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COMPARATIVE EVALUATION OF BRUSHSAW-MOUNTED SCARIFIERS

Denis Cormier, ing.f.*

Abstract

Motor-manual scarification attachments mounted on brushsaws were tested under four different site conditions to compare their performance. Short-duration time studies and observations of the treatment results formed the basis of the analysis of five scarifiers (ECO, EIA, Nordforest, Scarri and La Taupe) and a manual tool (mattock). Technical, ergonomic and economic considerations are presented to assist the potential user in the selection of a scarifier.

Introduction

Biological, technical or financial constraints make conventional site preparation methods inappropriate on some sites. Motor-manual scarifiers mounted on brushsaws offer an alternative to conventional techniques and allow access to sites which otherwise would not be treated (Figure 1). These tools also offer innovative treatments such as scarifying under a canopy (Cormier and Ryans 1988).

The increasing interest in brushsaw-mounted scarifiers is reflected by the number of models available or being developed. These scarifiers fill a niche in spot scarification which up to now has been held by the mattock. However, to replace the mattock, they must make the site preparation job easier and be more productive.

Figure 1. Brushsaw-mounted scarifier operating on a steep slope.

The objective of the study was to evaluate the performance of the scarifiers in terms of productivity and microsite quality. Five motor-manual models and a mattock were compared.

* Denis Cormier is a researcher, Silvicultural Operations, Eastern Division.
KEYWORDS: Site preparation, Motor-manual method, Scarifying equipment, Spot scarifiers, Difficult sites, Machine evaluation, Treatment quality, Product review.

Cette Fiche Technique est disponible en français.

FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GENIE FORESTIER
143 Place Frontenac, Pointe Claire, Québec, Canada H9R 4Z7, (514) 694-1140
201-2112 West Broadway, Vancouver, B.C., Canada V6K 2C8, (604) 732-3711

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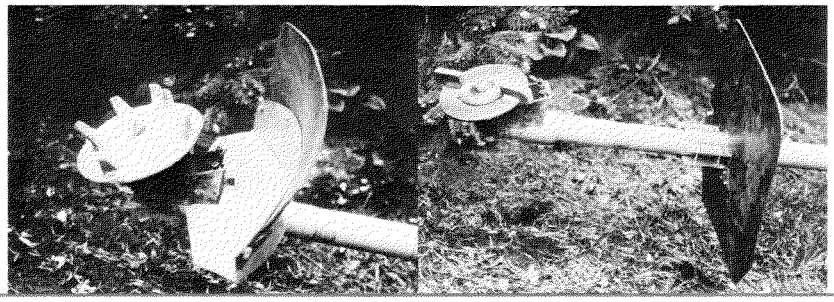
Table 1. Description of scarification tools adapted to brushsaws



	ECO	EIA
Description		
- scarifier	• circular, convex steel plate welded to a frame with 4 braces • 8 teeth	• 2 teeth welded directly onto a circular steel plate
- guard	• protective guard located on the tube • rounded metal framework with a flexible rubber shield	• protective guard located on the tube • semi-rigid rubber shield attached by a metal frame
Manufacturer	ECO-fräsen HB Åselet 1032 930 52 Fällfors Sweden	Edsbyns Industri AB S-828 00 Edsbyn Sweden
Distributor	No Canadian distributor	No Canadian distributor

