AN EVALUATION OF SITE PREPARATION WITH THE DONAREN 180D POWERED DISC TRENCHER ON FULL-TREE LOGGED SITES

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ABSTRACT

The Donaren 180D Powered Disc Trencher was evaluated on three full-tree logged sites in Ontario. The implement produced from 7.5% to 14.4% plantable disturbance (receptive seedbed) and the number of plantable and marginal planting spots ranged from 2,073 to 2,253 per ha for an average effective plantability of 87.7%. Productivity varied from 1.11 to 1.86 ha per productive machine hour (PMH); silvicultural productivity averaged 2,631 plantable and marginally plantable spots per PMH. Mechanical availability and utilization were 83.6% and 80.0%, respectively.

RÉSUMÉ

Le planteur à disques hydraulique Donaren 180D a été évalué dans trois stations ontariennes où les arbres avaient été récoltés entiers. La proportion préparée par l'engin pour servir de planches à semis varie de 7.5 à 14.4%, et le nombre d'emplacements plantables et marginaux varie de 2,073 à 2,253 par ha, pour une plantabilité efficace moyenne de 87.7%. La productivité a varié de 1.11 à 1.86 ha par heure-machine productive (HMP); la productivité sylvicole a été en moyenne de 2,631 emplacements plantables et marginaux par HMP. La disponibilité mécanique et l'utilisation des machines avaient un taux respectif de 83.6 et de 80.0%.

ACKNOWLEDGMENTS

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INTRODUCTION

In an effort to improve the quality of scarification and to increase machine productivity, Scandinavian manufacturers of foresty equipment have developed disc trenchers from fairly simple mechanical devices to comparatively sophisticated implements utilizing hydraulic and electronic controls similar to those commonly used in harvesting and other off-road equipment.

A first-generation mechanical disc trencher, the Finnish TTS-35 disc trencher with two passively rotating discs, has been widely used in Canada since the early 1970s (Masters 1978, Smith 1980, Smith et al. 1985 and footnotes 2, 3, 4, 5). A similar unit, the Finnish MM disc trencher, was recently introduced to Canada. The first major refinement of the disc trencher consisted of the addition of hydraulic down pressure and zero-load float and lift capability to the discs. The TTS-35H and TTS Delta are two second-generation trenchers of this type that have been used recently in the Maritimes, Quebec, Ontario and western Canada (Hedin 1985).

A third-generation disc trencher with the added feature of hydraulically driven discs, the Donaren 180D Powered Disc Trencher, was first introduced to Canada in 1981. Ryans (1982) and Bamsey[6] report on its use in Quebec and Alberta.

In 1984, the Donaren was evaluated by the University of Toronto under contract to the Great Lakes Forestry Centre (GLFC) in cooperation with E.B. Eddy Forest Products Ltd. on sites located in the boreal forest near Ramsay in northeastern Ontario. The scarifier, a Caterpillar 528 wheeled skidder prime mover, and an operator were supplied under contract to E.B. Eddy Forest Products Ltd., who also provided the sites, supervisors and mechanical support for the study.

The purpose of the evaluation was to determine the ability of the unit to satisfy a local site preparation prescription on a range of full-tree logged sites. The trials were partly a follow-up to an evaluation of the TTS-35, Leno 77 patch scarifier and Bräcke cultivator (two-row) carried out in 1982 on nearby full-tree and tree-length logged sites (Smith et al. 1985). The same prescription applied in both cases. GLFC Standard

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2 Anon. 1978. D-6 widetrack scarification report. Ont. Min. Nat. Resour., Timber Br., Geraldton Distr. Intern. Rep. 20 p.

3 Kelertas, R.A.. 1978. Mechanical site preparation in the boreal forest with special reference to Ontario. Univ. Toronto, Fac. For., Toronto, Ont. M.Sc. thesis. 278 p.

4 McAlister, P.A. 1975. The Finnish TTS Disc Trencher. Ont. Min. Nat. Resour., Thunder Bay Distr. Intern. Rep. 8 p.

5 McMinn, R.G. and Homoky, S.G. 1975. Biological effectiveness of equipment tested in silvicultural-mechanical site preparation trials. Dep. Environ., Can. For. Serv., Victoria, B.C. Prelim. Rep. Exp. Proj. 741. 40 p.

6 Bamsey, C.R. 1985. Trials of Donaren Disc Trencher, 1983. Alta. For. Serv., Edmonton, Alta. Intern. Rep. 3 p.

Assessment Procedures[7] were applied to ensure a reasonable comparison between these and other equipment evaluations.

LOCATION AND SITE DESCRIPTION

Timber rights for the area are held by E.B. Eddy Forest Products Ltd. under a Forest Management Agreement. Three sites located in Cortez Township approximately 44 km southwest of Ramsay, Ontario were selected for the study (Fig. 1). The area is also located in the transition zone between the boreal (Missinaibi - Cabonga Sec. B.7 [2] West) and Great Lakes-St. Lawrence (Timagami Sec. L.9) forest regions (Rowe 1972).

The area lies within the Precambrian Shield and has been left with a thin mantle of glacial moraine over bedrock and small lacustrine deposits in lowland areas. Soils are classified as sandy-loam tills.

Sites 1 and 2 were well drained, upland sites with flat to gently rolling topography, and contained deep, sandy loam soils with surface and subsurface boulders. Prior to harvesting, Site 1 supported a mixed softwood stand composed predominantly of black spruce (*Picea mariana* [Mill.] B.S.P.) with a minor component of jack pine (*Pinus banksiana* Lamb.), balsam fir (*Abies balsamea* [L.] Mill.) and white birch (*Betula papyrifera* Marsh.). The stand was approximately 120 years old and 70% stocked.

Site 2 also supported mixed softwoods--predominantly black spruce with a minor component of jack pine. The stand was 70 years old and 90% stocked.

Site 3 supported a black spruce stand with scattered jack pine; it was 120 years old and fully stocked. The topography was flat and the soil was a mixture of loam and clay. The stand bordered a small bog containing alder (*Alnus* spp.) and unmerchantable black spruce. Surface water was evident in some locations.

The sites were full-tree harvested between December 1983 and March 1984 in conventional cut and skid operations, with mechanical delimbing at roadside. At harvest the jack pine and black spruce were removed, and hardwoods and unmerchantable softwoods were left as standing residuals.

The company's silvicultural prescription for the three sites called for the use of a disc trencher to create continuous furrows and to prepare microsite conditions suitable for planting. Planting of jack pine paperpot stock with Pottiputki planting tubes at 2-m x 2-m spacing was scheduled for the spring of 1985.

IMPLEMENT AND PRIME MOVER

The Donaren 180D is a powered disc trencher manufactured by AB Skogsbruksmaskiner, Sweden (specifications in Appendix A). The trencher was mounted on a 130-kw Caterpillar 528 wheeled skidder (specifications in Appendix A) as shown in Figure 2. The equipment was owned and operated by a contractor under agreement with The Ontario Paper Co. Ltd. The work was carried out for E.B. Eddy Forest Products Ltd. and the contractor was paid on an area basis. The operator was experienced and was very interested in the results of his work.

The trenching discs are mounted on two separately articulated arms (Fig. 3). The arms have three operating positions:

- continuously adjustable down pressure (0-40 bars);

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7 Sutherland, B.J. 1985. Standard assessment procedure for evaluating silvicultural equipment: a handbook for pretreatment assessment: site preparation and planting. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. (in prep.).

