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Contents

Evaluation of the Bräcke M36a three-row mounder

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Abstract

Feric evaluated the Bräcke M36a three-row mounder in cooperation with the Coopérative Forestière de Girardville and AbitibiBowater Inc. in the Lac Saint-Jean region of Quebec. The study's main objectives were to identify a niche for the Bräcke M36a (the most appropriate site conditions) and to determine whether the mounder could increase scarification productivity by 50% thanks to the third mattock wheel. We performed a detailed study that measured plantability as a function of site conditions and a long-term study that determined overall productivity throughout the season. To evaluate plantability, we established three study sites with semi-permanent sample plots to determine the relationship between pre-treatment site conditions and treatment quality. We monitored long-term productivity using GPS data throughout the 2007 operating season. Contractors also filled out a daily journal to record details on the areas that were treated and the costs related to operation of the mounder. Because the Bräcke M36a performs a unique type of scarification, it fills a niche in Quebec's fleet of scarification equipment. Despite its three-row configuration, it did not attain the predicted productivity (50% greater than a comparable two-row device). However, its productivity (plantable microsites) equaled and sometimes surpassed that of a powered-disc trencher.

Keywords:

Bräcke M36a, Productivity, Plantability, Bräcke three-row mounder, Disc trencher, Site preparation, Scarification equipment, Machine evaluation, Scarification.

Introduction

FPInnovations, Feric Division partnered with the Coopérative Forestière de Girardville to study the Bräcke M36a mounder. This machine, which treats three rows simultaneously rather than the conventional two-row scarifiers, could potentially improve site preparation productivity. In addition, the mounds or patches produced by the Bräcke M36a offer the possibility of a wider range of treatments than those provided by conventional disc scarifiers. Under favorable conditions, this scarifier would provide microsites that are more suitable for the plant growth and thus, could potentially increase the yield of certain sites.

Trials conducted in Ontario and New Brunswick (Cormier 2006) demonstrated that this new scarifier provided adequate work quality on sites with abundant debris produced by harvesting with at-the-stump delimbing. Compared with the teeth of disc scarifiers, those of the Bräcke mounder can more easily penetrate between debris, thereby facilitating the machine's ability to treat the soil. However, it was not yet clear whether the mounder could produce mounds in soils with a thick layer of organic matter (humus and debris).

The trials in the present study were designed to evaluate the new scarifier's effectiveness under a range of site conditions and to identify its operational constraints. We also monitored operations throughout the operating season to determine the long-term utilization rate and treatment costs.

Site preparation techniques

Bräcke M36a

The M36a represents a new generation of hydraulic-controlled mounders developed by Bräcke Forest AB (Figure 1). The mounder consists of three arms equipped with toothed mattock wheels that create mounds or patches at regular intervals. The three-row system theoretically offers the possibility to cover 50% more area per pass than with a comparable two-row system.

The mattock wheels of the M36a are mounted on articulated arms, and each wheel is equipped with three rows of ripper teeth (Figure 2). A model with four sets of teeth per wheel is also available. The mattock wheels have a 725-mm radius and are 450 mm wide. Each wheel is equipped with a pressure sensor that allows the machine to detect shocks caused by obstacles and react appropriately so as to prevent breakage of mechanical components. The three arms are independently articulated and offer a wide range of combinations of angles of attack and spacings between the mattock wheels. The maximum spacing between the arms is 2.2 m.

The M36a offers eight predefined site preparation programs. These programs allow the operator to control the configuration parameters. In the present study, three of pre-set programs were used (Table 1). The onboard computer can record a range of information, such as the number of mounds created per block and per time period, the area scarified, the distance covered, and the number of hours of operation.

The manufacturer recommends using the Bräcke M36a with a forwarder to provide sufficient hydraulic capacity. In the present study, the M36a was mounted on an eight-wheeled Timberjack 1710D forwarder with a net power of 160 kW. The prime mover and the scarifier were leased, and neither underwent major modifications except for the addition of a push bar

Figure 1. (*left*) The Bräcke M36a mounder mounted on an eight-wheeled Timberjack 1710D forwarder.

Figure 2. (*right*) The mattock wheels of the Bräcke M36a are equipped with three sets of ripper teeth.

