LABOR AND MACHINE PRODUCTIVITY FOR PRE-COMMERCIAL THINNING, MANUAL TREE PLANTING AND MECHANICAL SITE PREPARATION IN MANITOBA: 1987 DATA.

A File Report

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ABSTRACT

Several silvicultural operations were examined at various locations in Manitoba during 1987 to determine labor or machine production rates over a range of site conditions. Silviculture treatments observed were pre-commercial thinning (brush saw and chain saw operations) manual tree planting (bare-root and container planting), and mechanical site preparation (Delta disc trenching and Bracke scarifying).

Data summaries are presented describing site conditions, operational methods, and production rates for each study area observed during 1987. This report is intended to update previous file reports for this study investigating production rates for silviculture treatments.

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INTRODUCTION

This report is an update to Project C/M 7.2, Economics of Intensive Forest Management, of the Canada-Manitoba Forest Renewal Agreement. The purpose of project C/M 7.2 is to determine costs of various silvicultural treatments and to determine how those costs are affected by site conditions. In the preliminary stages of this project, labor and machine times required to create a prescribed treatment are examined. Later stages will address costs associated with each treatment. To date, field data collected during 1985 and 1986 on productivity of labor and machines has been summarized in a series of File Reports prepared for individual silviculture treatments. Those reports provided background information and details on study methods as well as presented summaries on study area descriptions and production rates for labor or machines. The following reports have been prepared to date for this project:

> Machine Productivity for Shear Blade Site Preparation in Manitoba. April 1986.
>
> Labor Productivity For Pre-Commercial Selection Thinning in Young Coniferous Stands in Manitoba. August 1986.
>
> Labor Productivity For Manual Tree Planting in Manitoba. March 1987.
>
> Machine Productivity For Disc Trenchers, Drum Choppers, and Bracke Scarifiers in Manitoba. November 1987.

This report provides summaries of field data collected from silvicultural treatments examined during the 1987 field season. Treatments observed include pre-commercial thinning (brush saw and chain saw), manual tree planting (bare-root and container stock), and mechanical site preparation (Delta disc trencher and Bracke scarifier).

The following sections provide comments on site conditions and data summaries for the 1987 study areas. Production rates are presented and briefly discussed for each treatment. Summary data are provided in tables with similar formats to those presented in the previous reports to facilitate update or comparisons between study areas or treatments. As the purpose of this report is mainly to update the previous reports, study methods and background information are not included here. The reader is referred to the appropriate report listed above for additional information.

General locations of the 1987 study areas are shown in Figure 1.

