LOGGING DAMAGE

IN PARTIALLY CUT HARDWOOD STANDS

IN THE PARRY SOUND DISTRICT

by
J.R. Irwin

MINISTRY OF NATURAL RESOURCES

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ABSTRACT:

This report presents information on logging damage in tolerant hardwood forests in Parry Sound District. The study area was harvested under the selection or the uniform shelterwood method.

Removal of 43% of the basal area generally caused damage to 16% of the residual trees. Most of the damage occurred to pole sized trees. Thirty four percent of the sapling size class was destroyed.

Felling caused damage to the pole class trees, whereas skidding caused damage to the sapling class.

The selective marking program that was carried out did not significantly reduce damage. Tree length skidding, compared to log length skidding did no result in any less damage.

Site deterioration did not seem significant due to skidding practices, except that an increase in number of trails, or extent of the cutover impacted by skid trails, led to an increase in damage.

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INTRODUCTION

The Parry Sound District is presently managing their tolerant hardwood stands under the selection or uniform shelterwood systems. Harvesting in the past was based solely on a diamter limit, but is now based on a tree marking program aimed at stand improvement as well as harvest cutting.

The stands being treated are mainly hard maple, beech, and yellow birch in the 120 to 170 year age class. The soils are glacial tills of the Canadian Shield.

Few facts are available concerning the stands harvested, percentage of basal area removed, the damage to the residual stand and to the site during logging, or the percentage of the stand removed in subsequent cull-removal operations.

The study was initiated to determine the extent of logging damage caused by felling and skidding to the residual stand. The project also assesses the damage to the site related to the percent of the stand removed by both felling and girdling.

METHOD OF STUDY

The cutovers sampled are listed in Table 1. These were chosen because they represent a wide range of conditions:

- selection marking v.s. a diameter limit
- tree length v.s. log length skidding
- improvement operations v.s. non-girdling
- large v.s. small operators
- summer v.s. winter cutting

The areas were sampled by establishing random points on a grid. The grid was then placed over the aerial photograph showing the cutover, and points transferred to the photograph. These points were located on the ground, by plotting bearings and distances, and circular tenth acre plots were established at the selected locations. Some plots, when located, were not measured if they had no evidence of loggin, or fell within landings or on major roads.

In each plot the depth of ruts, erosion, and mineral soil exposure were noted. The percentage of the plot consisting of skid trails was noted by the class of skid trail. This ranged from main haul road to single-use skid trails. Each tree from four inches dbh was tallied by diameter, crown class, and quality class (table 2). To obtain the dbh of cut trees, a conversion factor was applied to stump diameters. Diameters were recorded for the trees cut, marked for cut and left standing, or girdled and/or marked for girdling.

Table 1
Areas Sampled

Area	Marked	Diam. Cut	Marked Girdled	Tree Length	Log Length	Season	Total Plots	Sample Plots
Oakley 1	X			X		Winter	31	27
Ridout 2	X		X		X	Winter	24	13
Ridout 3	X		X		X	Winter	22	15
Ridout 4	X		X	X		Winter	36	21
Living-Stone 5		X		X		Fall & Winter	40	30
Hunter 6	X		X	X		Winter	35	30
McCra-ney 7		X	X	X		Sum-mer	38	35
McCra-ney 8		X		X		Sum-mer	39	30
						Total	265	201

All damage was tallied by cause, location on the tree, nature and size of the injury, and the seriousness (Table 3). Wounds were divided into major and minor wounds using the criteria established by Nyland et. al. (1971) (Table 4). Trees above 14 inches dbh were classified as sawlog or mature trees, and those 4 to 13 inches were classified as polewood.

Table 3

Damage Cause:	F - Felling			
	S- Skidding			
	B- Bulldozing			
Damage Location:	Limbs -	1 - Bole	Bark -	1 - Roots or Stump
		2 - Primary limb		2 - First Log
		3 - Secondary limb		3 - Second Log

Table 4

Type of injury	Wounds Judged as Major Injuries
Bark Abrasion	Bark scuffed off, exposing 90 or more square inches of wood surface for yellow birch, or 150 or more square inches of wood surface for other species.
Broken Branches	Branches larger than 3 inches in diameter broken from the tree.
Root Damage	Roots exposed over 25% or more of the ground surface area within the drip line of the tree crown.
Broken Off	The main stem broken off, destroying the tree and most or all of the crown.
Bent Over	The tree partially or entirely uprooted, noticeably tipped out of its normal growing position.