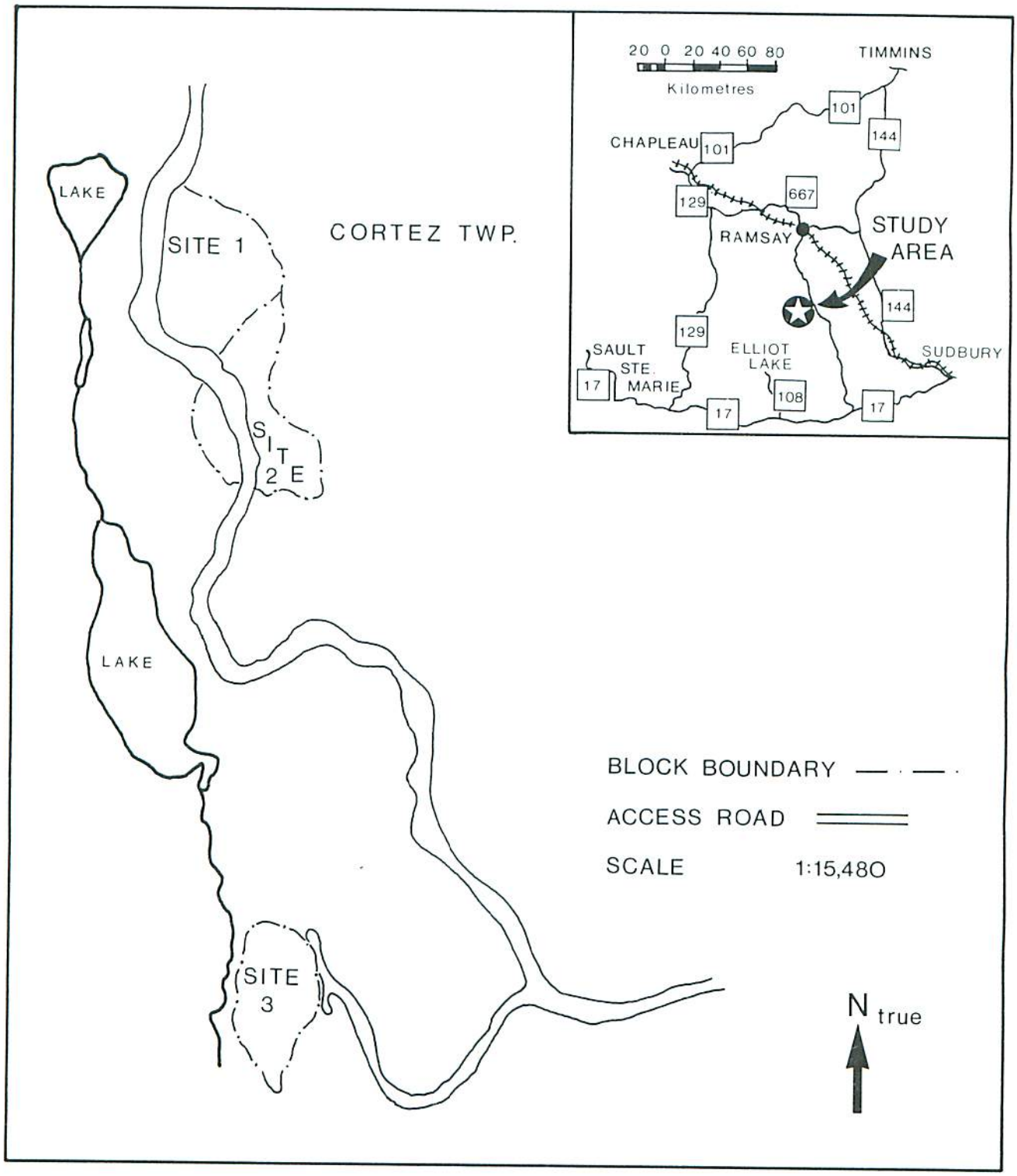

Figure 1. General location of study area and configuration of sites.

Figure 2. Donaren mounted directly on rear of Caterpillar 528 skidder.

Figure 3. Discs mounted on two separately articulated arms. Hydraulic cylinders provide down pressure to the discs.

- 0-pressure float position where the discs operate entirely under their own weight;
- raised position for transport or maneuvering.

Hydraulic cylinders on the arms provide down pressure and lift when required. The scarifying discs are hydraulically driven in the direction of forward travel. Spacing between furrows can be adjusted from 1.0 to 2.75 m by setting welding stops on the mounting plate to restrict the lateral movement of the arms.

An electronic control box mounted in the cab controls the raising and lowering of the discs, down pressure (0-40 bars) and rotation of the discs.

Power for the Donaren was supplied from a hydraulic pump run off the engine of the skidder. The fixed-displacement, gear-driven pump was not original equipment and was installed by the Caterpillar dealer.

ASSESSMENT PROCEDURE

The data were collected according to the GLFC Standard Assessment Procedures[7]. The field work was divided into three components: (i) pretreatment assessment, (ii) continuous time study, and (iii) post-treatment assessment. Key parameters in the pre- and post-treatment assessments (including slash volume, soil depth, duff depth, plantable soil disturbance and number of plantable spots) were sampled at a minimum level of 10% significance with a 15% confidence interval. Sample size for the key parameters was determined according to Payandeh et al. (1978) with data collected in a presample.

Pretreatment Assessment

Pretreatment assessment plots were clustered, each cluster consisting of 20-m lines divided into 10 2-m segments with a 2-m x 2-m quadrat located at the 20-m end of each line.

At the beginning of each 2-m segment one measurement was taken of each of the following: duff depth, mineral soil depth, percent stoniness and slash depth. A tally was taken of all pieces of slash from 1 cm to 5 cm in diameter; the diameter of all pieces greater than 5 cm in diameter was measured and recorded along the entire length of each 2-m segment according to a modified version of the line intersect method of slash assessment (Van Wagner 1968, 1982). The percent slope was measured along the 20-m axis of the line.

In each of the 2-m x 2-m quadrats, the proportion of area covered by minor vegetation and the major species of minor vegetation were estimated. The frequency and species of all brush-size stems less than 5 cm DBH and greater than 1.5 m tall were also recorded. Within the quadrat the average diameter outside bark, the height and the species of all stumps less than 1.5 m in height were recorded. The frequency and height/depth of other ground obstacles and depressions were determined and combined with stumps in a composite measure of ground roughness (Anon. 1969).

A prism sweep was made at the 20-m point of each line with a BAF 2 prism. The species, DBH, and average height of all trees within the prism sweep were recorded. This information was used later to determine the percent stocking, from Plonski's (1974) normal yield tables, for the predominant species in the plot.

Continuous Time Study

A continuous time study was conducted for the entire time the implement was working on the sites. The activities were timed and recorded in

activity categories. Reasons for delays were noted and charged against the implement or prime mover. (See Appendix B.)

Post-treatment Assessment

Post-treatment assessment was carried out by means of cluster plots consisting of 20-m-long transects containing 10 2-m x 2-m quadrats. The plots were established perpendicular to the direction of travel.

In each quadrat the quality and quantity of soil disturbance were estimated. Though not part of the prescription, the amount of receptive seedbed for jack pine (Riley 1980) was determined from the disturbance assessment. An assessment of the plantability (opportunities for planting) was made within each furrow crossing the 20-m line. Planting spots were assessed as plantable, marginally plantable or non-plantable on the basis of an area approximately 30 cm x 30 cm with microsite conditions meeting established criteria for duff depth, amount of debris and vegetative competition, and type of soil disturbance. A Pottiputki planting tube was used to test whether the selected spot was penetrable. Reasons for non-penetration as well as micro-relief class were also recorded (Smith et al. 1985). If the spot with the best type of soil disturbance was not plantable because of penetration, duff, debris or vegetative competition, the spot was described as a first choice, and a second choice was then described.

RESULTS

Pretreatment Assessment

Soil and Ground Conditions

Mineral soil depth within the top 30 cm of the surface averaged approximately 23 to 25 cm on all three sites (Table 1). Soils were most frequently shallow on sites 1 and 2 (Fig. 4).

The average depth of duff was 7 cm on sites 2 and 3 and 12 cm on Site 1 (Table 1). Site 1 contained duff up to 24 cm deep in places, whereas the duff on Site 3 did not exceed 16 cm (Fig. 5).

Stoniness, a measure of buried stones and boulders within 30 cm of the surface, averaged 38% and 56% on sites 1 and 2, respectively, while site 3 was generally free of stones (Table 1). These results, along with the results of the mineral soil depth assessment, identify the more important differences among the three areas.