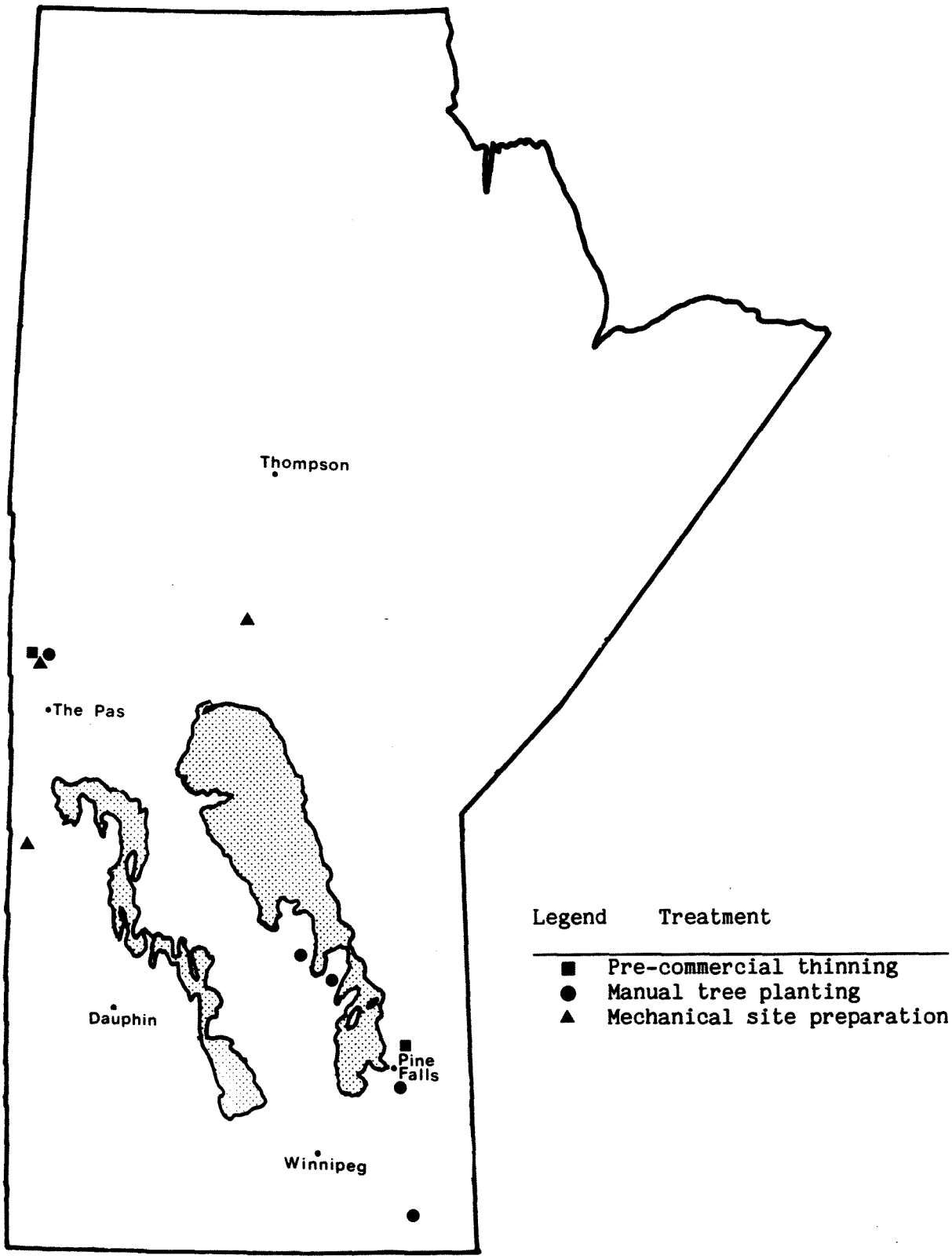

FIGURE 1. General locations of study areas of silviculture treatments observed during 1987.

1. PRE-COMMERCIAL THINNING

Three thinning operations were examined during 1987, one North of The Pas along the Atik Road (T61, Rge 28WPM), and two near Pine Falls at locations referred to as Beaver Pond and the Trans License cutting area (T21, Rge 11EPM). General locations of study areas are shown in Figure 1. Pre-treatment stand statistics are presented in Table 1.1 for study areas examined during 1987.

At the Atik Road site, the original stand containing jack pine, poplars and spruce was logged in 1972 and scarified with chains in 1974. The resulting natural regeneration was comprised mainly of jack pine and aspen. Conifer stocking was variable with aspen dominating in patches however sample plots were restricted to clumps containing mostly conifers. Sample plot measurements indicated conifers averaged 2.4 cm in dbh and 3 m in height while aspen heights ranged up to 9 m. Stand densities averaged about 27 000 stems per ha for all species combined. Stand age was 10-12 years.

Local topography is flat to gently rolling. A one-half metre deep snow cover precluded reliable assessment of slash conditions however casual observations suggested there was little slash interference to the cutters particularily in view of the snow depth.

The thinning work was done with brush saws during the winter. Cutters were employed by a private contractor and paid on a piece-work basis. Generally the cutters spaced the conifers to 2 m and removed all the hardwoods. However where conifer stocking was very low, hardwoods were also spaced rather than completely removed.

The Pine Falls thinning operations were both located in stands which had regenerated naturally following logging in the early 1960's. Black spruce and tamarack predominated although scattered pockets of hardwoods occurred. Regeneration was clumpy consequently stand density varied considerably. Sample plots however were restricted to patches where stocking was fairly uniform both within as well as around plot boundaries. Advance growth, i.e. conifers not harvested during the logging operation, was common throughout. Based on sample plot measurements, conifer regeneration averaged 4 cm in dbh and about 4 m in height at both sites while stand density averaged from 19 000 to 22 000 stems per ha for all species combined. Stand age was estimated at 20 to 25 years.

Topography at both sites is flat. Slash cover was not

determined due to the 0.5 m deep snow cover, however as at the Atik Road site, little slash interference was apparent.

Chain saws were used at both Pine Falls operations. The thinning work was conducted by private contractors paid on a piece-work basis. Cutters were instructed to thin to 3200 stems per ha (1.8 m spacing) favouring the spruce. Hardwoods or other conifers were cut only when they interfered with the spruce. The clumpy nature of the regeneration facilitated the thinning work since the cutter often had openings into which felled trees could be directed.

Table 1.2 provides a summary of sample plot sizes by study area for thinning operations observed during 1987.

Results

As in the previous reports, no analyses were conducted to determine the effect of site characteristics on labor productivity therefore only a few highlights from the 1987 data summaries are presented here.

Table 1.3 presents the distribution of cutter activities as observed during the thinning of sample plots, and Table 1.4 summarizes production rates for each study area. Cutter productivity averaged 11.4 hours per ha at the Atik Road site where thinning was done with brush saws. This production rate is faster than that indicated in the previous report for similar operations (i.e. Dragline Lake and Cowan study areas in the 1986 report showed average productivity of 19.5 hours per ha.). Production rates at the Trans License area where thinning was with chain saws appear much lower, (Table 1.4) although as indicated in Table 1.3, the cutters were experiencing some mechanical problems. The Beaver Pond area, also thinned with chain saws, resulted in the best production rates however with only four observations available from that operation, no conclusion can be drawn. As in the 1986 data, the 1987 data indicate considerable variation in both production rates and stand conditions.

TABLE 1.1. Stand summaries before thinning (1987 study areas).

