Advantage

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Contents

Mechanical wood damage associated with overhead cranes and butt-n-top loaders

Abstract

The Forest Engineering Research Institute of Canada (FERIC) examined the level of mechanical wood damage associated with the use of overhead cranes and butt-n-top loaders to retrieve decked tree-length stems in a logyard. The frequency of breakage and the loss of sawlog volume were projected using a method developed by FERIC. Factors that may have affected damage levels were discussed.

Keywords

Wood damage, Breakage, Tree-length stems, Portal cranes, Butt-n-top loaders, Fibre loss.

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Introduction

FERIC has performed several case studies as part of its utilization project aimed at examining mechanical wood damage associated with various harvesting and wood handling operations. The studies were conducted in response to individual companies' requests for wood damage information on some specific aspect of their operations, and the overall objective was to help develop strategies to reduce mechanical wood damage. The studies have included damage to aspen short logs handled by a combination of overhead cranes and butt-n-top loaders (Andersson and Dyson 2005), wood loss from stem breakage during central yard and roadside processing operations (Andersson 2004), butt damage associated with feller-buncher operations (Andersson 2003a), and wood damage associated with millyard handling operations for tree-length stems (Andersson et al. 2002) and long logs (Andersson 2003b).

This report documents the results of a study that examined mechanical wood damage associated with decking and retrieving stored tree-length stems in a logyard using an overhead crane and a butt-n-top loader. The study was conducted in cooperation with Canadian Forest Products Ltd. (Canfor) in Grande Prairie, Alberta. It was originally scheduled for September 2002, but wet ground conditions delayed the study to November 2002. However, at that time there was insufficient volume of stored stems left in the logyard to complete the study, and thus a second set of data was collected in October 2003. At both times, the stems examined for damage were the remaining quantities of stems stored in the yard from the previous year's harvesting season.

Objectives

The overall objective was to determine the mechanical wood damage resulting from using the overhead crane and butt-n-top loader to deck tree-length stems and retrieve them from the inventory decks following 12 months of storage. To achieve this, FERIC identified the following study approach:

- Record the visual stem damage in two batches of stored tree-length stems handled by the overhead crane and butt-n-top loader, respectively.
- Record the visual stem damage in one batch of tree-length stems that had not been stored in the logyard.

- Convert the physical stem damage data into a quantitative measure of the damage's impact on sawlog lumber recovery (projected loss of sawlog volume).
- Compare the projected loss of sawlog volume among the two handling systems of stored stems and the non-stored stems.

Study methods

The wood examined in the study consisted of two batches of tree-length stems that had been stored in the yard for approximately one year, and one batch (386 m^3) of non-stored tree-length stems from eight randomly selected logging trucks arriving at the logyard during the study period. One batch (370 m^3) of the stored stems had been decked and retrieved by a portal crane ("crane wood"), while the other batch (196 m^3) of stored stems had been decked and retrieved by a butt-n-top loader ("loader wood").

All stems included in the study were transported to a designated study site located in the logyard and spread on brow logs by a butt-n-top loader. The crane wood was transported directly from the inventory deck to the study site by the crane (Figure 1). The loader wood was taken from the inventory deck and put on a tractor-trailer, transported to the study site, and unloaded by a butt-n-top loader. The non-stored wood was off-loaded directly at the study site by a butt-n-top loader.

Figure 1. Portal crane and butt-n-top loader at study site in millyard.

All stems were scaled and all visual damage was recorded (Appendix I). When possible, the source of the damage was also recorded. The data were analyzed using a method developed by FERIC that converted the physical damage data into a quantitative measure of the damage's projected impact on sawmill lumber recovery, expressed as percentages of the gross sawlog volume. This calculated volume loss does not necessarily correspond to an equal percentage reduction in lumber recovery. Rather, these figures should be regarded as wood loss indices and used mainly to compare the amount of wood damage between different harvesting and wood handling practices.

Stem characteristics

The distribution of stem sizes among the three batches varied considerably, particularly between the crane wood and the loader wood (Table 1). Stems with butt diameters up to 30 cm were fairly similar in length in all batches, while the larger diameter stems in the crane wood tended to be longer than those in the loader wood and non-stored wood. It appeared that proportionally more of the larger stems in the non-stored and the loader wood had been subjected either to more long butting or more of them had been bucked into two logs compared to the stems in the crane wood. The difference in length was particularly large for stems with butt diameters more than 40 cm.