-Nyland and Gabriel, 1971

One area (area 7) was tallied down to one inch in diameter for a sample of damage done to the sapling class of trees.

RESULTS AND OBSERVATIONS

To determine the number of plots required in each area, the basal area injured on each plot in area 1 was computed. The standard deviation and standard error of the mean basal area injured per plot was obtained. The number of plots required for a standard error of 0.20 was 34, and the number for a standard error of 0.25 was 21. Since approximately ten plots could be established and measured each day, it was decided to use 30 plots or three days work for each area. It was assumed that the variation in basal area injured would be similar in each area.

A total of 265 plots were located, of which 64 were undisturbed by logging and were not tallied. Table 1 lists the plots by logging areas. Tables 5 and 6 show a comparison of the damage and percent cut in different operations. The average percent injury of the basal area before cutting is 11.9%. Table 5 shows the percentage of the cutover consisting of skid trails. As the percentage of the cutover occupied by skid trails increases, the number of skidding injuries also increases.

Table 5
Damage by Area

Area	% Cut of BA	Inj. % of BA	Major Fell. #/Acre	Major Skid. #/Acre	Skid Trails %	Minor Fell. #/Acre	Minor Skid. #/Acre	Total # inj. /Acre	B.A.
1	39.0	11.9	10	2	6	10	8	30	88.6
2&3	39.9	12.2	9	5	15	5	2	21	86.6
4	38.5	9.2	9	4	14	2	1	16	94.1
5	35.0	11.4	8	17	30	3	6	34	84.1
6	42.5	12.4	14	6	21	2	4	26	74.3
7	53.8	6.0	3	6	21	2	5	16	78.1
8	51.0	20.3	14	11	17	0	3	28	74.8
Av'g.	42.8	11.9	10	7	16	3	4	24	82.9

Table 6
Injured Trees in Each Area

Area	Orig. B.A.	%cut	Resid. B.A.	Inj. B.A.	% or Orig.	% of Res.	B.A. Pole.	B.A. Mat.	% Poles	% Mat.	Res. Mat.
1	118.6	39.0	88.6	14.1	11.9	16.0	41.8	76.8	35.0	65.0	46.8
2&3	112.3	39.9	86.6	13.7	12.2	15.8	47.9	64.4	43.5	56.5	38.7
4	119.2	38.5	94.1	10.9	9.2	11.6	53.8	65.5	45.0	55.0	40.3
5	105.1	35.0	84.1	12.0	11.4	14.3	45.2	59.9	56.9	43.1	38.9
6	98.9	42.5	74.3	12.2	12.4	16.4	41.1	57.8	41.7	58.3	33.2
7	116.8	53.8	78.1	7.0	6.0	9.0	44.9	71.9	61.2	38.8	33.2
8	104.8	51.0	74.8	21.2	20.3	28.5	46.1	58.7	44.0	56.0	28.7
		42.8	82.9	13.0	11.9	15.9	45.8	65.0	46.8	53.2	37.2

Table 7 shows a comparison between various methods of logging. Tests of significance show that there is no significant difference between diameter limit cutting and shelterwood marking/cutting in relation to logging damage, or between log length and tree length skidding.

On no area was site damage significant. Deep ruts and mineral soil exposure were evident, but did not result in erosion or washing of the soil after one to two years.

Table 7
Comparison of Logging Methods

	% of Original Stand Damaged, B.A.	Number of Injures per Acre: Skidding	Number of Injures per Acre: Felling
Diameter Limit	12.6	16	10
Shelterwood Marking	11.4	8	15
Log Length Skidding	12.2	7	
Tree Length Skidding	11.9	12	
Winter Cut	11.4	11	14
Summer Cut	13.1	12	10

Of the damage that occurred in the stands, 60% is major injury in both the polewood and sawlog size trees. Most of the major damage is caused by felling, and most of the minor damage by skidding. Most of the damage occurs in the polewood size classs, although this size class represents a slightly smaller proportion of the stand than the sawlog size. Table 8 shows the damage by severity and cause within the size class. Table 9 shows the damage by severity and size class, and Table 10 shows the damage by nature and location on the tree.

