



# FOREST RESEARCH REPORT

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## WORKER PRODUCTIVITY IN STAND CONVERSIONS

### INTRODUCTION

In Nova Scotia, stand conversion is defined as the removal of an overstory of mature trees in order to release a desirable understory. To be eligible for financial assistance under the current Federal-Provincial Forestry agreement, the overstory must have a minimum merchantable volume of 75 solid cubic metres per hectare ( $m^3/ha$ ). In addition, the understory must have a live crown to stem ratio of 1/3 or greater. During the harvest operation, care must be taken to ensure that following treatment, the site is at

least 60% stocked to desirable regeneration exceeding 1 m in height. Between 1979 and 1989, stand conversion operations were carried out on over 2,000 hectares of Nova Scotia forest land.

This study is one in a series, designed to quantify the relationship between productivity of manual and mechanical operations and various stand, site, and climatic factors (NSDLF 1989, 1991a, 1991b, 1991c, 1991d, 1991e).

### STAND DESCRIPTION AND TREATMENTS

Eight stands meeting the stand conversion criteria were identified and twelve blocks with uniform site and stand conditions within these stands were designated for the study. These blocks were of sufficient size to keep one woods worker fully engaged for a minimum of 8 hours and were comprised primarily of hardwood overstories [mainly maples (*Acer* spp.) and birches (*Betula* spp.)] with softwood understories [mainly fir (*Abies balsamea* (L.) Mill.)]. Site and stand characteristics capable of affecting worker productivity were recorded by

block (Appendices I & II).

The merchantable trees were cut with chainsaws into 2.4 metre pulp and/or random length sawlogs. The pulpwood was manually piled to within reach of parallel extraction trails located at 20 metre intervals. All merchantable wood was later extracted by a forwarder. All unmerchantable trees in the overstory were felled and left in place.

The operations were performed between May, 1987 and November, 1988. Eight blocks were harvested by 6 experienced forestry instructors

## DATA COLLECTION AND ANALYSIS

Fixed-interval activity sampling (Stjernberg, 1991) was used to determine the relative amount of time spent on various activities by each worker. The activities being executed by the worker (e.g. felling, limbing, saw maintenance, etc) were noted every 30 seconds. The activities were grouped as either productive or non-productive (Appendix III). Productive man hours (PMH) were calculated by multiplying the percentage of productive activity occurrences by the total time to harvest the block. On average, each block was observed for 6 hours and 27 minutes out of a total harvest time of 21 hours and 10 minutes. These observations were taken at intermittent periods spread throughout each sampled work day. This resulted in an average

of 773 activity samples per block (Appendix I).

All wood harvested was scaled for solid volume. The inside bark volume of each pulp stick was determined by measuring top and butt diameters, and inserting these into Smalian's formula (Husch et al. 1972). Sawlog volume was calculated using the New Brunswick log scale. Productivity was calculated by dividing the volume harvested (from the block) by the productive man hours.

Stand Index is a variable based on pretreatment stand values which is often a good predictor of productivity (NSDLF 1989, 1991a, 1991b, 1991e). In this study, it is computed by dividing either the number of merchantable or total trees by the solid merchantable volume.

## RESULTS AND DISCUSSION

### Activities

The time spent on productive activities was 83% (Table 1). Limbing and bucking took most of the productive time (40%) followed by piling (18%), felling merchantable trees (14%) moving (9%), felling unmerchantable trees (7%), felling

preparation (6%), other productive (4%) and freeing hung up trees (2%). As a percentage of the total non-productive time, breaks accounted for 46%, saw maintenance 37%, saw repair 14%, and other non-productive activities 3%.

Table 1. Percent of time spent on productive and non-productive stand conversion activities.

Activities	Percent of		
	Total Time	Productive Time	Non-productive Time
<b>PRODUCTIVE</b>			
Felling Unmerchantable Trees	6	7	-
Felling Preparation	5	6	-
Felling Merchantable Trees	12	14	-
Freeing Hung-up Trees	2	2	-
Limbing and Bucking	33	40	-
Piling	15	18	-
Moving	7	9	-
Other	<u>3</u>	<u>4</u>	-
<b>Total Productive</b>	<b>83</b>	<b>100</b>	
<b>NON-PRODUCTIVE</b>			
Breaks	8	-	46
Saw Maintenance	5	-	37
Saw Repair	3	-	14
Other	<u>1</u>	-	<u>3</u>
<b>Total Non-Productive</b>	<b>17</b>	-	<b>100</b>