Results

Overall, the projected loss of sawlog volume from mechanical damage was 1.3 and

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Table 1. Summary of stem characteristics

	Portal crane wood	Butt-n-top loader wood	Non-stored wood
Species composition	S_8P_2	S_7P_3	S_7P_3
Scaled volume (m^3)	369.63	196.18	385.87
Unbroken stems (no.)	478	842	784
Average butt diameter (cm)	29	19	23
butt diameter ≤20 cm (%)	18	66	52
butt diameter 21–30 cm (%)	47	32	33
butt diameter >30 cm (%)	35	2	15
Average stem length (m)	15.1	10.9	11.8
Average volume (m^3)	0.71	0.23	0.43
Broken stem sections (no.)	68	57	98
Average butt diameter (cm)	24	17	27
Average length (m)	10.0	5.3	11.2
Average volume (m^3)	0.42	0.10	0.52

Table 2. Summary of damage and volume loss

	Portal crane wood	Butt-n-top loader wood	Non-stored wood
All stems (no.) [a]	520	878	853
Breakage frequency (%)	8.1	4.1	8.1
Breakage volume loss (%)	0.8	0.8	1.2
Other volume loss (%)	0.5	1.1	0.7
Stems 10–20 cm at butt (no.)	93	582	422
Breakage frequency (%)	6.4	4.8	3.6
Breakage volume loss (%)	0.8	1.1	0.7
Other volume loss (%)	0.9	1.3	0.7
Stems 21–30 cm at butt (no.)	244	277	280
Breakage frequency (%)	8.2	3.6	8.9
Breakage volume loss (%)	1.0	0.7	0.9
Other volume loss (%)	0.6	0.8	0.7
Stems 31–40 cm at butt (no.)	132	13	83
Breakage frequency (%)	10.6	0.0	27.7
Breakage volume loss (%)	1.3	0.0	2.2
Other volume loss (%)	0.4	0.6	0.9
Stems >40 cm at butt (no.)	51	6	67
Breakage frequency (%)	3.9	0.0	10.4
Breakage volume loss (%)	0.1	0.0	0.5
Other volume loss (%)	0.4	0.9	0.8

[a] Unbroken stems and stems with broken tops (other broken stems are considered to be part of stems with broken tops).

1.8% for the crane wood and loader wood, respectively; and 1.9% for the non-stored wood. The majority of the volume loss was attributed to breakage (0.8–1.2%), while damage attributed to gouging and end-splitting was 0.5–1.1% (Appendix II and Table 2).

The fact that the projected loss of sawlog volume for the non-stored wood was higher than for the stored wood eliminates its intended use as an estimate of the amount of wood damage present on the stored wood prior to logyard handling. Thus, the results in this study are only indications of the maximum amount of damage that could have been caused by the logyard operations.

Stored wood

The breakage frequencies[1] among the stems handled by the crane and the loader were 8.1% and 4.1%, respectively. The breakage frequency was also higher among the crane wood than among the loader wood for stems of the same butt diameter class. However, the difference in the breakage frequencies among stems of different diameter classes was not statistically significant for either the crane wood or the loader wood.

The projected loss of sawlog volume attributed to breakage was 0.8% for both the crane wood and the loader wood. The fact that the percentage volume loss was the same despite the large difference in the breakage frequency is attributed to the difference in stem size between the two batches. Most of the breakage had occurred at diameters less than 20 cm (Figure 2) for all stem sizes, which meant that there was proportionally lower volume loss among larger-diameter stems than among smaller-diameter stems. The largest component of the volume loss from breakage was from broken-off and non-recovered (missing) pieces, which made up about three-quarters of the total estimated volume loss from breakage (Figure 3).