Table 1. Average soil and ground conditions.

Site	Mineral[a] soil depth (cm)	Duff depth (cm)	Stoniness (% areal coverage) Avg	Stoniness (% areal coverage) Range	Ground[b] roughness class
1	24.7	11.5	37.5	0.0 - 100.0	1 (2)
2	23.1	6.7	56.3	0.0 - 100.0	2 (1)
3	23.1	6.9	1.3	0.0 - 100.0	1 (2)

[a] within 30 cm of the surface

[b] numbers within parentheses reflect a % occurrence greater than 10% of the sample area.

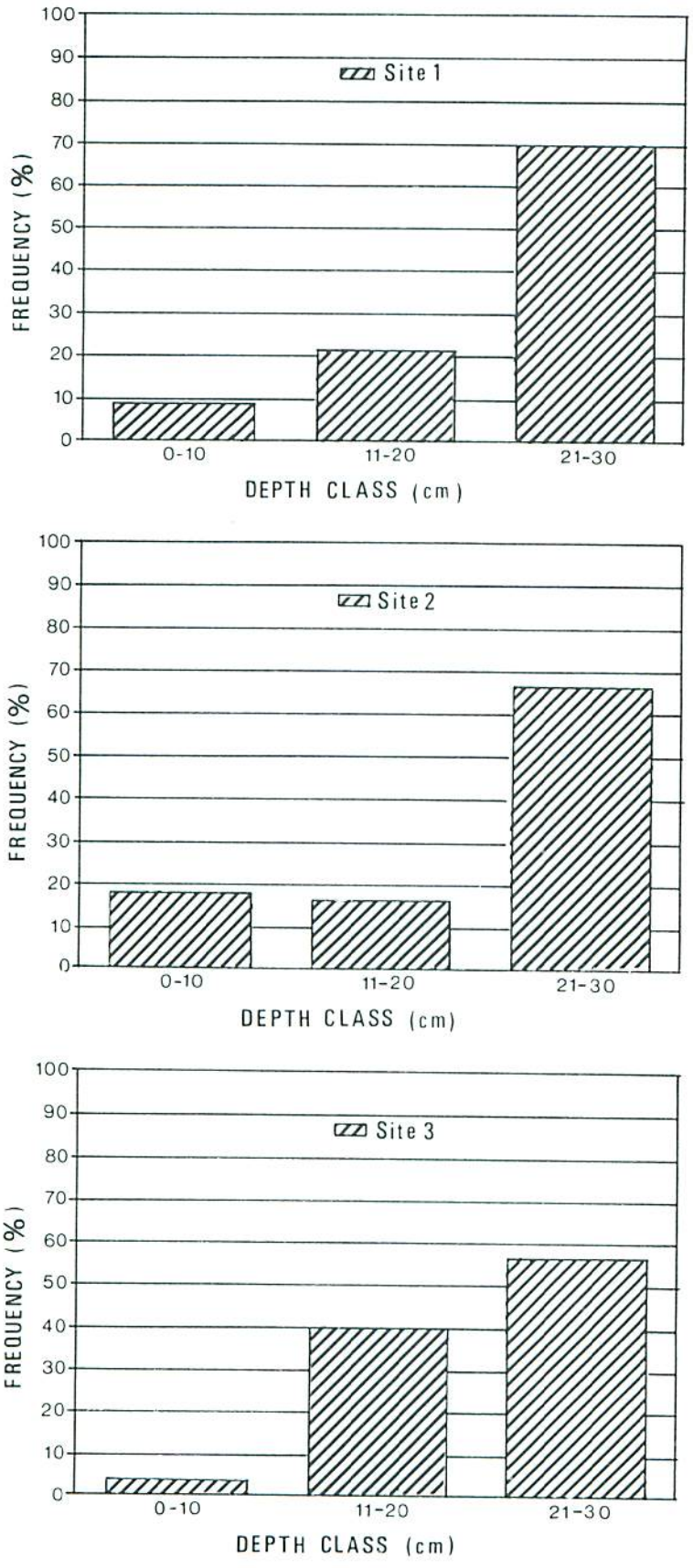

Figure 4. Mineral soil depth.

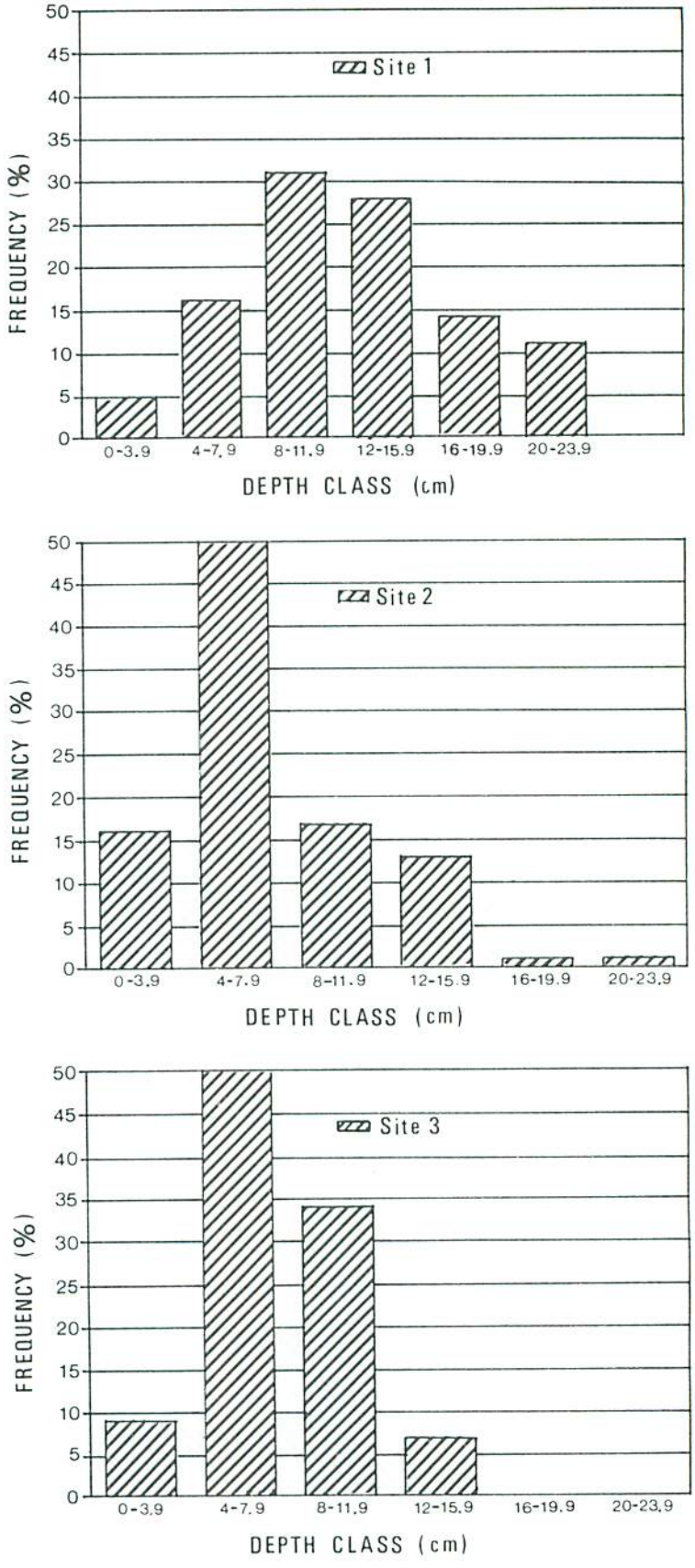

Figure 5. Duff (LFH) depth.

Ground roughness includes stumps, surface boulders, mounds and depressions and is measured on a scale of 1 to 5 with 1 being the least severe. Sites 1 and 3 were both in class 1 with respect to roughness while Site 2 was in class 2 and therefore somewhat rougher (Table 1).