## Productivity

No strong correlation was found between productivity and the variables summarized in Appendices I & II. Productivity varied by 41% from a minimum of 1.36 m<sup>3</sup>/PMH (4.0 cords/day) to a maximum of 1.92 m<sup>3</sup>/PMH (5.6 cords/day) (Appendix I). This variation in productivity is relatively small compared to the variation in stand measures between blocks. For example:

- (i) total volume varied by 111% (115 to 243 m<sup>3</sup>/ha) (Appendix I),
- (ii) stand index by 230% (3.73 to 12.32 merchantable trees per merchantable solid cubic metre) (Appendix I),
- (iii) understory density by 279% (10,625 to 40,312 trees/ha) (Appendix II) and,
- (iv) average crop tree height of understory by 294% (1.77 to 6.98 metres) (Appendix II).

## SUMMARY

Productivity did not appear to be strongly related to any factors measured for this study. Although no strong correlations were found, the stands measured did vary considerably in their condition (volume, density, etc.). The

productivities achieved varied from a minimum of 1.36 m<sup>3</sup>/PMH (4.0 cords/day) to a maximum of 1.92 m<sup>3</sup>/PMH (5.6 cords/day) and averaged 1.59 m<sup>3</sup>/PMH (4.7 cords/day).

## LITERATURE CITED

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**NSDLF, 1991b.** *Worker productivity in merchantable thinning operations - Part II*. Nova Scotia Department of Lands & Forests. For. Res. Rept. No. 28, 8pp.

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**NSDLF, 1991d.** *An evaluation of 4 methods of site preparation*. Nova Scotia Department of Lands & Forests. For. Res. Rept. No. 31, 8pp.

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**Stjernberg, E. 1991.** *Methodology for planting productivity studies*. Forest Engineering Research Institute of Canada. Unpublished manuscript. 7 pp.+ Appendices.

# APPENDIX I.

## Site and stand characteristics prior to a stand conversion treatment.

Block	Prod <sup>1</sup> (m <sup>3</sup> /PMH)	Temp <sup>2</sup> (°C)	Site <sup>3</sup> History (code)	Height (m)		Basal Area (m <sup>2</sup> /ha)		Density (trees/ha)		Volume (m <sup>3</sup> /ha)		Diameter (cm)		Crown <sup>13</sup> (code)	Limbs <sup>13</sup> (code)	Stand Index		Species <sup>16</sup> (initial)	Operator <sup>17</sup> (code)	Observa- tions <sup>18</sup> (number)
				Total <sup>4</sup>	Merch <sup>5</sup>	Total <sup>6</sup>	Merch <sup>7</sup>	Total <sup>9</sup>	Merch <sup>9</sup>	Total <sup>10</sup>	Merch <sup>11</sup>	Total <sup>10</sup>	Merch <sup>11</sup>			MF/MV <sup>14</sup>	TF/MV <sup>15</sup>			
1	1.36	8	1	13.6	14.1	19	17	919	519	115	100	16	21	2	1	5.20	9.21	bF	1	960
2	1.39	14	3	ND <sup>19</sup>	11.0	ND	26	ND	1321	ND	117	ND	16	ND	ND	11.28	ND	yB	2	788
3	1.40	14	3	ND	11.5	ND	23	ND	1130	ND	106	ND	16	ND	ND	10.71	ND	yB	3	754
4	1.50	27	3	16.2	16.4	26	25	1416	1179	184	155	15	17	2	2	7.60	9.13	rM	4	607
5	1.53	16	3	ND	14.8	ND	33	ND	1640	ND	188	ND	16	1	1	8.73	ND	tA	2	667
6	1.60	8	1	15.3	15.4	23	22	600	529	153	142	22	23	2	1	3.73	4.24	bF	5	720
7	1.62	13	2	ND	16.0	ND	22	ND	679	ND	134	ND	20	1	1	5.07	ND	sM	2	964
8	1.68	16	3	ND	14.9	38	36	2057	1356	243	209	15	17	1	1	7.46	9.86	tA	3	679
9	1.68	13	2	ND	16.5	ND	28	ND	722	ND	178	ND	22	1	1	4.04	ND	sM	3	700
10	1.68	20	4	ND	13.7	ND	26	ND	971	ND	138	ND	18	1	1	7.01	ND	rM	2	938
11	1.74	20	4	ND	11.8	ND	20	ND	780	ND	94	ND	18	1	1	8.26	ND	rM	3	922
12	1.92	27	3	14.0	14.3	28	26	2189	1690	174	137	13	14	2	2	12.32	15.96	wB	6	581
Average	1.59	16	-	14.8	14.2	27	25	1436	1060	174	142	16	18	-	-	7.62	9.68	-	-	773