Attribute		Atik Road (The Pas)	Beaver Pond (Pine Falls)	Trans License (Pine Falls)
Stand age		10-12	20-25	20-25
Stems > 1 cm dbh				
Living conifers	Stems/ha	10 264	10 483	14 027
	Avg dbh (cm)	2.4	4.1	4.1
	Avg height (m)	3.0	4.1	4.3
Living hardwoods	Stems/ha	7 782	5 454	814
	Avg dbh (cm)	2.1	1.2	0.8
Dead standing (all species)	Stems/ha	532	139	406
	Avg dbh (cm)	1.2	0.8	5.9
Total	Stems/ha	18 578	16 076	15 247
	Avg dbh (cm)	2.3	3.3	3.9
All species: dbh < 1cm or height < 1.3m				
Living	Stems/ha	8 027	5 559	3 670
Dead standing	Stems/ha	331	0	125
Total	Stems/ha	8 358	5 559	3 795
Total: all standing stems	Stems/ha	26 936	21 635	19 042

TABLE 1.2. Summary of sample plot sizes by study area (1987).

Study area	Number of sample plots	Plot sizes (square meters) Average	Minimum	Maximum
Atik Road	49	65.7	49.0	100.0
Beaver Pond	4	50.2	49.0	54.0
Trans License	8	57.4	50.0	100.0

TABLE 1.3. Distribution of worker activity while thinning sample plots (1987).

	Activity distribution (%)					
Study area	Felling	Releasing hang-ups	Brushing	Walking	Stopped	Other
Atik Road (Brush saw)	38	17	24	17	1	3
Beaver Pond (Chain saw)	46	21	12	21	0	0
Trans License (Chain saw)	33	14	10	24	9	10*

* saw stalling was a common occurrence

TABLE 1.4. Labor productivity summary for pre-commercial thinning by study area (1987 study areas).

Attribute		Atik Road	Beaver Pond	Trans License
Before thinning all standing stems (stems/ha)	Avg	26 936	21 635	19 042
	Min	10 500	11 628	10 400
	Max	57 200	33 465	25 921
Maximum height of slash on plot before thinning (cm) *	Avg	49	62	48
	Min	30	45	40
	Max	65	90	65
Number of stems cut (stems/ha)	Avg	18 989	13 279	12 027
	Min	6 300	7 407	5 800
	Max	43 600	22 508	19 258
Thinning time ** (hours/ha)	Avg	11.5	9.6	21.3
	Min	4.0	8.3	8.9
	Max	25.1	10.4	38.3

* Snow depth measured in lieu of slash heights.

** Based on time to thin sample plot. Does not include rest breaks, tool maintenance, etc.

2. MANUAL TREE PLANTING

Twelve manual tree planting operations distributed among the Southern, Eastern, Interlake, and Northern Regions were observed during the 1987 season. General locations of study areas where tree planting operations were observed during 1987 are shown in Figure 1.

Planting operations observed during 1987 included those planting bare-root as well as those planting container stock. The planting crews observed were either hourly paid provincial government employees, or piece-work planters hired by a private contractor or by a forest industry firm. Shovel, pottiputki, or planting spear (a narrow shovel) was used to plant the seedlings. All study areas had been prepared for planting by disc trencher or by Bracke scarifier. Table 2.1 presents a summary of general location of study areas, stand histories and planting site conditions for each area examined during 1987. Table 2.2 provides a summary of operational methods, planting stock, and planting tool(s) used at each operation.

Planter productivity was determined for 411 sample planting lines established over the 12 study areas. Sample lines were installed following methods described in the previous report. A summary of sample line lengths and number per study area are presented in Table 2.3.

Planter productivity was measured over several planting lines for each planter or planting team (at some study areas, planters worked in two-person teams). 87 different planters or planting teams rerpresenting a cross-section of the planting crews at each study area were observed during 1987. Number of observations per planter by study area are listed in Table 2.4. Occasionally, more than one study area was planted by the same crew therefore the same planter code could appear in more than one study area (eg. Table 2.4, planter code #39 worked in study area 8 and 9).

Slash conditions and residual stems or standing stems such as suckers or larger brush may affect planter productivity by impeding their movements. Size and frequency of slash pieces and standing stems are summarized in Table 2.5. Stem and slash piece counts in Table 2.5 have been adjusted to an arbitrary 100 m long planting row to facilitate comparisons between study areas.

Several planting activities which may contribute to planter productivity rates were identified. These activities describe either the difficulty of planting a particular line, (eg. number of times stones or roots are encountered at the planting spot) or

describe an individual planter's work style (eg. number of times he/she checks tree spacing). The frequency of occurrence of these activities along with number of seedlings planted per line, all adjusted to a 100 m long planting row are presented in Table 2.6.

Results

Planter productivity, in terms of average number of seedlings planted per hour is presented in Table 2.7. Planter productivity ranged from a low of 85 trees per person hour at Study Area 11 where bare-root stock was planted with shovels on disc-trenched sites to a high of 312 at Area 16 where container stock was planted with a Pottiputki also on disc-trenched sites. These production rates are somewhat lower than those reported for the 1986 data where productivity ranged from 138 to 353 trees per person hour. Planter productivity is based on the time required to plant a sample line and does not include unproductive time such as rest breaks, walking to get more seedlings, etc.