Configuration parameter	Program		
	Mound	Short patch	Long patch
Wheel rotation speed	-5% of the forwarder's speed	-5% of the forwarder's speed	-25% of the forwarder's speed
Angle of attack for patch creation (°)	9	9	9
Mattock locked distance (cm)	60	90	220
Angle of mound compaction (°)	105	105	105
Mound length (cm)	30	30	50
Distance over which down pressure is exerted to compact the mound (cm)	0	20	50
Spacing between the wheels (cm)	200	200	200
Distance between the mounds (cm)	250	282	440
Potential number of mounds/ha	2000	1775	1135

Table 1. Description of the three programs used during Feric's trials of the Bräcke M36a mounder

on the front of the forwarder in mid-season to push over standing stems. The operator had no previous experience in site preparation or in driving a forwarder.

Disc scarification

Disc scarification is the most commonly used type of site preparation in Quebec. This technique accounts for more than 75% of the total area treated each year, so we chose it as the basis for comparison in the present study.

Bräcke T26a powered disc trencher

The Bräcke T26a powered disc trencher belongs to the most recent generation of scarifiers. It is fully powered, and can be controlled by the operator from the cab. Its onboard computer offers six predefined programs that control the following variables: the angle of attack of the discs, the spacing between them, their down-pressure, their rotation speed, and their direction of rotation. In addition, it's possible to pre-program the desired type of scarification (continuous or intermittent). The onboard computer also provides a range of information that is useful to forestry contractors, such as the area treated, the distance traveled, and the number of hours worked.

In our comparative study, we used the Bräcke T26a in the Lac Dobleau test area. The scarifier was mounted on a John Deere 748G skidder, and its discs were equipped with short teeth (Figure 3). For

Figure 3. The Bräcke T26a powered disc trencher mounted on a John Deere 748G skidder.

the comparison, we used the following parameters: a disc rotation speed less than 60% of the forwarder's speed, a 60° angle of attack of the discs, no hydraulic down-pressure, and 200 cm between the centers of the discs. These settings provided 2500 potential microsites/ha.

TTS-Delta powered disc trencher

Although it is an older model, the TTS-Delta powered disc trencher is still widely used in Quebec. The device was used at the Hertel and Philippe study sites, with a distance of 2 m between the centers of the discs. The disc rotation speed, their angle of attack, and their down-pressure were not recorded. The scarifier used at the Hertel site was mounted on a John Deere 748E skidder (Figure 4) whereas the one at the Philippe site was mounted on a Timberjack 640 skidder.

Figure 4. The TTS-Delta powered disc trencher mounted on a John Deere 748E skidder.

Methods

Detailed studies

Three test sites were used to evaluate the effectiveness of the Bräcke M36a and identify its operational constraints under a range of site conditions and as a function of various program configurations.

We established semi-permanent sample plots to let us establish a relationship between the pretreatment and post-treatment measurements at the same location.

Pretreatment inventories

In the pretreatment inventories, we gathered the following data: the location and description of the sample plots, stump height, humus thickness, the number of residual trees and saplings, stoniness, debris, herbaceous vegetation cover, and the disturbance characteristics of the site.

Machine productivity

For our detailed monitoring, we analyzed the work performed by the machines using onboard dataloggers equipped with GPS recorders. The GPS information was analyzed using Feric's Geofor software.

Post-treatment inventories

We measured all the patches and mounds produced within the study plots. Gingras and Cormier (2008) provide details of the criteria used to evaluate the quality of the microsites that were produced. These criteria are relatively strict because they account for the presence of advance regeneration and the absence of herbicide use to control the herbaceous competition.

Long-term monitoring

Long-term monitoring of the results produced by the Bräcke M36a scarifier was carried out throughout the study period using an onboard Geotrack electronic datalogger equipped with a GPS system. The description of the treatment areas was also recorded in a daily journal filled in by the foreman who supervised the work.

Description of the study areas

The three study sites monitored during the detailed studies were located in different parts of Quebec's Saguenay–Lac Saint Jean administrative region. Each was established in AbitibiBowater Inc.'s limits managed under a wood supply and forestry management contract ("contrat d'approvisionnement et d'aménagement forestier", CAAF).