Table 8
Damage by Cause and Severity
(Derived from Damage by Basal Area of the Stand)

	Total Damage %	Felling % of Total Damage	Skidding % of Total Damage
Mature Wood			
Major Damage	62.5	80.0	20.0
Minor Damage	37.5	33.0	67.0
	100%		
Pole Wood			
Major Damage	59.6	86.0	14.0
Minor Damage	40.4	41.7	58.3
	100%		
Major Damage		85.5	14.5
Minor Damage		41.1	58.9
	Total:	68.0	32.0
Mature Wood	8.5		
Pole Wood	91.5		

Table 9
Damage By Size Class

	Total Damage %	Mature Wood % of Damage	Polewood % of Damage
Major Damage	59.7	9.2	90.8
Minor Damage	40.3	8.2	91.8
	100%		

Table 10
Damage By Location on the Tree

Location	Mature Trees Major Damage	Mature Trees, Minor Damage	Polewood Major Damage	Polewood Minor Damage
FELLING: LIMBS				
Main Stem	25.0		88.1	
Primary Limb	69.0		9.7	31.4
Secondary Limb			1.1	43.6
FELLING: BARK				
First Log	6.0	100.0	1.1	25.0
	100%	100%	100%	100%
SKIDDING – BARK				
Root or Stump	33.3	12.5	10.3	13.0
First Log	11.0	87.5	3.4	87.0
SKIDDING – LIMBS				
Main stem	55.7		86.3	
	100%	100%	100%	100%

When the numbers of injured saplings were totaled for area 7, Table 11 was obtained. 34.4% of the saplings were damaged and all of the damage was major. Skidding was twice felling damage, and 27% of the cut area consisted of skid trails. There was no relationship between the amount of damage and the basal area before or after cutting. This agrees with the findings of Nyland et. al. (1971).

Table 11
Sapling Damage, Area 7

Saplings Undamaged	Damage Cause	Major Injury	Total Saplings	% Injured
	Skidding	27.4		21.4
	Felling	16.4		13.0
839		438	1277	34.4
% of area occupied by skid trails:				27%

The damage percent relative to the size of the trees cut is shown in Table 12. The damage is calculated as a percent of the original basal area rather than as a percent of the basal area after logging. This reduces the variation caused by the percent of the stand cut. This table was obtained by taking the average dbh of the trees cut on each plot, and sorting the plots according to the average dbh obtained. The damage increases slightly, but not consistently, with larger trees being cut, but is also dependent on the amount of understory and different age classes present in the stand.

Table 12
Damage by Tree Size

Dbh Range	Avg. Dbh	No. Plots	Mat. BA Injur.	% of Resid.	Pole. BA Injur.	% of Resid.	Total inj. BA	Total % of Resid.	% of Orig. BA
14-17	16	53	2.86	12.75	7.71	21.59	10.58	24.61	9.04
18	18	33	1.37	5.07	6.73	20.78	8.10	14.60	7.25
19+	20.6	54	3.18	8.70	9.03	26.37	12.22	20.51	9.54
		140							

To compare damage occurrence to cutting intensity, Table 13 was compiled in the same manner as table 12. The damage is high in the 0 to 10% category because this damage is done only by trees felled into the plots. The damage is therefore caused by felling and is higher than if stumps were present and some of the trees were felled out of the plots and damage was by skidding. The results indicate that damage as a percent of the original basal area peaks when 50% of the merchantable trees are cut. Damage to the residual stand increases as the percentage of the stand removed, increases.

Table 13
Damage by Cutting Intensity

Av. % Harvest	BA Inj. Mature	BA Inj. Poles	% of Orig. BA Mature	% of Orig. BA Poles	Total BA Injured	% of Residual BA	% of Original BA
0.5	4.8	6.7	8.2	12.9	11.5	13.9	11.0
28.9	2.7	7.4	3.6	15.7	10.1	11.9	9.7
51.2	3.8	8.6	5.4	20.1	12.4	21.5	11.2
84.9	0.8	7.7	1.3	17.8	8.5	27.7	8.2

Tables 14 and 15 were compiled in the same way as Tables 12 and 13 to show the effects of tree size and cutting intensity on saplings. The damage increases with tree size and with higher percentage of the merchantable volume removed.