Table 2.7 also presents planting quality for disc-trenched sites while planting quality for Bracke-prepared sites are summarized in Table 2.8. Planting quality is based on observations made on each seedling planted along the sample lines on which time measurements and site conditions were determined. However these seedlings were not assessed by excavating but were examined in their planted position. No trend is evident between planting quality and planter productivity. As with the 1986 data, there is wide variation in both planting quality and productivity.

TABLE 2.1. Summary of stand history and site conditions for planting areas examined in 1987.

Study Area No.	Location	Stand History: Original stand	Disturbances	Site Prep.	Planting Site Conditions: Soil	Duff	Slash	Vegetative cover
7	T3 R12EPM Southern Region	Jack pine	Logging 1973, drum chopped, and disked	DT* 1986	Fine sand	NM**	Light	Light, few shrubs or suckers
8	T6 R10EPM Southern Region	Jack pine	Logging 1979, barrelled 1980	DT 1986	Sand	NM	Light to Nil	Light, few shrubs or suckers
9	T4 R11EPM Southern Region	Jack pine	Logging 1981, drum chopped, disked 1982	DT 1986	Fine sand	NM	Light	Light, few shrubs or suckers
10	T6 R10EPM Southern Region	Jack Pine	Wind damage 1983, salvage logged 1980	DT 1986	Sand	NM	Moderate	Light, shrubs in wet areas
11	T7 R10EPM Southern Region	Jack Pine	Logging 1970-73, fire 1984	DT 1986	Coarse sand rocky	NM	Light	Medium, suckers patchy
12	T15 R9EPM Eastern Region	Aspen/ jack pine	Wildfire 1979, salvage logged 1985	DT winter 1986	Coarse sand rocky	5cm	Moderate	Heavy
13	T15 R9EPM Eastern Region	Aspen/ jack pine	Stand conversion, hardwoods removed	DT/ blade March 1987	Sand to clay	5cm	Moderate	Light
14	T16 R10EPM Eastern Region	Aspen/ jack pine	Wildfire 1984 salvage logged 1985/86	DT March 1987	Fine to coarse sand, rocky	NM	Moderate	Dense aspen/ birch 2-3m ht.
15	T27 R4EPM Interlake Region	Spruce/ aspen	Wildfire 1979 salvage logged 1986	DT fall 1986	Clay	NM	Heavy	Dense aspen 3m ht.
16	T30 R1EPM Interlake Region	Jack pine/ spruce/ aspen/ birch	Logging 1980-83, salvage logged 1983-87	DT fall 1986	Clay loam to loam and gravel	5cm	Moderate	Light to heavy
17	T61 R27WPM Northern Region	Spruce/ aspen	Logging 1984-86, Bracke 1985	Bracke spring 1987	Clay loam	8cm	Heavy	Very light
18	T61 R28WPM Northern Region	Spruce/ aspen	Logging 1985 Bracke 1985	Bracke spring 1987	Clay	10cm	Heavy	Very light

* DT - Disc Trenching
** NM - not measured. Planters instructed to plant in the trench.

TABLE 2.2. Planting stock description, planting tool, and method of payment, by study area (1987).

Study area	Planting stock description				Planting tool	Method of payment
	Species	Stock type	Length(cm) * Top	Roots		
7	Jack pine	2-0 Bare-root	19	24		
8	Jack pine	2-0 Bare-root	17	24		
9	Jack pine	2-0 Bare-root	17	25		Provincial
10	Jack pine	2-0 Bare-root	16	25		employees,
11	Jack pine	2-0 Bare-root	16	24	Shovel	hourly
12	Jack pine	3-0 Bare-root	20	21		paid
12	Red pine	3-0 Bare-root	18	29		
13	Red pine	3-0 Bare-root	17	24		
14	White spruce	3-0 Bare-root	30	23		
14	Red pine	3-0 Bare-root	23	26		
15	White spruce	3-0 Bare-root	25	21	Shovel	Private contractor, piece-work
16	Black spruce	Can-Am #1 container	10-18	-	Shovel/pottiputki	Private contractor,
	Jack pine	Spencer-Lemaire container	10-18	-	Shovel only	piece-work
17	Jack pine	Can-Am #1 and Paperpots	10-18	-	Spear	Industry employees,
	Black spruce	Paperpots	10-18	-	Spear	piece-work
18	Black spruce	Can-Am #1 container	10-25	-	Shovel	Private contractor, piece-work

* Length for bare-root stock was measured on excavated seedlings (top= length from root collar to top of foliage; roots= length from root collar to root tips). Length for container stock was measured for tops only while seedlings were in trays.

TABLE 2.3. Sample line summary by study area (1987).

Study area	Number of sample lines	Length of sample lines (m)		
		Average	Minimum	Maximum
7	15	42.1	21.8	63.9
8	15	50.5	26.2	64.1
9	16	49.4	25.1	62.7
10	32	25.2	14.7	37.5
11	55	19.2	10.5	31.7
12	47	24.7	9.8	36.5
13	13	21.0	18.2	24.4
14	65	23.2	14.5	42.6
15	38	16.2	8.1	28.0
16a*	21	41.5	27.7	58.8
16b*	14	31.1	22.3	48.6
17	40	44.4	24.0	79.8
18	40	53.6	24.8	76.9

* 16a - planted with Pottiputki
16b - planted with shovel

TABLE 2.4. Number of observations per planter by study area (1987).