Slope

Sites 1 and 3 were generally flat to gently sloping; 82.0% and 100% of the observations, respectively, were in the 0-5% slope class (Fig. 6). Site 2 proved to have the greatest variability of slope, with 62.0% in the 0-5% slope class, 21% in the 5-10% class and 15% in the 11-25% class.

Logging Slash

Slash depth averaged 9.3 cm on Site 1 in comparison with 7.9 cm and 5.5 cm on sites 2 and 3, respectively (Fig. 7). Sites 2 and 3 contained 38.1 and 38.2 pieces of slash per 20 m of lineal tally, respectively, in the 1-5 cm diameter size class[8]. Site 1 contained 53.2 pieces per 20 m in this size class (Fig. 8). The volume of slash in this smallest size class (Fig. 9) also reflects this difference.

The number of pieces per 20 m of lineal tally for slash more than 5 cm in diameter (Fig. 10) and their corresponding volume (m^3/ha) (Fig. 11) show important differences among areas. Site 1, in comparison with the other two areas, contained a greater number of pieces that were larger and up to 53% more volume of slash in pieces more than 5 cm in diameter. The site also contained a greater proportion of overmature stems that had fallen to the ground. These stems contributed to the higher frequency and volume measurements. Frequency distributions of slash volume for the three areas are shown in Figure 12. A summary of the slash assessment is provided in Table 2.

Stumps

Stumps on Site 3 were shorter and had a smaller diameter and greater density (Table 3).

Residual Vegetation

Site 1 was the only area that contained residual timber. White pine (*Pinus strobus* L.), white birch and immature balsam fir were scattered throughout the site. The average DBH

8 The estimation of slash pieces in the 1-5 cm diameter classes is subject to error because the diameter of the smallest pieces in this class is usually estimated by eye.

Table 2. Slash.

	Pieces per 20 m of lineal tally		Diameter	Depth		Volume					Species	
Site	1-5 cm (no)	>5 cm (no)	Avg >5 cm (cm)	Avg (cm)	Range (cm)	Avg 1-5 cm (m^3/ha)	Range 1-5 cm (m^3/ha)	Avg >5 cm (m^3/ha)	Range >5 cm (m^3/ha)	Total vol (m^3/ha)	Conifer (%)	Hardwood (%)
1	53.2	6.8	15.0	9.3	0 - 97	11.6	0 - 32	60.5	0 - 299	72.1	95.0	5.0
2	38.1	8.6	9.0	7.9	0 - 61	8.3	0 - 26	51.6	0 - 200	59.9	97.5	2.5
3	38.2	7.4	8.5	5.5	0 - 25	8.4	0 - 33	39.6	0 - 246	48.0	100.0	---

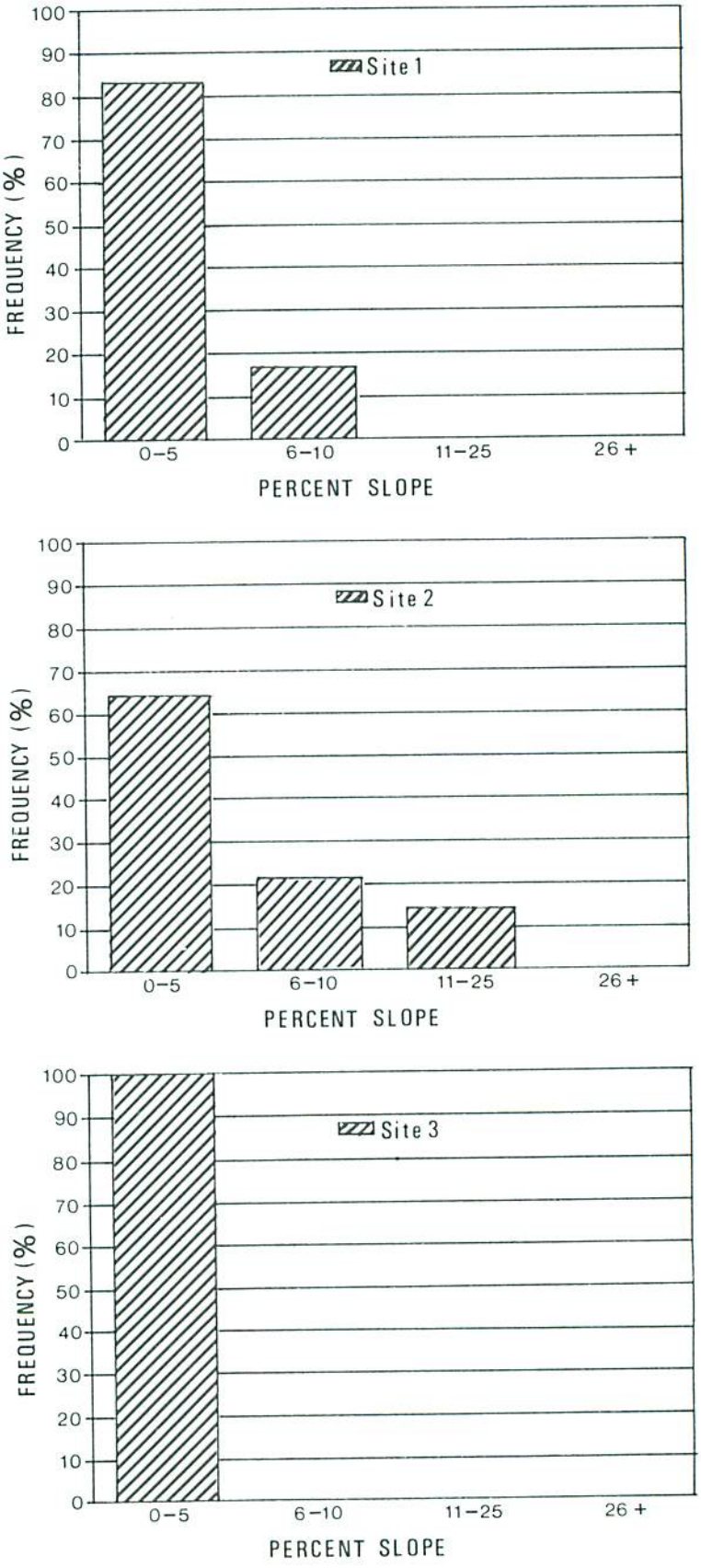

Figure 6. Maximum slope.

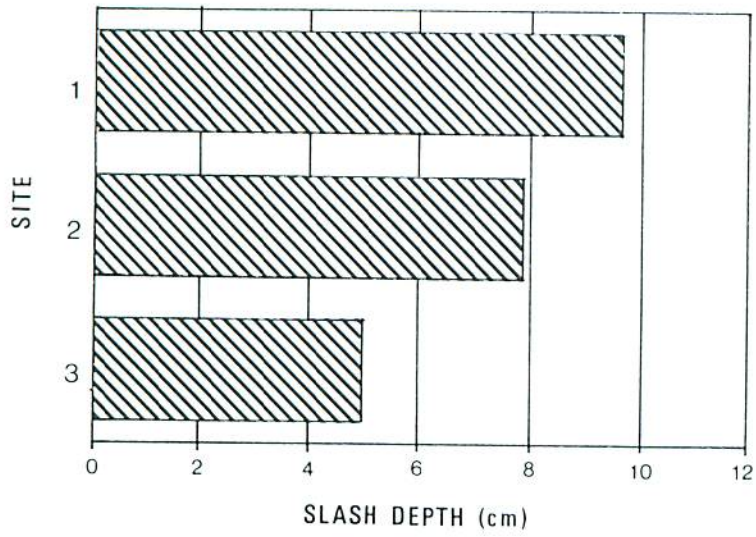

Figure 7. Slash--average depth.