Table 14
Sapling Damage with Varying Tree Size Cut

Av. Dbh Cut	Damaged	Total Saplings	% Damage
16.3	77	235	32.9
18.0	140	405	35.6
20.4	151	304	49.6

Table 15
Sapling Damage with Varying Cutting Intensity

Av. % Harvest	Residual Trees	Trees Damaged	Total Saplings	% Damage
15.0	342	89	431	20.8
50.5	197	98	295	39.2
75.0	104	83	187	45.9
95.0	184	138	322	42.9

By tallying the quality of the trees damaged, it was found that the trees are injured in direct proportion to their abundance in the stand. The larger proportion of “A” trees in the stand, the higher will be the percentage of class “A” trees injured. (Tables 16 and 17). A slightly higher proportion of class “A” saplings are injured because these trees are not large enough to have developed defects which would lower them to a “B” or “C” class. The logging increases the percentage of “C” trees, but does not significantly decrease the quality of the residual stand.

Table 16
Classes of Injured Trees

Crown Class	Quality A	B	C	C
Dominant	3	1	2	
Co-Dominant	45	64	20	10
Intermediate	88	75	32	11
Suppressed	4	5	4	1
Total	140	145	58	22

Table 17
Classes of Injured and Residual Trees

	Quality A	B	C	D
All Trees Injured	140	145	58	22
Trees Remaining (Area #8)	102	123	88	27
Saplings Damaged	251	131	55	1

The quality class of the trees girdled is shown in Table 18. Most of these trees are class "C" or "D". The percentage of the stand girdled is shown in Table 19. This averages 9.2% of the basal area before cutting, or 12.6% of the residual stand.

Table 18
Quality of Trees Girdled

Area	Quality A	B	C	D
2	1	3	9	3
3		7	2	3
2&3	1	10	11	6
4	4	13	29	11
6		3	11	12
7	2	2	19	23
Total	8	38	81	58

Table 19
Percentage of Stand Girdled (BA/acre)

Area	Poles Girdled	Poles Marked*	Mature Girdled	Mature Marked*	Total Girdled	% of Original Stand	% of Residual BA
2&3	2.1	1.0	6.7	.05	8.8	7.8	10.0
4	4.6	0.3	3.0	1.9	7.6	6.4	8.1
6	1.0	1.8	7.6	1.3	8.6	8.7	11.6
7	0.0	4.2	16.0	0.0	16.2	13.8	20.7
Total						36.7	50.4
Average						9.2	12.6

* Marked for girdling but not girdled.

SUMMARY

1. Logging under the all-aged selection system in the study area injures 11.9% of the original basal area of the stand, or 15.9% of the basal area which remains after logging.

2. 92% of the damage is on polewood trees

3. 60% of the damage is major.

4. 60% of the damage is due to felling.

5. In one cutover, 34.4% of the sapling class was destroyed.

6. Very little significant site deterioration occurred.

7. Felling in the study area removed 42.8% of the merchantable basal area.

8. The two methods of cutting control and skidding did not influence amount of damage.

9. An increase in the percent of the area covered by skid trails raised the amount of skidding damage.

10. Larger trees cut increased the logging damage, and the damage was greatest when 50% of the mature basal area was removed.

RECOMENDATIONS

(When this study was originally completed, the report was reviewed by Chuck Heeney, provincial silviculturist. In reply to his questions, additional information has been added to the original text, in italics. JRI).

The damage that is occurring in the study area is half that which is occurring in New York (Nyland et. al., 1971). In this case, they are removing 48.5% of the merchantable stand while in Parry Sound, the practice is to remove 42.8%. Damage in New York is 30.0% of the residual stand, while in this area it is 15.9%.

This report states that the percent of the merchantable trees removed by logging was 42.8% (Table 6). The 25% removed in New York refers to the percent removed of the total stand. When this 25% is adjusted as a portion of the merchantable trees in the stand, the percentage removed in New York is 48.5%. The intensity of logging is therefore relatively similar.

The comparison of the damage percent, 15.9% in Parry Sound (Table 6) and 27% in New York still stands. Originally it was thought that this difference could be explained by the composition of the stand, whether the stand was mainly polewood or mature trees. However, in the New York study, the stands were 42% polewood and 58% mature, compared with 46.8% and 53.2% in Parry Sound. These figures do not differ enough to account for the variation in damage occurrence.