Planter code	Study areas 7	8	9	10	11	12	13	14
*36	1	-	-	-	-	-	-	-
*37	8	-	-	-	-	-	-	-
*38	6	-	-	-	-	-	-	-
*39	-	2	5	-	-	-	-	-
*40	-	7	-	-	-	-	-	-
*41	-	3	4	-	-	-	-	-
*42	-	1	-	-	-	-	-	-
*43	-	2	-	-	-	-	-	-
*44	-	-	7	-	-	-	-	-
*45	-	-	-	3	10	-	-	-
*46	-	-	-	2	6	-	-	-
*47	-	-	-	6	-	-	-	-
*48	-	-	-	7	-	-	-	-
*49	-	-	-	8	-	-	-	-
*50	-	-	-	6	-	-	-	-
*51	-	-	-	-	2	-	-	-
*52	-	-	-	-	4	-	-	-
*53	-	-	-	-	8	-	-	-
*54	-	-	-	-	6	-	-	-
*55	-	-	-	-	8	-	-	-
*56	-	-	-	-	4	-	-	-
*57	-	-	-	-	6	-	-	-
*58	-	-	-	-	1	-	-	-
*59	-	-	-	-	-	3	-	-
60	-	-	-	-	-	4	-	-
61	-	-	-	-	-	5	-	-
62	-	-	-	-	-	5	-	-
63	-	-	-	-	-	5	-	-
64	-	-	-	-	-	4	-	-
65	-	-	-	-	-	5	-	-
66	-	-	-	-	-	5	-	-
67	-	-	-	-	-	5	-	-
68	-	-	-	-	-	5	-	-
69	-	-	-	-	-	1	5	-
70	-	-	-	-	-	-	5	-
71	-	-	-	-	-	-	3	-
72	-	-	-	-	-	-	-	5
73	-	-	-	-	-	-	-	5
74	-	-	-	-	-	-	-	3
75	-	-	-	-	-	-	-	5
76	-	-	-	-	-	-	-	5
77	-	-	-	-	-	-	-	4
78	-	-	-	-	-	-	-	6
79	-	-	-	-	-	-	-	7

Planter code	Study areas 14	15	16a	16b	17	18
80	5	-	-	-	-	-
81	5	-	-	-	-	-
82	5	-	-	-	-	-
83	5	-	-	-	-	-
84	5	-	-	-	-	-
85	-	4	-	-	-	-
86	-	4	-	-	-	-
87	-	4	-	-	-	-
88	-	3	-	-	-	-
89	-	4	-	-	-	-
90	-	6	-	-	-	-
91	-	5	-	-	-	-
92	-	1	-	-	-	-
93	-	4	-	-	-	-
94	-	3	-	-	-	-
95	-	-	3	3	-	-
96	-	-	2	3	-	-
97	-	-	2	2	-	-
98	-	-	3	1	-	-
99	-	-	3	2	-	-
100	-	-	3	2	-	-
101	-	-	1	1	-	-
102	-	-	4	-	-	-
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104	-	-	-	-	1	-
105	-	-	-	-	4	-
106	-	-	-	-	5	-
107	-	-	-	-	5	-
108	-	-	-	-	4	-
109	-	-	-	-	4	-
110	-	-	-	-	4	-
111	-	-	-	-	4	-
112	-	-	-	-	2	-
113	-	-	-	-	2	-
114	-	-	-	-	4	-
115	-	-	-	-	-	7
116	-	-	-	-	-	5
117	-	-	-	-	-	3
118	-	-	-	-	-	7
119	-	-	-	-	-	6
120	-	-	-	-	-	5
121	-	-	-	-	-	5
122	-	-	-	-	-	2

* Planters in group of two persons.

TABLE 2.5. Residual stems and slash conditions by study area (1987).

Study area	Number of standing stems *		Number of slash pieces all sizes **	Slash piece diameter		Slash height from ground	
	Average (per 100m row)	Maximum (per 100m row)	(per 100m row)	Average (cm)	Maximum (cm)	Average (cm)	Maximum (cm)
7	3	10	16	5	16	40	120
8	4	9	7	7	33	14	60
9	2	10	22	5	25	28	150
10	2	32	71	6	40	18	100
11	8	51	21	4	22	17	110
12	31	117	68	5	21	27	120
13	10	28	59	8	45	22	100
14	37	123	108	5	40	31	200
15	18	58	223	5	50	36	190
16a	1	5	114	6	30	30	150
16b	3	19	128	6	36	28	200
17	1	34	144	6	38	17	130
18	0	5	152	6	35	16	70

* Stems taller than 1 m within 1 m wide planter's walking path.
** Pieces crossing centre line of planter's walking path.
Note: Included in slash measurements are uprooted stumps/windfalls which account for the large diameters and heights.

TABLE 2.6. Seedlings planted and frequency of planter activites over a standardized 100m planting row, by study area (1987).