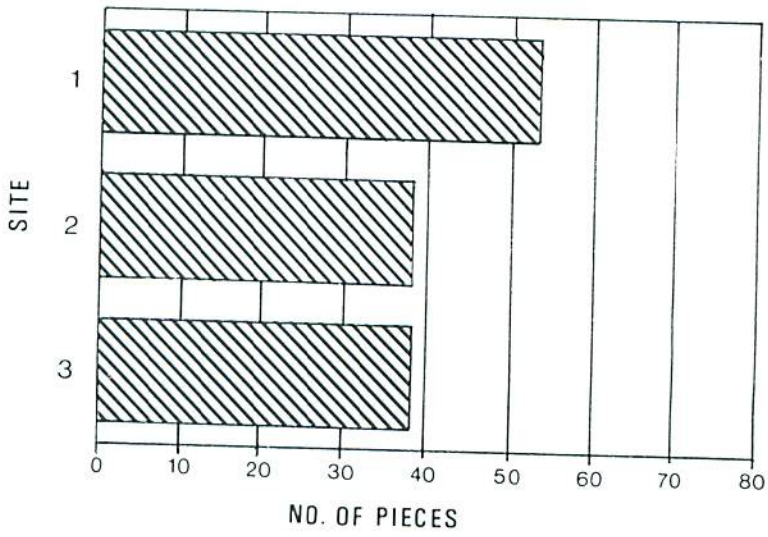

Figure 8. Slash--pieces per 20 m of lineal tally, 1-5 cm in diameter.

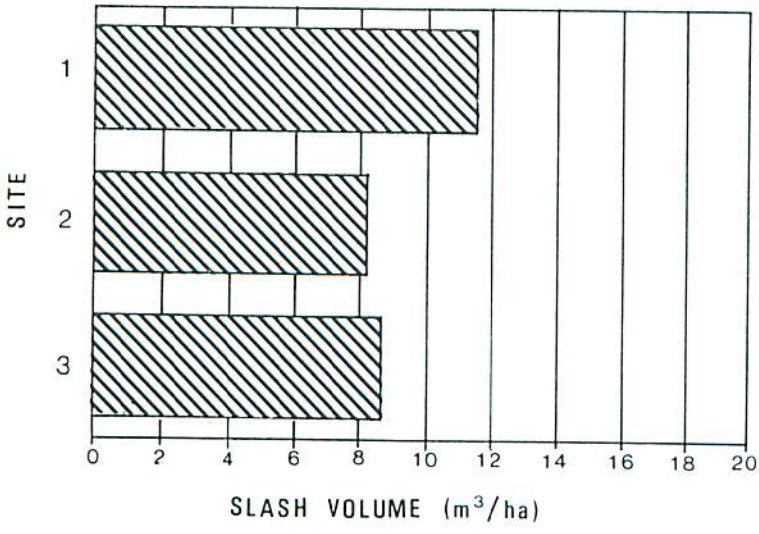

Figure 9. Slash--average total volume of pieces 1-5 cm in diameter.

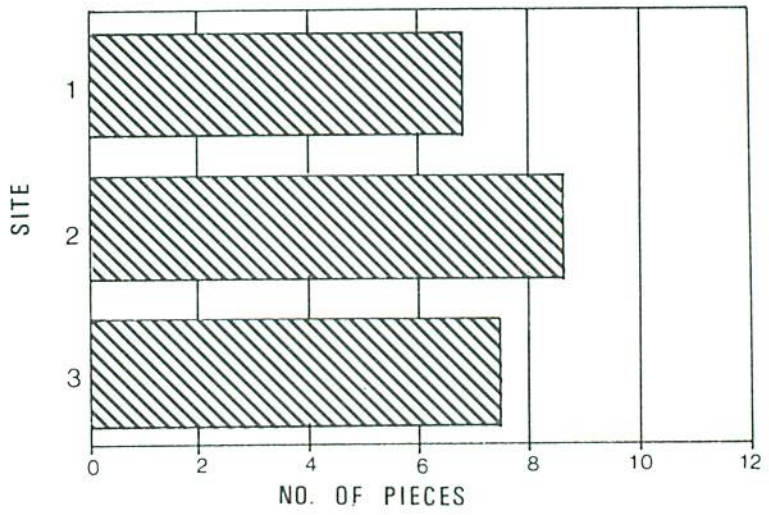

Figure 10. Slash--pieces per 20 m of lineal tally that were more than 5 cm in diameter.

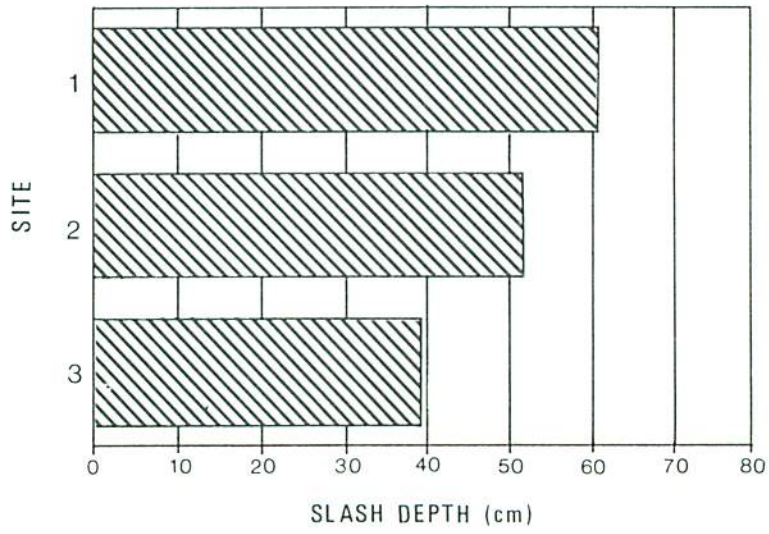

Figure 11. Slash--average total volume of pieces more than 5 cm in diameter.

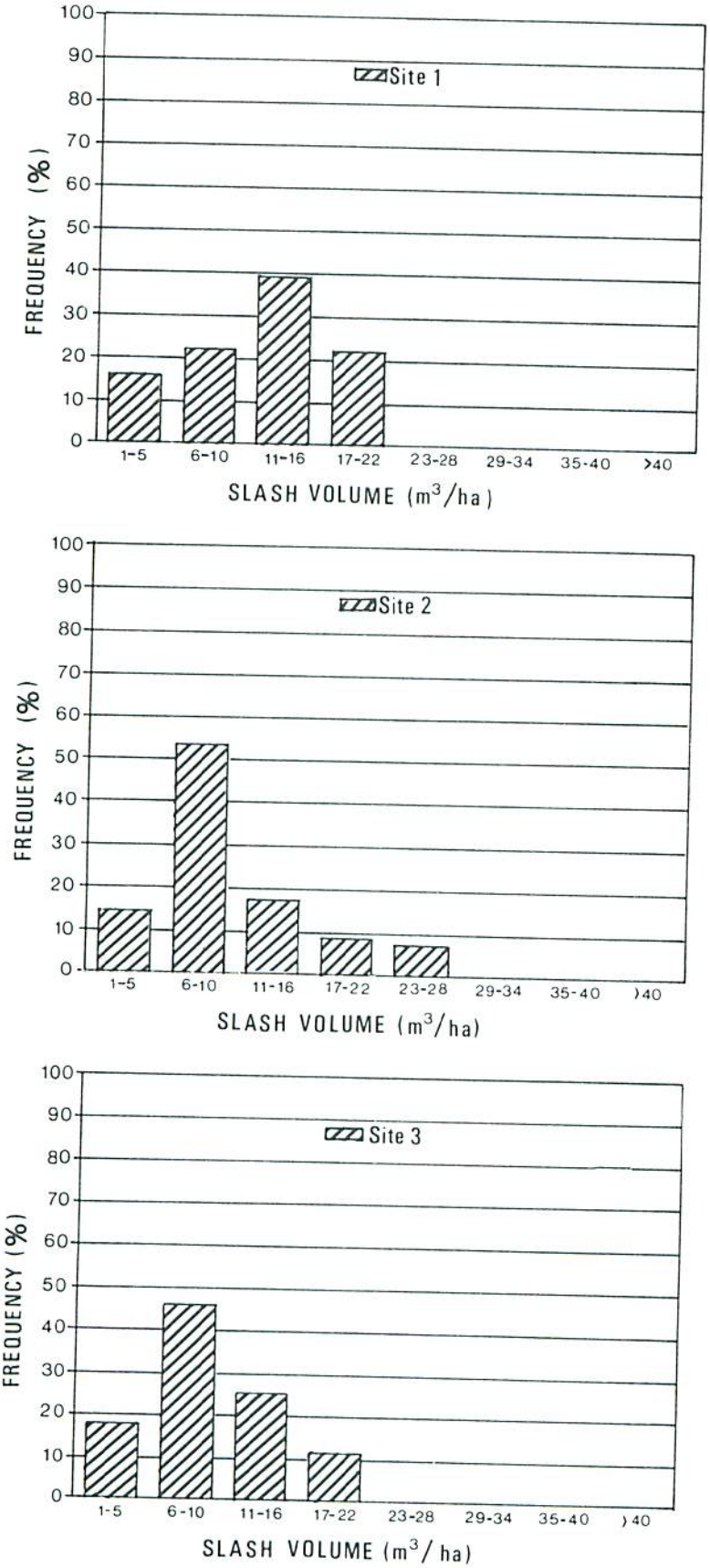

Figure 12. Slash--frequency distribution by diameter class.