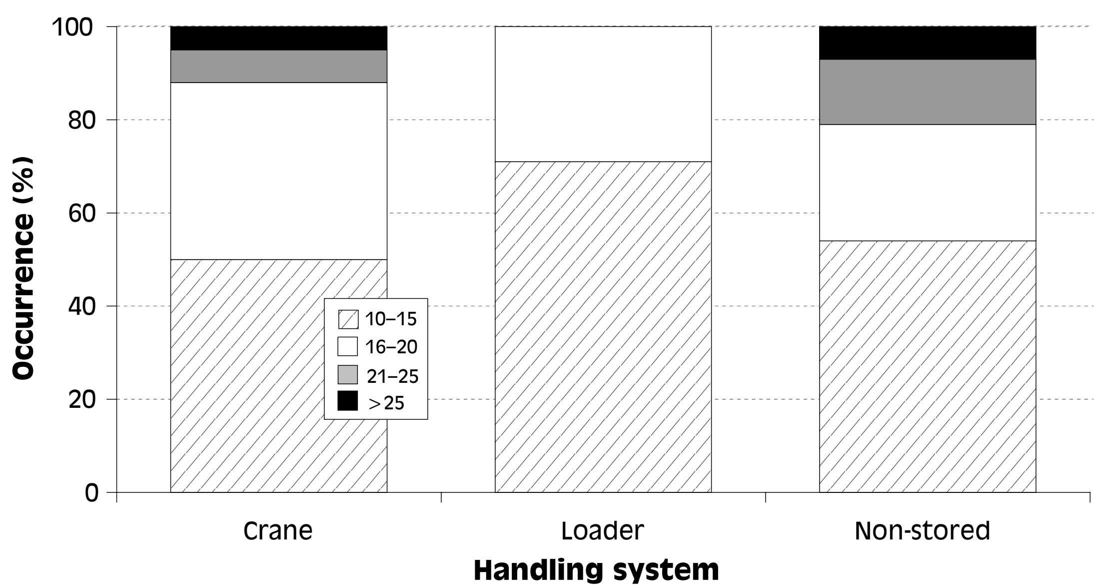
The projected losses from gouging among the crane wood and the loader wood were 0.4 and 0.8%, respectively. However, the portion of the gouging losses attributable to harvesting appeared to be higher among the loader wood than among the crane wood (Figure 4). Some of the gouging attributable to handling was likely caused during the out-loading of stems at the cutblock.

Non-stored wood

The overall breakage frequency of the non-stored stems was 8.1%, but it was significantly higher for the larger stem diameter classes than for the smaller diameter classes. It also varied from 0.7 to 23.8% among the eight truckloads that made up the non-stored wood. Most of the breakage of the non-stored wood had occurred at diameters less than 20 cm, but the non-stored wood had more breakage at diameters over 20 cm than the stored wood. The

[1] The amount of stems with broken tops (B) expressed as a percentage of unbroken stems (A) plus stems with broken tops, i.e., [B] ÷ [A + B] × 100.

Figure 2. Occurrence of breaks by diameter at location of breakage.



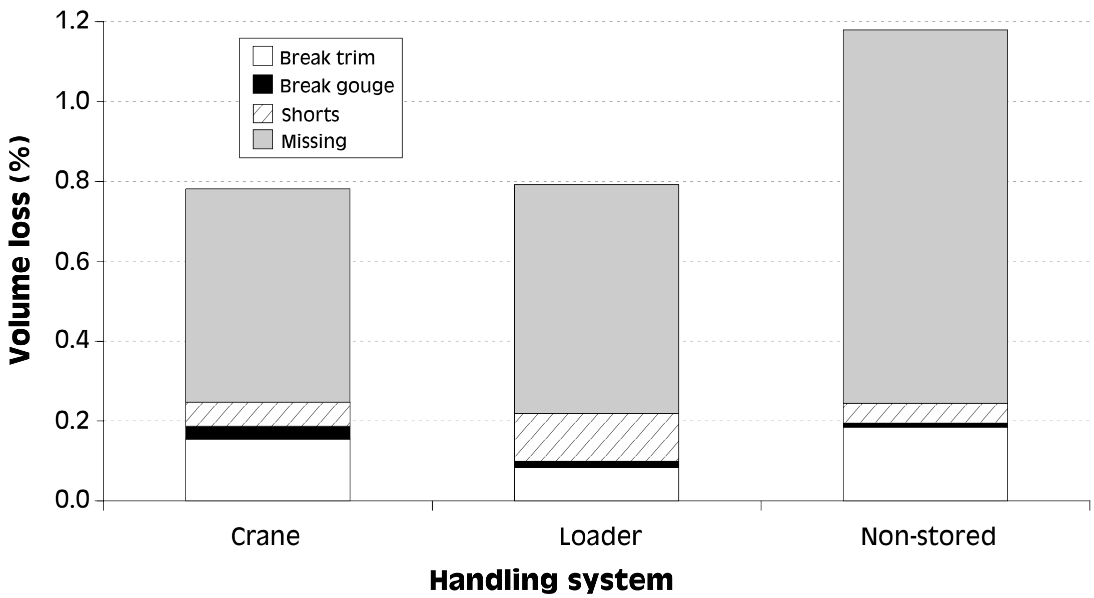


Figure 3. Volume loss from breakage by category.