Study area	Average number of seedlings planted (per 100m row)	Activity codes *						
		a	b	c	d	e	f	g
		(average counts per 100m row)						
7	73	1	1	0	0	2	0	0
8	64	2	1	0	0	1	0	0
9	61	1	2	0	0	1	0	0
10	70	13	3	0	0	1	0	1
11	78	35	3	0	0	1	0	2
12	59	47	14	0	0	1	0	1
13	67	12	68	0	0	2	1	0
14	51	20	34	0	0	0	0	1
15	51	0	19	1	0	1	6	3
16a	65	7	3	0	0	0	2	4
16b	65	28	9	0	0	0	0	2
17	42	7	16	1	0	0	0	0
18	45	11	4	1	0	0	0	0

* Planter activity codes:
- a - stones/roots at planting spot.
- b - clear planting spot.
- c - search for planting spot.
- d - check spacing or check tree.
- e - refill planting bag or open new seedling bundle.
- f - clean/adjust planting tool.
- g - personal or other.

TABLE 2.7. Planter productivity per hour and planting quality, by study area (1987).

Study area	Site preparation	Planting stock	Planting tool	Observed average spacing within rows (m)	Number of seedlings planted * (per person hour)	Planting quality **			
						A	B	C	D
						(%)			
7	Disc trencher	Bare-root	Shovel	1.4	226	92	0	8	0
8	Disc trencher	Bare-root	Shovel	1.6	242	86	0	14	0
9	Disc trencher	Bare-root	Shovel	1.7	226	78	1	21	0
10	Disc trencher	Bare-root	Shovel	1.4	107	64	1	34	1
11	Disc trencher	Bare-root	Shovel	1.3	85	73	1	26	0
12	Disc trencher	Bare-root	Shovel	1.7	170	82	2	16	0
13	Disc trencher	Bare-root	Shovel	1.5	159	89	1	10	0
14	Disc trencher	Bare-root	Shovel	2.0	139	91	0	9	0
15	Disc trencher	Bare-root	Shovel	2.0	94	85	1	12	2
16a	Disc trencher	Container	Pottiputki	1.6	312	72	0	27	1
16b	Disc trencher	Container	Shovel	1.6	241	84	1	14	1
17	Bracke	Container	Spear	2.5	238	--	na	--	
18	Bracke	Container	Shovel	2.3	304	--	na	--	

* Based on time spent to plant sample lines. Does not include unproductive time elements such as rest breaks, travel times, walking to planting areas, etc.

** Planting quality codes:
A - planting spot acceptable; planted tree acceptable.
B - planting spot not acceptable; planted tree acceptable.
C - planting spot acceptable; planted tree not acceptable.
D - planting spot not acceptable; planted tree not acceptable.

na - Not Applicable. Planting quality for Bracke prepared sites are presented in a separate table.

TABLE 2.8. Planting quality by type of planting spot selected on Bracke prepared sites (1987).

Study area	Planting spot type selected *	Planting quality (%) ** A	B	C	D	TOTAL
17	1	91	0	9	0	100
	2	84	2	13	1	100
	3	88	1	10	1	100
	4	73	9	15	3	100
	All spots	83	4	12	1	100
18	1	97	0	3	0	100
	2	99	0	1	0	100
	3	96	0	4	0	100
	4	47	48	2	3	100
	All spots	84	13	2	1	100

* Planting spot type is in reference to where the seedling was planted in relation to the Bracke scalp:

1 - Seedling planted at the scalp hinge;
2 - Seedling planted at the beginning of the scalp, i.e. opposite the hinge area;
3 - Seedling planted at the sides of the scalp; and
4 - seedling planted either in the scalp depression or not in the scalp but to one side.

** Planting quality codes:

A - planting spot acceptable; planted tree acceptable.
B - planting spot not acceptable; planted tree acceptable.
C - planting spot acceptable; planted tree not acceptable.
D - planting spot not acceptable; planted tree not acceptable.

3. MECHANICAL SITE PREPARATION

Mechanical site preparation treatments were observed at seven operations in Manitoba during 1987. Figure 1 presents general locations of mechanical site preparation study areas. Four study areas were located in the Western Region (study areas 16-19) on areas treated with the Delta Disc Trencher, and three were in the Northern Region (study areas 20-22) on Bracke prepared sites. Stand histories are summarized in Table 3.1 for each study area observed in 1987 and a brief description of site conditions before treatment is presented in Table 3.2. Table 3.3 describes the scarifying implement, prime mover and method of payment used at each operation.

The four study areas in the Western Region are located in the Porcupine Mountains in the vicinity of Spider Lake (T43, R27 and 28 WPM). The original stands containing spruce, jack pine and trembling aspen were logged during 1977-79. During the summer of 1987, these areas were prepared for planting using a Delta disc trencher attached to a D7 caterpillar tractor.

Topography in the Spider Lake study areas is generally rolling and soils are a clay loam. Average duff thickness at each area ranged from 3 to 10 cm. During the period of observation, soils were moist. Few residuals occurred and all but the larger stems were pushed over by the tractor. Shrubs and suckers 1.5 to 3 m in height were common throughout but were concentrated in the wetter areas. Most of the areas supported a heavy grass cover. Slash conditions were generally light and stumps were brittle enough to offer little or no resistance to the scarifying tool.