Table 3. Stumps.

Site	Frequency (no./ha)	Height Avg (cm)	Height Range (cm)	Diameter Avg (cm)	Diameter Range (cm)	Species Jack pine (%)	Species Black spruce (%)
1	2,813	25.0	14-33	22.8	8-29	----	100.0
2	1,875	25.0	10-61	27.7	11-71	16.7	83.3
3	4,063	17.3	8-28	19.2	10-36	7.7	92.3

of residual timber is reported in Table 4. Most of the immature balsam fir were classed as brush because of their small size. Site 1 was the only area to contain brush (Table 5) (Fig. 13).

Site 1 also contained the greatest concentration of minor vegetation.

Table 4. Residual timber.

Site	Stocking[a] (%)	Avg DBH (cm)	DBH range (cm)
1	3.8	34.2	19 - 62
2	-	-	-
3	-	-	-

[a] Plonski (1974)

Table 5. Brush.

Site	Stocking (%)	Frequency (no./ha)	Species[a]
1	92.0	4350	Bf, Bw, Ha
2	-	-	-
3	-	-	-

[a] Bf: Balsam fir *(Abies balsamea* [L.] Mill.)
Bw: White birch *(Betula papyrifera* Marsh.)
Ha: Hazel *(Corelus cornuta* Marsh.)

Blueberry *(Vaccinium angustifolium* Ait.) and other less frequently occurring species covered an average of 31.3% of the site, but only 3.8% and 2.5% on sites 2 and 3, respectively (Table 6).

Table 6. Minor vegetation.

Site	Areal coverage (%)	Species
1	31.3	blueberry[a]
2	3.8	blueberry
3	2.5	blueberry

[a] *Vaccinium angustifolium* Ait.

Continuous Time Studies

Continuous time studies of the Donaren and its prime mover were conducted on all three areas to determine how the scheduled operating time of the implement was utilized and to identify any problems and sources of unproductive time.

The combined results, including sources and cumulative time of delays, are shown in Figure 14. Service and repairs accounted for 15.6% of total machine hours, and consisted mostly of the operator's daily servicing, cleaning and routine inspection of the prime mover and implement. There was

Figure 13. Residual timber was scattered throughout Site 1.

one instance of repair to the equipment which amounted to 0.6 hr when a hydraulic hose was replaced on the Donaren.

Maneuvering time accounted for 13.3% of total machine hours, and of this 13.3%, 81% was spent turning with the implement in the raised position. This occurred most often at the ends of the blocks before a new set of furrows was begun. The average time per turn was 20 sec.

Large pieces of slash such as tops and chunks of logs became entangled in the implement's discs on 83 occasions, freezing them (Fig. 15). This was particularly evident on Site 1. The operator lifted the implement in an attempt to free the discs and usually was successful; however, such delays accounted for 1.9 hr or 5.5% of the total machine time.

Average machine productivity varied from 1.05 ha per productive machine hour (PMH) on Site 2 to 1.86 ha/PMH on Site 3 (Table 7). Travel speeds averaged 3.4 km/hr on sites 1 and 2 and 6.1 km/hr on Site 3 (see Table 10). These speeds appear slow for a wheeled prime mover and indicate that the engine speed was not being maintained at a high enough level for adequate flow to the trencher. The higher travel speed and productivity achieved on Site 3 were due primarily to the flat topography and absence of boulders on the site.

Utilization and mechanical availability are measures that reflect both the reliability and effectiveness of the machine. These measures were calculated from the formulae in Appendix B. Utilization of the Donaren was 80.0% (Table 8), less than the 85% routinely considered acceptable for

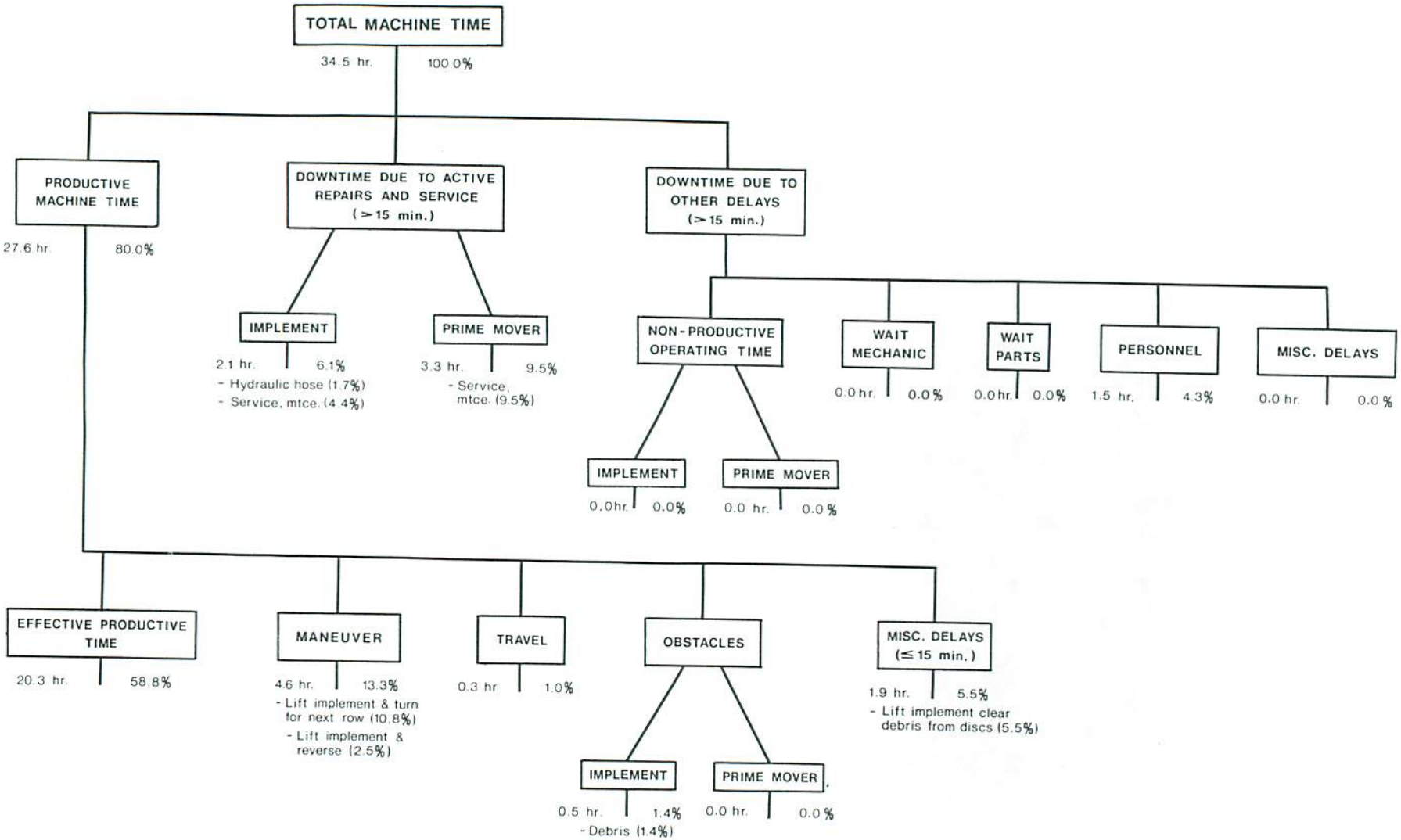

Figure 14. Results of continuous time study.