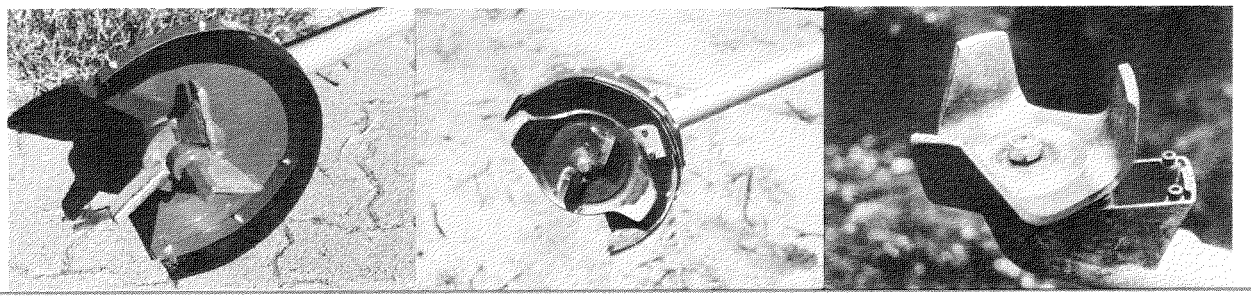
Description of the Tools

Brushsaw

The brushsaw used in the study was the Husqvarna 165RX. It weighs 10.2 kg, has a 65-cm^3 two-cycle engine, and develops a maximum working speed of 12 500 rpm. The only modification to the brushsaw was the removal of the saw guard to attach the scarifiers.

Scarification attachments

The scarification attachments are simply interchanged with the saw blade. The following models were tested: ECO, EIA, Nordforest, Scarri and La Taupe. The La Taupe is designed and built in Canada; the others are from Sweden. Protective guards are available as an option for each attachment. Some of the guards are installed on the tube of the brushsaw to protect the operator from flying objects, while others are attached



Nordforest	Scarri	La Taupe
• steel plate equipped with 3 welded teeth held by rear reinforcement plates • conventional hex nut replaced by either a long pointed nut or auger-type nut	• made of 2 parts which fit together and turn simultaneously • outer sections of the upper plate are slightly curved downward to form 2 teeth • inner plate equipped with 2 welded teeth held by a rear support	• steel plate with outer sections curved downward 90° to form 3 teeth
• soil-retaining and protective guard located on the housing • metal case with opening at front surrounded by a flexible rubber skirt	• soil-retaining and protective guard located on the housing • plastic case with opening at front surrounded by a thin, flexible, double rubber skirt	• protective guard located on the tube • flat metal frame fitted with a semi-rigid rubber shield
Nordforest AB 783 00 Säter Sweden	Silvesco AB Box 108 182 12 Danderyd Sweden	Innovations forestières 3R inc. 401 Cap St-Fidèle Charlevoix, Quebec G0T 1T0
No Canadian distributor	No Canadian distributor	Nova Sylva inc. Box 1624 1587, Denault Street Sherbrooke, Quebec J1H 5M4

on the housing of the angle gear to limit the expulsion of soil caused by the rapid rotation of the scarifying head. Table 1 provides a description of the various scarifiers used in this study. Technical characteristics and approximate retail prices of the scarifiers are provided in Table 2.

The forestry mattock, used as a reference tool, is of Nordic origin (Figure 2). It has a curved blade 125 mm wide by 210 mm long. The straight handle is 830 mm in length. The tool weighs 1.5 kg.

In 1988, two other motor-manual scarifiers were being developed in British Columbia (Maxwell 1989), but were not part of this study. The Hawk Power Scalper is mounted on an Echo chain saw rather than a brushsaw. The Rippa uses a brushsaw, but was not commercially available. Both of these scarifiers use double-torsion springs to work the soil rather than fixed teeth.

Figure 2. Microsite prepared with a mattock.

Table 2. Technical characteristics of the scarifiers

	ECO	EIA	Nordforest[1]	Scarri	La Taupe
Weight (kg)					
scarifier	0.82	0.70	1.11	1.19	0.68
guard	0.96	0.56	1.42	0.29	0.71
Diameter (cm)					
scarifier	15.2	16.7	18.4	20.3[2]	13.0
Height (cm)					
scarifier	7.1	2.8	6.4	4.2	6.0
teeth	2.5	2.3	2.5	3.0	5.6
Price (approx.)					
scarifier	$72	$32	$79	$74	$32
guard	$39	$32	$82	$83	$35

[1] Installing the auger-type nut instead of the long, pointed nut increases the weight to 1.16 kg, the height of the scarifier to 10.1 cm, and the price to $117.

[2] The inner plate is 11.0 cm in diameter and 2.8 cm high.

Study Methods

The scarification tools were evaluated on two different sites. Each site was further divided into two homogeneous blocks providing distinct slope conditions. All six tools were tested side by side in three of the four blocks; the fourth block was not of sufficient size to test all the tools. In all blocks, the tools were used to create 25 spots each, at a 2-m spacing and with a defined diameter of 30 cm. Each spot was outlined with spray paint beforehand. The depth of the spots was largely a function of humus depth. The operator was instructed to work the spots until mineral soil was reached and to create, when possible, a mix of mineral soil and humus.