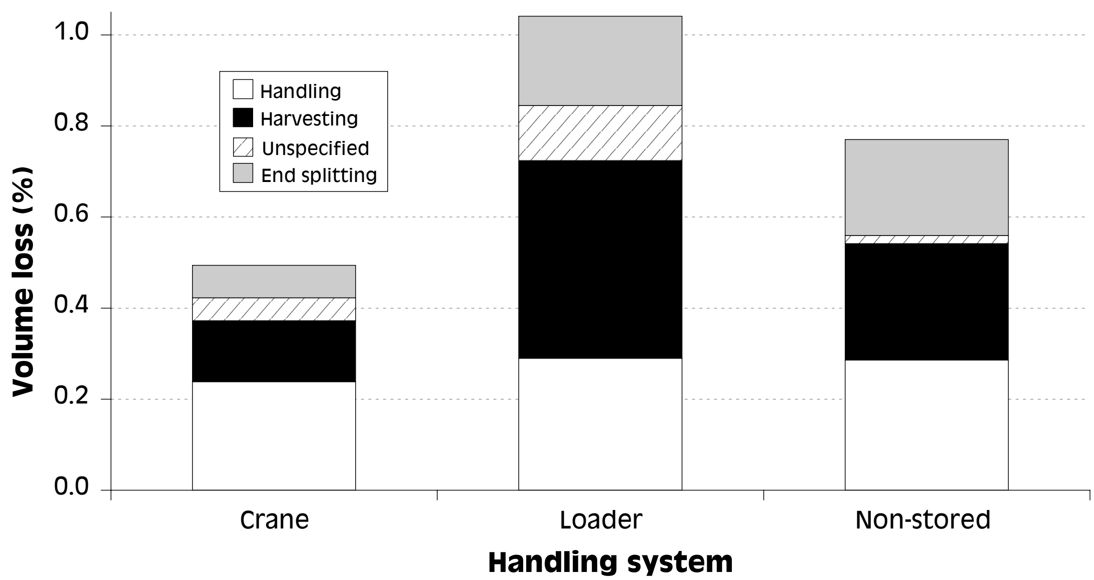


Figure 4. Volume loss from gouging (from handling, harvesting, and unspecified) and end-splitting.

projected loss of sawlog volume from breakage was 1.2%, and ranged from less than 0.1% to 2.3% for the eight truckloads. The breakage did not appear to have been a function of the average stem size in the truckloads. Thus, the variation in the breakage likely resulted from differences in stand characteristics and/or from differences in the operating practices at the harvesting site.

The projected volume loss from gouging was 0.6% of the gross log volume. Some of the loss attributed to handling may have occurred at the designated study site in the logyard when the loader spread the stems on brow logs.

Discussion

As the batch of non-stored stems was found unsuitable as an estimate of the amount of damage present on stems delivered to the logyard, the study could not determine the amount of damage solely attributable to the logyard handling operations, or determine if the crane caused more damage than the butt-n-top loader or vice versa. The study can only conclude that the breakage frequency attributable to logyard storing and handling operations was less than or equal to 8.1% for the crane wood, and less than or equal to 4.1% for the loader wood. However, even if all recorded damage was attributable to logyard handling, the results compare favourably with the breakage recorded in a previous FERIC study that examined damage of tree-length stems stored for up to 14 months and handled by butt-n-top loaders (Andersson et al. 2002). As broken-off ends were cut off by the processor prior to the delivery of the stems to the logyard, the breakage recorded in that study was nearly all attributable to logyard handling operations.

The breakage recorded among the non-stored wood was also not inconsistent with data from another previous FERIC study that attributed up to two-thirds of the breakage recorded in the logyard to harvesting when broken ends are not removed during processing (Andersson 2004).

Conclusions and implementation

The breakage frequencies among the tree-length stems handled by the overhead crane and the butt-n-top loader were found to be 8.1% and 4.1%, respectively. In both cases, the projected loss of sawlog volume due to breakage was 0.8% of the gross sawlog volume. FERIC could not determine what portion of the breakage was attributable to the logyard handling operations, and what portion had occurred during harvesting. However, the volume loss from damage recorded for the crane wood and loader wood compared favourably with the volume loss recorded in a previous study (Andersson et al. 2002) on logyard damage involving butt-n-top loaders handling tree-length stems.

The breakage frequency of the non-stored stems was 8.1%, but it varied considerably among the eight truckloads that made up the non-stored wood. The projected loss of sawlog volume from breakage was 1.2% of the gross volume.

As the breakage and projected loss of sawlog volume from the non-stored wood equalled or exceeded that of the stored wood, more emphasis needs to be placed on work practices to reduce stem breakage during harvesting. Bucking off broken ends during processing will conceal the level of harvesting breakage, and can result in resources being focused on logyard operations when they would be more effectively directed at the harvesting site.

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Appendix I

Analysis method and definitions

Description

The following is a brief description of the analysis method used to determine the projected loss of sawlog volume due to damage. A detailed description of data collection and analysis is available from the author upon request.

The stems were classified into one of four classes: unbroken (A), broken top (B), broken butt (C), broken both ends (D).