Figure 15. Pieces of slash and chunks of logs became tangled in the discs and prevented them from rotating.

Table 7. Productivity summary.

Site	Total machine time (hr)	Productive machine hours (PMH)	Travel speed[a] (km/hr)	Area (ha)	Productivity	
					Productivity per effective productive time (EPT) (ha/hr)	Productivity per PMH (ha/hr)
1	14.3	11.8	3.4	13.12	1.43	1.11
2	14.7	11.4	3.4	11.98	1.43	1.05
3	5.5	4.1	6.1	7.61	2.45	1.86
Comb.	34.5	27.3	---	32.71	1.67	1.20

[a] Without stops, i.e., during effective productive time. Prime mover operated in 2nd gear.

equipment of this type. It must be remembered, however, that the equipment was under trial and not fully operational at the time of the study. The mechanical availability of the implement was very good at 92.9% (Table 8).

Post-treatment Assessment

The effectiveness of the site preparation treatment is reflected in three ways: (a) overall soil disturbance including receptive seedbed, (b) plantability, i.e., the proportion of the area treated that is suitable for planting, and (c) the distance between plantable spots across and along the furrows.

Overall Soil Disturbance Including Receptive Seedbed

Soil disturbance was classified on the basis of the amount of exposed mineral soil, mixture of mineral soil and duff and thickness of reduced or compressed duff.

Most of the plantable disturbance, which is synonymous with receptive seedbed, consisted of mineral soil with a firm base. Plantable disturbance was 7.5% and 9.7% on sites 1 and 2, respectively, and approximately 50% greater on Site 3 at 14.4% (Table 9). Marginally plantable disturbance was predominantly moderately thick duff on firm mineral soil.

Plantability Assessment

The number of plantable spots per hectare averaged 970, 1,323 and 1,408 on sites 1, 2 and 3, respectively (Table 10). The combined numbers of plantable and marginally plantable spots were 2,252, 2,073 and 2,253, respectively (Table 10). Of the total number of spots assessed (2,500/ha), 90.1%, 82.9% and 90.1%, respectively, were plantable or marginally plantable (Table 10).

A summary of the relevant information concerning the microsite conditions created by the implement on the first-choice planting spots is provided in Table 11.

Penetration on all three areas was high, averaging 88.8%, 87.8% and 97.4% on sites 1, 2 and 3, respectively. Rock was the only source of inadequate penetration on Site 2 where subsurface stones and boulders were encountered on 56.3% of the area

Table 8. Machine utilization and availability.

Site	Machine utilization	Machine availability		
	(%)	CPPA availability (%)	Implement and prime mover (%)	Implement (%)
1	82.5	82.5	82.5	99.1
2	79.6	85.7	84.5	85.4
3	74.5	85.5	83.7	100.0
Comb.	80.0	84.4	83.6	92.9

Table 9. Overall soil disturbance including receptive seedbed created by implement.

Site	Plantable disturbance and/or receptive seedbed[a]				Marginally plantable disturbance				Total plantable and marginally plantable disturbance
	Min. soil with firm base (%)	Thin (<1.5 cm) duff/min. soil mix; will settle to firm base (%)	Thin (< 1.5) duff on firm base (%)	Total (%)	Mounded min. soil on firm base (%)	Mod. thick (1.5 <3 cm) duff/min. soil mix; will settle to firm base (%)	Mod. thick (1.5 <3 cm) duff on firm base (%)	Total (%)	(%)
1	5.4	0.6	1.5	7.5	0.2	0.1	10.0	10.3	17.8
2	7.2	0.0	2.5	9.7	0.0	0.2	7.8	8.0	17.7
3	13.0	0.0	1.4	14.4	0.3	0.0	11.8	12.1	26.5

[a]Corresponds closely with receptive seedbed criteria for jack pine in northeastern Ontario (Riley 1980).

Table 10. Plantability assessment.

Site	Plantable spots		Marginally plantable spots		Plantable & marginally plantable spots		Non-plantable spots		Total spots	
	(no./ha)	(%)	(no./ha)	(%)	(no./ha)	(%)	(no./ha)	(%)	(no./ha)	(%)
1	970	38.8	1,282	51.3	2,252	90.1	248	9.9	2,500	100.0
2	1,323	52.9	750	30.0	2,073	82.9	427	17.1	2,500	100.0
3	1,408	56.3	845	33.8	2,253	90.1	247	9.9	2,500	100.0

Table 11. Microsite conditions of first choice planting spots.

Site	Soil penetration			Debris			Duff depth			Vegetative competition	Micro-relief			
	Penetrable[a] (%)	Rock[c] (%)	Roots[c] (%)	None[a] (%)	Light[b] (%)	Heavy[c] (%)	< 1.5 cm[a] (%)	1.5 < 3 cm[b] (%)	⩾ 3 cm[c] (%)	None (%)	Level (%)	Raised (%)	Side (%)	Hollow (%)
1	88.8	2.4	---	93.1	6.9	---	68.8	22.5	8.7	100.0	98.6	---	---	1.4
2	87.8	6.2	---	100.0	---	---	76.5	17.2	6.3	100.0	100.0	---	---	---
3	97.4	---	2.6	100.0	---	---	84.6	15.4	---	100.0	100.0	---	---	---

[a] Plantable condition.
[b] Marginally plantable condition.
[c] Non-plantable condition.

(Fig. 16a, 16b). Roots that are characteristic of the associate root mat in conjunction with black spruce lowland areas were the cause of inadequate penetration on Site 3.

Distance between Plantable Spots

The mean distance between plantable spots or marginally plantable spots across the furrows was approximately 2.1 m on sites 1 and 2 and 2.0 m on Site 3. The similar value along the furrows was approximately 2.3 m on sites 1 and 2 and 2.1 m on Site 3.

DISCUSSION

The average depth of mineral soil was 23.1-24.7 cm on all three sites and duff depth averaged 8.0-11.9 cm on Site 1 and 4.0-7.9 cm on the other two areas. Sites 1 and 2 contained considerable quantities of buried stones, and this undoubtedly accounts for the lower penetration levels of 88.8% and 87.8% on these two areas. The topography was generally flat to moderately broken on all three areas. Logging slash was also generally light as a result of the full-tree logging operation. However, slash did present an obstacle to the implement and approximately 6.9% of the total time was spent clearing this debris. This was particularly evident on Site 1, where larger slash pieces often became caught in the discs. Lifting the discs was usually effective in releasing the lodged material. Other site parameters did not appear to present problems for either the implement or the prime mover.

The favorable site conditions no doubt contributed to the high number of plantable and marginally plantable spots per hectare and to the average 90.4% penetration on first-choice planting spots.

A necessary determinant of the success of the operation is also an acceptable number of suitable planting spots. If we assume a desired planting density of 2,500 trees per ha (2-m x 2-m spacing), an overall effective plantability (marginal and plantable spots) of 87.1% was achieved with the Donaren. This measure is limited by microsite conditions and also by the width of the furrows and the distance between furrows. The latter is in part determined by the spacing of the discs on the implement and the operator's ability to maintain a consistent and acceptable (e.g., 2 m) spacing between consecutive passes with the implement. It is left to the forest manager to determine whether, in fact, the level of effective plantability achieved is adequate in view of the nature of the operation and the pretreatment site conditions.