Using the evaluation procedure generally followed by FERIC, a pre- and post-treatment site description was carried out, as well as a detailed time study. The operator for the study had been trained in the use of a brushsaw, but had only a few hours prior experience with the scarifiers. The studies were done in May 1988.

Study Sites

The two test sites were located in southwestern Quebec on the limits of Industries James MacLaren Inc. They had been clearcut less than a year earlier. A brief site description is given in Table 3.

The study sites had no standing residuals, a negligible number of saplings and very little ground vegetation. The number of stumps was similar on both sites. However, slash cover, soil stoniness and humus depth, which affected scarification, differed between the two sites. Site conditions at Val-des-Bois were rated as being very easy, and those at Buckingham as relatively easy. Each site had one flat block; the second block at Buckingham had a gentle slope while that at Val-des-Bois had a steep slope.

Table 3. Pretreatment site conditions

	Val-des-Bois		Buckingham	
Stumps (no./ha)	1170		1015	
Slash cover (%)	0*		17	
Stoniness (%)	2		22	
range (%)	0-24		4-42	
Humus depth (cm)	3		10	
range (m)	2-6		8-14	
Soil texture	sandy loam		loamy sand	
Slope	Block 1	Block 2	Block 3	Block 4
mean (%)	4	44	5	12
range (%)	4	21-51	5	0-25

* The test sites were manually cleaned before treatment since the debris conditions were not homogeneous.

Results

Figure 3 schematically presents a comparison of individual treatment means based on the time study data (in hundredths of a minute) for each tool in each of the test blocks. In general, the scarifiers performed equally well over the range of test sites. Under the observed conditions, the performance of those scarifiers without a guard at ground level did not differ significantly from each other. Differences in humus depth did not seem to influence their productivity. The operator had a tendency to scarify deeper than necessary with the scarifiers that had the faster digging speeds. However, the productivity of the scarifiers having a guard around the attachment (Nordforest, Scarri) had lower digging speeds and were more affected by site conditions.

Except for Block 2, where the Nordforest also performed poorly, the mattock was significantly slower than the motor-manual scarifiers. It is interesting to note that the mattock performed relatively better on the steep site. Slope allows for a better working position when using a mattock.

The Nordforest guard seemed to hinder the operator, particularly on the steep slope of Block 2. The greater average time per spot can be attributed to the scarifier becoming unbalanced and less effective in penetrating the soil when the heavy guard is attached. The difficulty in penetrating the soil is also indicated by its poorer digging index (Figure 4). When used without its guard on Block 3, the Nordforest performed similarly to the others. The guard on the Scarri allowed the operator to prepare well-mixed microsites rapidly when the humus was thin (Blocks 1 and 2), but it impeded the operation on the site which had deeper humus (Block 4).

The average manoeuvring time between spots for each tool reflects, among other things, the relative difficulty of handling each tool (Table 4). The Nordforest with the guard is much heavier than the four other motor-manual tools. This creates an uneven weight distribution on the brushsaw which makes it more difficult to manipulate. When using a mattock, the worker is required to make more physically demanding movements such as bending and swinging. The rhythm developed with the mattock while preparing just 25 spots during the trial would be much more difficult to maintain over an entire work day than for the motor-manual tools.