The 27% figure stated by Mr. Nyland includes the sapling size class, while the 15.9% in this report does not. However, when the New York figures are adjusted to exclude these smaller trees, the 27% damage, and the difference between this figure and the figure in this report, increases. This results from the sapling size class in New York receiving the lowest percent injury of the tree size classes.

One explanation for the difference in damage may be the condition of the stands. The stands in Parry Sound were site class 1 and 2, with approximately equal area of both. Larger trees in New York, caused by better site conditions, i.e. larger crowns, diameters or taller trees, could increase damage. Mr. Nyland did not provide a stand description.

Another source of variation was in the sampling procedure. The plots of Mr. Nyland were oriented along compass lines which ran at right angles to the direction of skidding. Due to the uncertainty of any attempt to plot the skidding pattern of a cut-over without a thorough knowledge of the terrain and the logging operation, this author chose a completely random sample design. Mr. Nyland also used prism plots, while this study was done using fixed area plots. Experience of this author has found considerable differences in data, when sampling tolerant hardwoods, using these two systems of sampling.

Since the majority of the damage in trees 4 inches and larger is due to felling, this is the area in which more caution by loggers would reduce the damage. However, there will always be a certain level of damage and it must first be decided what the acceptable level is.

A third of the sapling size class in area 7 was destroyed. If the stands are allowed to grow for 20 to 30 years and a substantial sapling size class is produced, subsequent logging may be expected to produce up to one third major damage in this size class. It must now be decided if this size class is the future stand to be harvested, or whether this age class is expendable and will soon be replaced by regeneration after a cut. This sapling damage can be reduced by lessening the number of skid trails and by using individual trails for a greater volume of wood or for a longer time. This is dependent on the terrain and the distribution of timber in the logging area. If the present stands are logged again in 20 to 30 years, and new skid trails are used to remove more scattered timber, the skidding damage to saplings may be cumulative.

Both skidding and felling caused major injuries to approximately 10% of the residual stand. Since these injuries are likely to develop onto rot and will eventually degrade the log quality, (Nyland et. al., 1971) there may have to be more salvaging of damaged timber, or a reduced time period between logging operations. However, repeated logging and salvage operations may increase damage. *This is meant to imply that salvage operations or periodic logging throughout the life of the stand would cause increased total damage present with each successive operation. This would be offset by focussing logging on upgrading the residual stand and removing previously damaged timber.*

Little site damage was found and log length logging does not significantly reduce damage. Selective marking before a cut may reduce logging damage, but not significantly.

The larger trees cut caused more damage, but this may be due to the overmature timber having an understory growing into the mature stand.

If more of the stand is cut, the damage is decreased. This is opposite to the damage trend which occurs in the sapling size class.

The damage that is occurring in this district is therefore quite acceptable by comparison with that occurring in New York stands. *I do not feel that the damage which has been recorded is significant, because when viewed in a positive manner, 85% of the polewood basal area and 99% of the residual mature trees were undamaged.*

One of the original goals of the study was to determine if selective marking and log length skidding would reduce logging damage. This reduced damage would then help determine an acceptable level of damage. Since these techniques did not reduce damage, an alternative method of comparing operators must be used. The lowest damage percent, 9%, and the lowest percent skid trails of the five operators, 6%, would be a goal, but would be unrealistic. The acceptable level of damage could be taken as the median of the *damage range, i.e., maximum 11.9% of the residual stand (12%), and 17% or less of the cutover impacted directly by skid trails.*

Another factor that must be considered is the natural mortality of the stand, or need for thinning in non-commercial portions of the stand. If a portion of the stand is going to die between successive logging operations, or a portion of the stand was not reduced to the proper stocking level by the harvest, then the stands can be thinned by girdling or fuelwood cutting subsequent to logging, to thin this portion of the stand, and to concentrate on removing damaged timber. During this operation, the stand components must not be reduced below the residual stocking levels suggested by the stand model in use. If subsequent salvage must reduce the stand component below recommended levels in order to salvage timber that will deteriorate prior to the next harvest, then the logging damage could be considered to be excessive.

References

Nyland, R.D. and W.J. Gabriel, 1971. Logging Damage to Partially Cut Hardwood Stands in New York, Applied Forestry Research Institute Research Report No. 5, July, 1971.