Productivity with the Donaren averaged 1.20 ha/PMH. Productivity may also be expressed as the number of plantable and marginally plantable spots produced per PMH, i.e., silvicultural productivity. This is a measure of the effectiveness of the implement in creating plantable spots while maintaining a given travel speed and distance between furrows. The average silvicultural productivity in this case was 2,631 plantable and marginally plantable spots/PMH. However, the engine speed may have been too low to provide adequate oil flow to the implement, and this could have reduced its overall effectiveness. A high engine speed (rpm) was required for this type of pump to supply adequate flow to the Donaren. The Caterpillar 528 has only a three-speed transmission and, as a result, the necessary engine speed can be obtained only if the prime mover is operated at a high travel speed. It was not able to achieve this speed, however.

Figure 16a. Site 2 prior to treatment, showing surface boulders.

Figure 16b. Site 2 after treatment. Boulders contributed to inadequate penetration on this site.

SUMMARY AND CONCLUSIONS

The Donaren was evaluated during a three-week period on the Upper Spanish Forest Management Agreement of E.B. Eddy Forest Products Ltd. Three full-tree logged sites were selected for the study, two of which were upland areas with gently rolling topography. The third site, a spruce lowland, was flat, with some surface water in evidence. Site conditions were generally light to moderate and the primary differences among the three areas were in the quantity of stones or bedrock on the sites and the quantity of timber remaining after harvesting.

The Donaren appeared to be well suited to the three areas evaluated. Plantable disturbance (receptive seedbed) varied from 7.5% to 14.4% and the combined effective plantability averaged 87.7%.

One repair to the implement was required--the replacement of a hydraulic hose. This required 0.6 hr. Servicing and cleaning accounted for 4.8 hr of downtime or 13.9% of total time. Mechanical availability was 92.9%. However, numerous minor delays resulted when the operator had to raise the implement in order to release the logging slash that accumulated between the discs; this reduced the overall utilization to 80.0%.

Travel speed was between 3.4 km/hr and 6.1 km/hr and machine productivity averaged 1.20 ha/PMH or 2,631 plantable spots/PMH.

The results indicate that the Donaren 180D has the potential to provide good-quality site preparation and acceptable performance on sites with light-to-moderate conditions.

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APPENDICES

APPENDIX A

MANUFACTURER'S SPECIFICATIONS

DONAREN 180D

Measurement:

Disc diameter	950 mm
or	1050 mm
Outer measurement, tooth edge	1250 mm
or	1350 mm
Track spacing	1500-2750 mm
Track width	600- 800 mm
Maximum movement up:	1200 mm
above horizontal position	
down:	1250 mm
below horizontal position	

Weight:

Gross weight	2300 kgs

Discs:

Number of replaceable teeth/disc	10

Hydraulic System:

Required hydraulic pressure	Max. 170 bars
Required flow	70 L/min.
Variable disc rotation (driven version)	Between 15-30 rpm

Hydraulic motors for the driven discs can be driven in three ways:
1) directly from the tractor's pump
2) from a separate pump mounted on the shaft from the power takeoff.
3) from a separate diesel motor with a pump.

Electrical System:

Current - 24 or 12 V
Electrical control panel placed in the driver's cab for desired working positions.

Power Requirement:

Engine power required is approximately 90-115 kW plus 35 kW to run the scarifier.

Cost:

$46,000 (12 August 1985). Power takeoff from prime mover, controls in cab.

Manufacturer:

AB Skogsbruksmaskiner
Box 5
S-783 00 Säter
Sweden
Telephone: 0225/51080

Distributors:

Canadian Forestry Equipment Limited, Western Office
17217-106 Avenue
Edmonton, Alberta T5S 1H9
Telephone: (403) 484-6687

Canadian Forestry Equipment Limited, Ontario Office
7355 Torbram Road, Unit 15
Mississauga, Ontario L4T 3W3
Telephone: (416) 678-1586

Canadian Forestry Equipment Limited, Quebec Office
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DDO Montreal, Quebec H9B 2C5
Telephone: (514) 685-1100

Canadian Forestry Equipment Limited, Maritime Office
65 Thornhill Drive, Burnside Industrial Park
Dartmouth, Nova Scotia B3B 1R9
Telephone: (902) 465-2558

CATERPILLAR 528 WHEELED SKIDDER

Flywheel power	130 KW
Operating weight	14,030 kg
Maximum unloaded operating weight	15,420 kg
Engine model	3,306
Rated engine RPM	2,200
No. of cylinders	6
Displacement	10.5 L
Oscillation, frame type, degrees	+14°
Tires, standard	62.2-81.3 cm
optional	77.5-81.3 cm
Turning diameter (outside rear wheel)	11.5 m
Turning radius	5.76 m
Winch line pull, max. at stall	18 140 kg
Line speed at rated engine RPM	70 m/min
	at 7 850 kg
Drum capacity	53 m
at cable size	19 mm
Fuel tank refill capacity	208 L
Hydraulic system refill capacity	45 L

Transmission:

Power shift with single-stage, single-phase torque converter

Speeds

	1st	2nd	3rd
Forward (km/ha)	8.4	16.3	30.1
Reverse	10.1	19.8	36.7

General Dimensions:

Length with blade	6.93 m
Wheel base	3.25 m
Width over tires	2.92 m
Height to top of ROPS	2.92 m
Height to exhaust	2.95 m
Ground clearance	698 mm
Tread width	2.31 m
Blade width	2.29 m

APPENDIX B

MACHINE TIME FORMULAS

The following formulas were used to calculate utilization and mechanical availability (Folkema et al. 1981):

$$\textbf{Utilization} = \frac{\text{PMH (in shift)}}{\text{SMH}} \times 100\%$$

$$\textbf{Mechanical availability} = \frac{\text{PMH}}{\text{PMH + repairs + service}} \times 100$$

(PMH, repairs and service include both in- and out-of-shift activities)

$$\textbf{CPPA availability} = \frac{\text{SMH-(repairs + service + wait [parts+mechanic])} \times 100}{\text{SMH}}$$

(Repairs and service include only in-shift)

PMH = productive machine hours
SMH = scheduled machine hours

DEFINITION OF TIME ELEMENTS

The productive machine hours (PMH) recorded in the continuous time study were broken down into the following elements. Note that the time study data are separated into shift level availability and productivity elements (Folkema et al. 1981) for reference to day-to-day operations as well as short-term study elements (Smith et al. 1985) for more detailed analyses.

Shift level availability and productivity elements

Scheduled machine hours (SMH): Nominal statement of intent for regular machine activity (e.g., 8-hr shift). It usually corresponds to operator's paid on-job time.

Productive machine time or productive machine hours (PMH): That part of total machine time during which the machine is performing its function.

Active repair: Repair consists of mending or replacement of part(s) in consequence of failure or malfunction. It also includes modifications or improvements to the machine.

Service: Service is routine and preventive maintenance performed to maintain the machine in satisfactory operational condition.

Delay (greater than 15 min.): That portion of SMH during which the machine is not performing its primary function for reasons other than active repair and service. Delay time is divided into:

Nonproductive operating time: Period of in-shift time during which the machine's engine is running but the machine is doing something other than performing its primary function.

Waiting for mechanic(s): That in-shift time during which the machine is broken and is not under repair because of the unavailability of mechanic(s).

Waiting for part(s): Period of in-shift time during which the machine is broken and is not under repair because of the unavailability of part(s).

Miscellaneous delay: Period of in-shift time during which the machine engine is not running for reasons other than for active repairs and service and/or waiting for repairs and service.

Short-term Study Elements

Effective productive time (scarify): Begins when the implement is in the soil and the prime mover begins forward travel. Does not include delays.

Maneuver (turn): Occurs from the time the scarifier has finished a pass until the scarifier begins the next pass. This element may include raising the implement from the ground, turning and then lowering the implement.

Obstacle delay: Occurs from the time the scarifier stops because of an obstruction until scarification resumes.

Travel: Is the time spent a) travelling in the block or to the roadside between breaks, and b) on repairs. It also includes travelling (if under 15 min) between sites.

Delays (less than 15 min): same as delays (greater than 15 min) but includes those times less than or equal to 15 minutes. Short-term delays are part of total productive machine time whereas delays over 15 minutes are not considered part of productive time.