The three study areas in the Northern Region are located north of The Pas on the Egg Lake Road in T62, Range 28WPM (areas 20, Ben's Point and 21, Tank Lake) and near the Jenpeg dam in T65 Range 6WPM (area 22). The original stands on these sites contained spruce, aspen and jack pine and all were logged during summer or fall of 1986. A Bracke patch scarifier dragged by a Caterpillar 528 wheeled skidder was used to prepare the site for tree planting.

Topography at study areas 20 and 21 is flat and soils are a loamy sand. At the time of observation, soils were moist. Duff thickness averaged 10 cm. Stones were not present at area 20 but were common at area 21 where in places, bedrock was within several cm of the surface. Aspen residuals were avoided by the operator however they were spaced wide enough apart that they did not hinder machine operation. Shrub cover was light and averaged 1.5 m or less in height. Slash cover was moderate to heavy. At

area 20, many mature aspen trees had been knocked down during the logging operation and now create a heavy slash cover. Also at this study area, high stumps (up to 50 cm) were common and although these did not appear to affect machine travel speed (based on the machine operator's comments), they did cause a greater number of unacceptable scalps.

At the Jenpeg site (area 22) topography is flat to gently rolling and the low lying areas are hummocky. During the observation period, the stone free clay soils were moist to wet. Duff thickness averaged 8 cm. There were no standing brush or residuals on the site and slash cover was moderate to heavy. The wet soils caused the Bracke's mattock wheels to stick thus creating larger scalps and mounds than usual as well as fewer scalps than expected.

Results

Results presented in this report include machine production in terms of hectares treated per hour, measures of treatment effectiveness in terms of plantability after site preparation, and summary statistics on pre- and post-treatment slash conditions.

Machine productivity rates are presented in Table 3.4 for each study area observed during 1987. Productivity rates are based on the time required to treat a 50 m long strip and do not include unproductive time elements such as rest breaks, repair and maintenance delays, etc. For the purpose of productivity calculations, strip width was assumed to be the width of the scarifying implement plus the distance between machine passes. For the Delta disc trencher, strip width was set at 4 m: 2 m between discs and 2 m between machine pass. Strip width for the Bracke was 4 m for the 2-frame and 6 m for the 3-frame; i.e. 2 m between frames and 2 m between machine passes.

Average production for the Delta disc trencher ranged from 1.22 to 1.32 ha per hour (Table 3.4). Productivity varied considerably within a study area however. For example, the widest range occurred at area 18 where productivity averaged 1.22 ha per hour and ranged from 0.88 to 1.33 - a 50% spread or almost one half ha per hour difference.

Bracke production averaged from 2.02 to 2.28 ha per hour for the 2-frame and from 2.84 to 3.26 for the 3-frame (Table 3.4). Although the sample size is limited, data in Table 3.4 suggest Bracke production increases directly with the width of the implement; i.e. the addition of another frame increases the effective scarified strip width by 50% and production also

increases by almost 50%. Apparently the machine's travel speed was not affected substantially by the additional workload imposed on it by the wider implement.

The degree to which treatment objectives were achieved was described by the plantability of the site after mechanical site preparation. The number of possible planting spots available to the planter was used as the evaluation criteria on disc trenched sites. On Bracke prepared sites, the frequency of scalps by quality classes was used to assess treatment effectiveness. Measures of treatment effectiveness are presented in Table 3.5 for disc trenched sites and in Table 3.6 on Bracke prepared sites.

Disc trenching resulted in a very high number of planting spots (Table 3.5). This is likely the result of the relatively stone free sites that were observed. Bracke prepared sites however showed a varying number of planting spots or scalps that were either not acceptable for planting (based on criteria established by the local site preparation supervisor) or were of lesser quality (Table 3.6). For example area 20, treated with the 3-frame Bracke, had 29% of the scalps as Class 4 (the poorest quality) and only 61% of Class 1 (the best quality).

Slash conditions before and after site preparation are presented in Table 3.7. As was found in the 1986 data, slash height appears to have been increased after treatment. This is likey the result of slash pieces being moved about and realigned by the scarifying implement. However, unlike the 1986 data, the number of slash pieces the planter is likely to encounter also appears to have increased after site preparation (Table 3.7). Further testing is required to substantiate these observations.

TABLE 3.1. Summary of stand histories and locations of study areas observed in 1987.

Study area			Stand history		Site preparation
Area no.	Reference name	Location	Original stand	Disturbances	implement
16	Spider Lake - 1 (Western Region)	T43,R27WPM	Spruce, jack pine	Logging 1977-79	TTS Delta Disc Trencher
17	Spider Lake - 2 (Western Region)	T43,R27WPM	Spruce, aspen	Logging 1977	" "
18	Spider Lake - 3 (Western Region)	T43,R28WPM	Spruce, aspen jack pine	Logging 1977	" "
19	Spider Lake - 4 (Western Region)	T43,R28WPM	Spruce, jack pine	Logging 1977-79	" "
20	Ben's Point (Northern Region)	T62,R28WPM	White spruce, aspen	Logging fall of 1986	Bracke (3-frame)
21	Tank Lake (Northern Region)	T62,R28WPM	Spruce, aspen	Logging summer of 1986	Bracke (2- and 3-frame)
22	Jenpeg87 (Northern Region)	T65,R6WPM	Spruce,aspen, jack pine	Logging fall of 1986	Bracke (2- and 3-frame)

TABLE 3.2. General description of site conditions before treatment (1987 study areas).