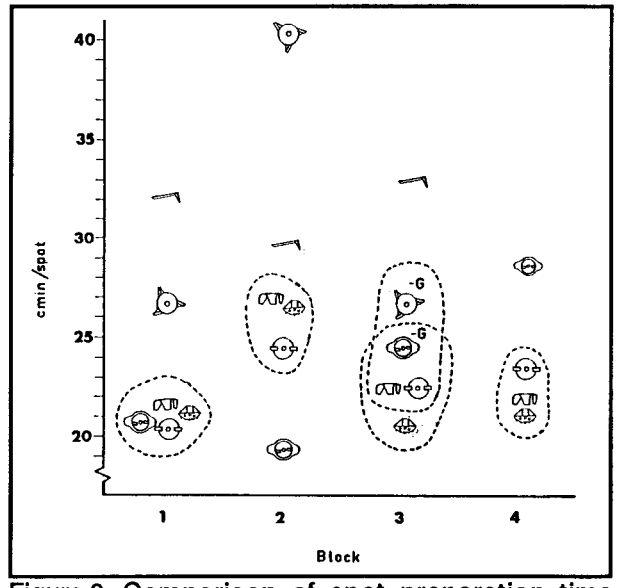


Figure 3. Comparison of spot preparation time (scarifying and manoeuvring) by block.

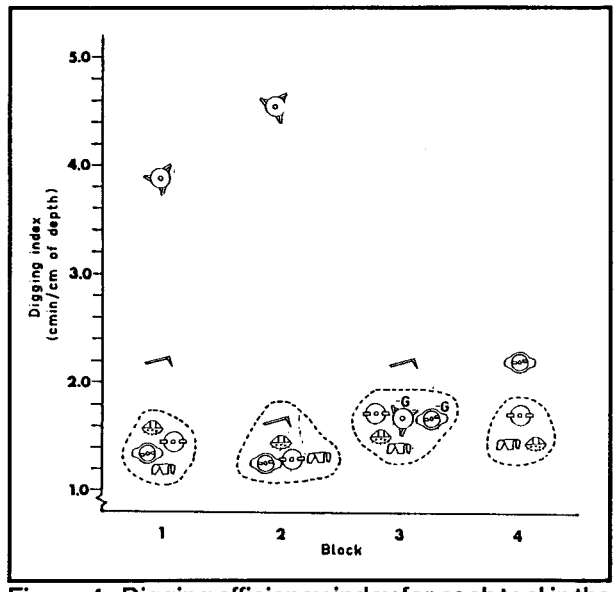


Figure 4. Digging efficiency index for each tool in the four blocks.

Legend

: ECO
: Scarri
: EIA
: La Taupe
: Nordforest
: Mattock

- All tools were tested with a guard except those indicated by the symbol -G.
- The performance of tools circled with a dotted line is not significantly different according to a Duncan multiple range test (ρ = 0.05).

Table 4. Average manoeuvring time between spots per tool (all blocks combined)

	Manoeuvre time per spot (cmin)
EIA	6.2
ECO	6.2
Taupe	6.3
Scarri	6.4
Nordforest	7.3
Mattock	9.0

According to our observations and the operator's opinion, this study likely overestimates the daily productivity of the six tools because of the short time duration. According to Cormier and Ryans (1988), the productivity was more in the range of 100 to 200 spots per productive hour when monitored over an entire shift.

The quality of work produced by each tool generally met the treatment objectives. The percentage of spots with mixed mineral soil and humus, or with exposed mineral soil, varied from 94 to 100% depending on the tool tested (Figure 5). Inadequately prepared spots were few, mainly occurring with the motor-manual tools on microsites which had deeper humus (greater than 15 cm). Rocks, large roots and the flipping back of the overturned root mat caused minor difficulties for the mattock. The Scarri provided the best mineral soil-humus mix, with 80% of spots meeting this criterion. The mattock also gave very good control over soil mixing.

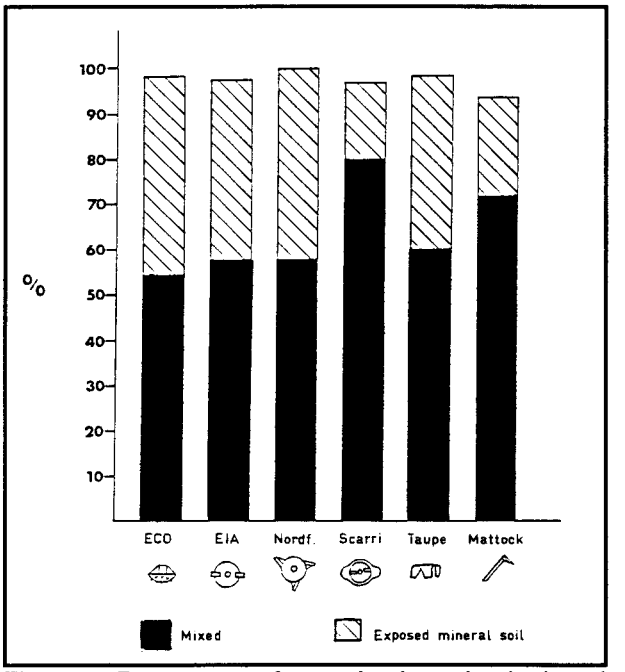


Figure 5. Percentage of spots having mixed mineral soil and humus, or with exposed mineral soil, by tool type.