- 1 Prod = Productivity measured in merchantable m<sup>3</sup> solid wood harvested per productive man hour
- 2 Temp = Average temperature in °Celsius on the day of observation
- 3 Site History = Origin of present stand: 1- Softwood cut 2- Hardwood cut 3- Mixedwood cut 4- Natural
- 4 Total Height = Total Lorey's height (height of the tree of average basal area)
- 5 Merch Height = Merchantable Lorey's height (height of the tree of average merchantable basal area)
- 6 Total = All trees taller than Breast Height (1.4 m)
- 7 Merch = All trees exceeding 9 cm diameter at Breast Height
- 8 Total Volume = Total inside bark volume of all trees
- 9 Merch Volume = Volume of merchantable trees excluding 15 cm high stump and <7 cm inside bark top
- 10 Total Diameter = Diameter of the tree of average basal area
- 11 Merch Diameter = Diameter of the tree of average merchantable basal area
- 12 Crown = Crown Length on merchantable bole of tree: 1- < 1/3 of bole, 2- ≥ 1/3 and < 2/3 of bole, 3- ≥ 2/3 of bole
- 13 Limbs = Average diameter of limbs where they are attached at the merchantable bole. code: 1- < 5 cm, 2- ≥ 5 cm
- 14 MF/MV = Stand Index expressed as merchantable trees per merchantable volume in m<sup>3</sup> (solid) prior to treatment
- 15 TF/MV = Stand Index expressed in total trees per merchantable volume in m<sup>3</sup> (solid) prior to treatment
- 16 Species = Most numerous overstory tree species in the block. bF - balsam fir (*Abies balsamea* (L.) Mill.) yB - yellow birch (*Betula alleghaniensis* Britton) wB - white birch (*Betula papyrifera* Marsh.) rM - red maple (*Acer rubrum* L.) sM - sugar maple (*Acer saccharum* Marsh.) tA - trembling aspen (*Populus tremuloides* Michx.)
- 17 Operator = Each operator was assigned a number: 1,4,5 & 6 - Contractors; 2 & 3 - Commercial Safety College instructors
- 18 Observations = Total number of activity observations
- 19 ND = No data

**APPENDIX II.**  
**Understory assessment prior to treatment.**

Block	Productivity (m <sup>3</sup> per productive man hour)	Understory Density (trees/ha)  (Height ≥ 10 cm)	Stocking (%) (100% = 1 tree/4 m <sup>2</sup> )		Crop tree height (m)
			Height ≥ 10 cm	Height ≥ 1 m (recommended)	
1	1.36	10625	81	69	6.98
2	1.39	28125	100	66	2.07
3	1.40	20312	97	72	1.78
4	1.50	27500	92	75	2.16
5	1.53	12812	97	75	3.34
6	1.60	16875	62	62	3.66
7	1.62	11667	100	96	4.28
8	1.68	20625	100	92	2.56
9	1.68	23333	94	78	2.71
10	1.68	40312	100	75	2.20
11	1.74	38437	100	81	1.77
12	1.92	14000	100	92	3.58
<b>Average</b>	<b>1.59</b>	<b>22052</b>	<b>92</b>	<b>78</b>	<b>3.09</b>

## Definitions of work activities recorded during the time studies.

**Productive Activities:**

*Felling Preparation.* Determining the direction of fall, clearing unmerchantable stems beside the crop tree, and limbing lower portion of the tree before felling.

*Felling Unmerchantable Trees.* Felling non-commercial or poor quality unmerchantable trees scattered throughout the stand or in clumps.

*Felling Merchantable Trees.* Includes all activities between the initial notching and the tree hitting the ground or becoming hung up.

*Freeing Hung-Up Trees.* Includes all activities required to free hung up trees and laying them on the ground, including getting help, if necessary.

*Limbing and Bucking.* Removing branches, top, and cutting the tree into products. Includes moving brush to facilitate limbing and bucking.

*Piling.* Piling pulpwood or logs for the forwarder or skidder.

*Moving.* Moving during productive activities only.

*Other.* Productive activities other than the preceding categories (e.g. freeing jammed saws, moving brush, helping partner).

**Non-productive Activities:**

*Breaks.* Personal breaks.

*Saw Maintenance.* Routine saw maintenance including filling the gas and oil, and filing. Includes moving to carry out these activities.

*Saw Repair.* Repairing the chainsaw (includes moving).

*Other.* Other non-productive activities not listed (e.g. looking for lost/misplaced equipment).

**Other:**

*Lunch.* Formal lunch break. The time taken for formal lunch breaks was subtracted from the total time and not considered either as a productive or non-productive activity.

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