The volume of the “broken-off piece” for individual B-stems (broken tops) was determined as the difference between the volume of the B-stem and the average volume of all A-stems (unbroken) with similar butt diameter and taper as the broken stem.

C-stems (broken-butt) and D-stems (broken both ends) were assumed to be “recovered broken-off pieces” from B-stems. The estimated volume of wood that was lost due to breakage was calculated as the difference in volume between the broken-off pieces of B-stems and the recovered C- and D-stems.

All stems were pencil-bucked into a combination of short logs (2.54 m, 3.15 m, 3.76 m, 4.37 m, and 4.98 m) that would result in the best utilization of the sawlog section (diameter ≥10 cm inside bark) of the stem with the fewest number of short logs.

The volume loss from gouging and end-splitting was determined based on the depth of the damage and the damage location on the pencil-bucked logs.

Definitions

Breakage frequency (%).	The amount of stems with broken tops (B-stems) expressed as a percentage of unbroken stems (A-stems) and stems with broken tops, i.e., [B] ÷ [A + B] × 100.
Broken-both-ends stem (D-stem).	A section of a tree with both ends broken.
Broken-butt stem (C-stem).	A stem with the top (small end) cut by a mechanical device and with the butt (large end) broken.
Broken-top stem (B-stem).	A section of a tree with the butt end cut by a mechanical device and with the top broken at a diameter ≥10 cm (inside bark).
End-splitting.	Mechanical damage resulting in split butts within the net butt diameter (excludes butt swell) or in split tops.
Gouging.	Any mechanical damage to the stem surface that penetrates into the wood >0.5 cm.
Gross sawlog volume.	Gross stem volume less the volume of any pulpwood section present on the stem.
Gross stem volume.	The volume of the stem under bark, calculated in 5-m sections (except for last section of the stem, and pieces shorter than 5 m) with Smalians’ formula, and assuming the stem to be perfectly round, free from natural defects, and uniformly tapered between the 5-m sections.
Missing pieces of wood.	The projected volume of broken-off pieces of wood >10 cm diameter lost prior to the wood arriving at FERIC’s study site.
Net sawlog volume.	The volume of manufactured sawlogs less volume reduction from mechanical wood damage.
Non-damaged trim ends.	The piece of the stem that is left after the stem is manufactured into sawlogs. Assumed to be at the top of the stem.
Short pieces or logs.	Any piece <2.5 m in length.
Unbroken stem (A-stem).	A complete or a partial merchantable portion of a stem with both ends of the stem cut by mechanical devices or with a broken top at a diameter <10 cm (inside bark).

Appendix II

Summary of stem characteristics and volume loss

	Portal crane wood	Butt-n-top loader wood	Non-stored wood
Species composition	S_8P_2	S_7P_3	S_7P_3
Scaled tree-length volume (m^3)	369.63	196.18	385.87
Projected missing volume (m^3)	1.97	1.10	3.60
Pulpwood section (m^3)	0.24	3.59	0.38
Non-damage trim ends (m^3)	2.74	2.67	4.19
Gross sawlog volume (m^3) [a]	368.62	191.02	384.90
Total sawlogs (no.)	546	899	882
With broken top (no.)	42	36	69
With broken butt (no.)	20	20	22
With both ends broken (no.)	6	1	7
Unbroken logs (no.)	478	842	784
Breakage frequency (%)	8.1	4.1	8.1
Unbroken stems			
Gross sawlog volume (m^3) [a]	338.17	185.20	330.26
Gouging, handling (m^3)	0.78	0.56	0.92
Gouging, harvesting (m^3)	0.43	0.84	0.89
Gouging, unspecified (m^3)	0.16	0.23	0.06
End-splitting, harvesting (m^3)	0.20	0.37	0.67
Net sawlog volume (m^3)	336.60	183.20	327.72
Broken stem sections			
Gross sawlog volume (m^3) [a, b]	30.46	6.74	54.64
Projected missing sawlog volume (m^3)	1.97	1.10	3.60
Break trim ends (m^3)	0.57	0.16	0.71
Short broken pieces (m^3)	0.22	0.23	0.19
Break-torn gouges (m^3)	0.12	0.03	0.04
Gouging, handling (m^3)	0.10	<0.01	0.19
Gouging, harvesting (m^3)	0.07	<0.01	0.11
Gouging, unspecified (m^3)	0.03	<0.01	0.01
End-splitting, harvesting (m^3)	0.07	0.01	0.15
Net sawlog volume (m^3) [b]	27.31	5.19	49.65

[a] Differences due to rounding.
[b] Includes projected volume of broken-off missing pieces.