Discussion

Terrain Conditions

Site conditions determine the applicability of brushsaw-mounted scarifiers, and partially dictate the choice of the most appropriate scarifier.

The microsite produced by these tools, a depression of varying depth, is itself restrictive. This type of microsite is suited to well-drained sites, but risks being regularly flooded on poorly-drained soils.

The manoeuvring time between spots increases with ascending slope. However, slope can have a positive effect on the overall operation when working upslope since the operator's posture is then similar to that during normal operation of a brushsaw.

The humus depth also has an important influence on working speed. Deep humus requires a larger spot, in depth and width, which takes more time to prepare. The scarifiers equipped with a guard at ground level are particularly affected by humus depth. Although the guard reduces soil expulsion and favours mixing of humus and mineral soil, it nevertheless hinders working the soil more deeply.

Ground vegetation conditions were very easy on the sites studied. Therefore, it was not possible to observe the influence of denser vegetation on the specific output of each tool. However, this factor was addressed during a study undertaken in British Columbia which included the La Taupe, the ECO and the Scarri (Maxwell 1989). This study showed that the operators preferred working with the La Taupe when ground vegetation was from medium to dense, in which they experienced problems with the other two scarifiers.

During the FERIC study, the relatively higher soil stoniness and the thin slash layer in Blocks 3 and 4 did not result in any appreciable operational differences. However, a heavy slash load could be a hindrance for this work, particularly affecting movement between spots. Carrying and using the brushsaw among branches and tops would render the operator's job much more difficult.

Technical Considerations

With the exception of the Nordforest, the tools tested produced similar results under the easy trial conditions. The auger and the pointed nut of the Nordforest attachment restricted lateral movement of the scarifier. Also, because of the inclined angle of the tool while scarifying, the hole made by the auger is not perpendicular to the ground and therefore can not be used to plant a containerized seedling as intended (Figure 6).

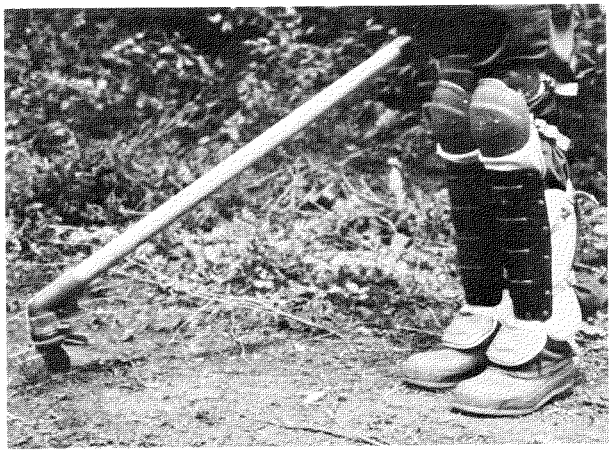


Figure 6. Working angle of the Nordforest at ground level. (Note that the auger is not perpendicular).

The shape of the different scarifiers also gives them distinctive characteristics. The leading edge of each tooth is a narrow face on the La Taupe, the ECO and the Scarri, while the EIA and the Nordforest both have a wide leading edge. Teeth with a narrow leading edge provide more of a cutting action rather than a throwing action and should perform better where the root layer is heavier.

The life span of the scarifying attachments was not evaluated during this study. However, a prior study showed that the La Taupe was good for about 2500 microsites (Cormier and Ryans 1988). Also, Maxwell (1989) contends that the ECO and the Scarri have a shorter life span than the La Taupe. No precise information on the subject is available for either the EIA or the Nordforest. In general, the guard does not require replacement when the scarifying attachment is worn out.

