relatively low volume (Figs. 5 and 6). Similarly, decay initiated on trees with a larger diameter has the potential of significantly larger losses (Figs. 1 and 2).

A decay progression model (Fig. 7) is shown for two trees at 10, 50, 90, and 130 years. When an injury occurs on an 8-cm-dbh, 10-year-old tree (top row), the resulting decay (shaded) is confined to a column 8 cm in diameter. Decay resulting from an injury on a 20-cm-dbh, 50-year-old tree (bottom row) can develop a 20-cm decay column by the end of a 130-year rotation, approximately 6 times the decay volume of a similar injury at age 10.

Management Implications

Stand entries with large equipment result in damage to tree stems. Often up to 48% of trees are injured and about 10% of these trees receive large (>400 cm²) injuries. A significant proportion of this damage will lead to decay.

Tree Species	Injury-related decay loss (% of merchantable volume)	Reference
Western larch	7.2% (median 3.5%)	Allen and White (unpubl.)
Lodgepole pine	5.6% (median 4.3%)	Allen and White (unpubl.)
Douglas-fir	<1%	Hunt and Krueger (1962)
	1.4%	Shea (1961)
	1-5%	Craig (1970)
White Spruce	up to 7%	Parker and Johnson (1960)
Subalpine Fir	up to 10%	Parker and Johnson (1960)
Western Hemlock	3%	Hunt and Krueger (1962)
	6%	Shea (1961)
	1%	Shea (1960)
Sitka Spruce	1%	Shea (1960)
White Fir	7%	Wallis and Morrison (1975)
	4.5%	Aho et al. (1983)
Red Fir	1.9%	Aho et al. (1983)

Table 2. Merchantable Volume Lost From Injury-related Decay By Species

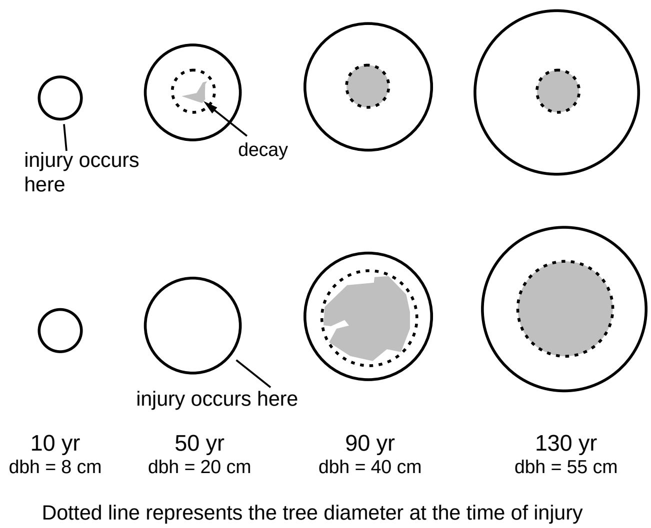

Figure 7. Decay Progression Model

The presence of decay can severely impact lumber grade. With 99% of injuries occurring under 2.5 m, in the most valuable portion of the butt log, there are higher lumber value losses than indicated from the volume figures alone.

There is a dramatic difference in the incidence of decay associated with wounding between species (an average of 88% for western larch and 7.8% for lodgepole pine). Injuries of any kind on western larch are likely to lead to decay and wood volume losses. Injuries to lodgepole pine are unlikely to cause significant levels of decay. The differences in susceptibility to decay resulting from injury means that operators will have to identify species and know their decay risk when planning entries into stands. Activities such as skid road development, tree extraction, falling techniques and equipment movement will require extra care in stands with a high percentage of western larch. Extreme care must be taken to avoid damaging this species during any stand entries, especially in mid-rotation. Wounding should be minimized in all situations. The cooperation of operators will be required to keep wounding to a minimum.

Forest managers may consider the following for *western larch*:
- Avoid wounding through careful layout of skid trails;
- Increase operator training and awareness of the impacts of wounding;
- Where possible, remove injured western larch trees during mid-rotation entries, particularly those with scars >400 cm²;
- Leave clumps of larch where possible; and
- Protect the stems of high-risk larch leave trees from skidding damage with branches, snow or other material.

Forest managers may consider the following for *lodgepole pine*:
- Multiple entries into stands with a high percentage of pine are possible with little risk of volume loss to decay;
- Where possible, avoid injuries to pine trees;
- Design skid roads in the most efficient manner for equipment and terrain; and
- Concentrate on desirable densities to achieve silvicultural objectives.

Other considerations:
- Light cuttings, less than 30% removal of merchantable volume, can result in more wounding to residual trees than a heavy cutting.
- Match equipment size and characteristics to densities and other stand factors to avoid damage to residual trees.

Additional Reading

Aho, P. E., Fiddler, G. and Srago, M. 1983. Logging damage in thinned, young-growth true fir stands in California and recommendations for prevention. USDA For. Serv. Pacific Northwest Research Station Res. Paper, PNW-RP-304. 8 pp.

Craig, H. M. 1970. Decay following scarring of Douglas-fir in the dry-belt region of British Columbia. Can. For. Serv. Inf. Rep BC-X-43. 16 pp.

Hunt, J. and Krueger, K. W. 1962. Decay associated with thinning wounds in young-growth western hemlock and Douglas-fir. J. For. 60:336-340

Parker, A. K. and Johnson, A. L. S 1960. Decay associated with logging injury to spruce and balsam in the Prince George region of British Columbia. For. Chron. 36:30-45.

Shea, K. R. 1960. Decay in logging scars in western hemlock and Sitka spruce. Weyerhauser Company For. Res. Note WC-25. 13 pp.

Shea, K. R. 1961. Deterioration from logging injury in Douglas-fir and western hemlock. Weyerhaeuser Company For. Res. Note WC-36. 5 pp.

Wallis, G. W. and Morrison, D. J. 1975. Root rot and stem decay following commercial thinning in western hemlock and guidelines for reducing losses. For. Chron. 51:203-207.

Wright, E. and Isaac, L. A. 1956. Decay following logging injury to western hemlock, Sitka spruce, and true firs. USDA Tech. Bull. 1148. 34 pp.

British Columbia Forest Practices Code Guidebooks. 1996. Tree Wounding and Decay Guidebook, Host and pathogen ecology.

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Acknowledgments

- Forest Renewal British Columbia for funding contribution.
- Dave Crampton, John Gay, and Liz Goyette BC Ministry of Forests, Nelson Region, B.C. for field assistance.
- Dean Mills, Editor, CFS, Victoria, B.C.
- Anne Dickinson, Technology Transfer, CFS, Victoria, B.C.

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Printed on recycled paper

ISSN 1209-6571 Cat. No. Fo29-47/7-1997E
ISBN No. 0-662-26006-6

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Canada