General location of study areas	Study areas	General soil descriptions				Duff thickness	Topography	Residual stems	Slash	Stumps
		Texture	Stoniness	Moisture *	Depth **					
Spider Lake (Western Region)	16-19	Clay loam	Few stones	Moist at areas 16, 17,18. Wet at area 19	Greater than 35cm	3 to 10cm	Rolling	None at area 19, few at others	Light to moderate	Common but mostly rotted
The Pas/Jenpeg vicinity. (Northern Region)	20-22	Loamy sand or clay	No stones at 20 & 22 stoney and bedrock at area 21	Moist at 20 & 21, moist to wet at area 22	>35 cm at 20 and 22, 9-35cm at area 21	8 to 10cm	Flat to gently rolling	None at area 22, common but well spaced at 20, and 21	Moderate to heavy	Frequent, (high at area 20)

* Moisture - soil moisture conditions at time of treatment.
** Depth - soil depth based on depth to which a steel bar could be pushed into the ground before encountering bedrock or large stones - maximum depth of 35 cm.

TABLE 3.3. Scarifying tool, prime mover and method of payment used at each study area (1987).

Study area	Scarifying tool	Prime mover	Method of payment
16 to 19	Disc Trencher TTS Delta	D7G Caterpillar tractor, 1972 (179 kw)	Contracted hourly rate
20 to 22	Bracke Patch scarifier (2 and 3 frame)	Caterpillar 528 skidder (130 kw)	Contracted on an area basis

TABLE 3.4. Machine productivity by study area for mechanical site preparation in Manitoba (1987).

Study area	Scarifying implement	Number of plots	Machine productivity * Average (ha per hour)	Range
16	TTS Delta	13	1.25	1.06-1.50
17	Disc	8	1.31	1.24-1.38
18	Trencher	11	1.22	0.88-1.33
19		4	1.32	1.26-1.36
20	Bracke 3-frame	12	2.84	2.57-3.38
21	Bracke 2-frame	4	2.02	1.89-2.12
	3-frame	1	3.00	-
22	Bracke 2-frame	6	2.28	1.94-2.57
	3-frame	10	3.26	2.92-3.72

* Machine productivity is based on time required to treat a 50 m long strip. Unproductive time elements such as repairs, maintenance, rest breaks, etc. are not included. Area treated was calculated assuming 2 m between machine passes and 2 m between trenches or Bracke scalps.

TABLE 3.5. Relative frequency of planting spots after disc trenching with TTS Delta (1987).

Study area	Scarifying implement	Planting spot frequency *			
		0 spots	1 spot	2 spots	>2 spots
		(%)			
16	TTS Delta	0	0	8	92
17	Disc	0	5	3	92
18	Trencher	2	0	7	91
19		0	0	0	100

* Based on 2 m square quadrats.

TABLE 3.6. Relative frequency of scalp classes after Bracke site preparation (1987).

Study area	Scarifying implement	Frequency of scalps by quality class *			
		Class 1	Class 2	Class 3	Class 4
		(%)			
20	Bracke 3-frame	61	6	4	29
21	Bracke 2-frame	75	2	4	19
	Bracke 3-frame	75	5	3	17
22	Bracke 2-frame	71	8	3	18
	Bracke 3-frame	82	4	2	12

* Quality classes for Bracke scalps are:

Class 1 : suitable planting spot in the hinge zone between scarified depression and mound.
Class 2 : plantable directly opposite the hinge zone at the beginning of the scarified depression.
Class 3 : plantable along the sides of the scarified depression.
Class 4 : not plantable.

TABLE 3.7. Pre- and post-treatment slash conditions for disc trenched and Bracke prepared sites (1987 study areas).

Study area	Scarifying implement	Number of slash pieces per 100 m transect *						Average piece size (pieces > 5cm diameter)			
		Pieces with diameter < 5 cm		Pieces with diameter > 5 cm		Total all sizes		Diameter (cm)		Height (cm)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
16	TTS	158	78	75	28	233	106	8	8	20	19
17	Delta	44	59	51	40	95	99	10	8	11	22
18	Disc	56	67	40	31	96	98	9	10	14	22
19	Trencher	222	38	108	30	330	68	8	9	8	19
20	Bracke 3-frame	288	319	98	150	386	469	9	9	13	17
21	Bracke 2-frame	235	268	58	177	293	445	10	7	11	12
	Bracke 3-frame	90	143	130	118	220	261	7	7	8	13
22	Bracke 2-frame	385	268	90	124	475	392	9	8	16	17
	Bracke 3-frame	305	295	69	134	374	429	9	8	14	16

* The number of slash pieces were determined from slash transects and adjusted to an arbitrary length of 100 m.

FUTURE WORK

The field data collection phase of this study is complete. Future work on this project - Economics of Intensive Forest Management - will focus on data analyses to determine the significance of various site factors in estimating labor and/or machine productivity. Predictive equations or other methods will be developed to estimate labor or machine requirements, and therefore costs of creating various silvicultural treatments over a range of site conditions.