The two types of protective guards, tube-mounted and ground-level, were indirectly evaluated. The guards only partially protect the operator, who should also be equipped with complete protective equipment, including leg protection and a visor. Guards installed on the tube interfere very little with the operation of the machine. When installed at the level of the housing, they directly affect both productivity and work quality. However, on thin humus, these guards help to prevent the expulsion of soil; conversely, on thick humus, they hinder the tools penetration into the soil. The lightweight construction of the Scarri guard and the pliable protective skirt made the Scarri much easier to use in comparison to the Nordforest with its heavy guard.

Ergonomic Considerations

Brushsaws are designed so that the harness can be attached at different places on the tube between the handle and the engine, so as to provide balance for operator comfort and ease of operation. Table 5 shows how the centre of gravity shifts when the brushsaw is equipped with scarifying heads instead of a saw blade. For an operator 1.85 m tall, the maximum weight at the housing that still permitted balancing the machine was 2.0 kg. This weight would vary slightly depending on the operator's height. During this test, only the Nordforest with the guard could not be balanced, and this made it harder for the operator to work with.

The horizontal handle bar on a brushsaw is designed for the cutting of stems above the ground level. Since the scarifier works between 10 and 30 cm lower, the handle bar should be rotated toward the operator to provide for a more comfortable working position. An upright handle bar with a longer right handle is available from some manufacturers.

A study done in Sweden by the National Safety Board shows that the high-frequency vibrations transmitted through the brushsaws were similar during scarification and brushcutting, but low-frequency vibrations (kickback) were greater when scarifying (Marntell 1988).

Table 5. Displacement of the centre of gravity of the brushcutter[1]

	Displacement (mm)	
	Without guard	With guard
Reference (saw blade and blade guard)	0	0
ECO	15	85
EIA	5	40
Nordforest	35	>105[2]
Scarri	35	55
Taupe	5	50

[1] Husqvarna 165RX brushsaw having a full gas tank and used by an operator 1.85 m tall.

[2] A displacement of 105 mm corresponded to the maximum distance possible between the reference point and the handles. A counterweight of 865 g had to be added.

Economic Considerations

It is difficult to make direct use of the time tests reported herein to derive productivity rates which could be used for cost analyses. Data from a recent report on the La Taupe show that a good operator can produce 800 to 1200 microsites per day for a total cost of $360 to $530/ha (Cormier and Ryans 1988). On sites similar to those studied, treatment costs with the ECO, the EIA or the Scarri should be similar to the cost for the La Taupe, but those of the Nordforest would generally be higher. Since labour represents most of the treatment cost, the use of these tools is of particular interest to private woodlot owners who already own a brushsaw and have the time to do the work themselves.

It is difficult to compare directly the work with a mattock to the motor-manual scarifiers. The mattock is used at the same time as planting, which means that the time spent mavoeuvring between spots should be attributed to planting rather than scarifying. If this manoeuvring time was subtracted from the total scarification time for the study data, the resultant productivity level would be similar to the motor-manual tools. However, the time studies were carried out on a limited sample and do not take into account the fatigue factor, which would be much greater with the mattock. Field personnel report a productivity of around 400 planted spots per man-day using the mattock.

Considering a scarification productivity of 1000 spots per man-day and a normal planting productivity of 1500 seedlings per man-day, the productivity of the system with motor-manual scarifiers would be around 600 planted spots per man-day. Assuming a daily rate of $200 per man-day for the motor-manual work (including the operator and the brushsaw), $180 per man-day for the manual work (planting/mattock), and a cost of $30/ha for wear to the scarifier, the motor-manual scarification and planting system would cost about $830/ha while the manual scarification and planting system would be $1125/ha. However, a more complete analysis of these systems would be necessary to verify this hypothesis.

Conclusions

Few differences were observed among the scarifiers in the test conditions, except for the Nordforest which proved less productive with the guard. Field conditions and certain technical, ergonomic and economic considerations will guide the user in the choice of a specific tool.

Even though the high cost of this scarification method may restrict its use, brushsaw-mounted scarifiers have some characteristics which could fill gaps in the present alternatives for site preparation.

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