Dobleau site

The Dobleau site is located northeast of Saint-Félicien, at 49°56'57"N latitude and 73°47'21"W longitude. The sites were established inside the area affected by a forest fire. Many burned saplings remained standing, and some mature residual trees had also been burned. The stems were well spaced because the young jack pine stand had undergone a precommercial thinning prior to the burn (Figure 5a). In addition, abundant shrubs had regenerated after the fire. The site was described as ecotype MS22. Field surveys classified the soil as a sandy loam with good drainage. The slope averaged 12%.

Hertel site

The Hertel site was the northernmost site in the study. It was located northeast of Saint-Félicien, at 50°11'1''N latitude and 73°16'95''E longitude, within an area of forest that burned. The burned wood was harvested using the full-tree or tree-length system. The original stands were 50-year-old black spruce, with a density in classes B and C. The site was described as ecotype RE22 under Quebec's site classification system. The field surveys classified the soil as loamy sand with moderate drainage (Figure 5b). The slope averaged 5%.

Philippe site

This site was located northwest of Roberval in the La Lièvre controlled-harvesting zone, at 48°34'79''N latitude and 72°60'50''W longitude. This site included areas harvested with the protection of advance regeneration and soils (HPRS) in a mature forest that had not been burned. The harvesting was performed by a single-grip harvester that delimbed and bucked the trees on the cutover. The site was classified as ecotype RE22. The harvesting debris was concentrated in the extraction trails. The sites are on a sandy soil with good drainage and the slope averaged 5% (Figure 5c).

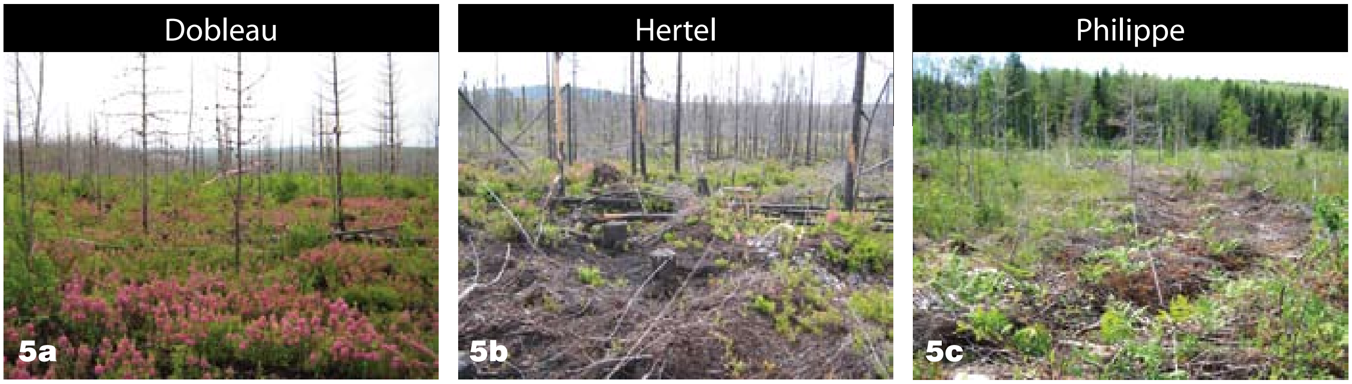


Figure 5. Overview of the sites before treatment for the (5a) Dobleau site, (5b) Hertel site, and (5c) Philippe site.

Results

Detailed study

Pretreatment site conditions

Table 2 summarizes the pretreatment site conditions in the areas where we conducted the detailed study.

Treatment quality

The Bräcke M36 scarifier produced plantable microsites on the mounds and in the patches excavated to create the mounds. The total number of ideal microsites on the mounds and in the patches averaged 1208/ha with the *mound* program and 1443/ha with the *short patch*

Table 2. Description of site conditions before treatment using the three scarifiers

Site conditions	Dobleau	Hertel	Philippe
Volume of debris (m^3/ha)	63	18	29.5
Number of pieces of debris/ha < 5.0 cm in diameter	8	12	114
Number of pieces of debris/ha > 5.0 cm in diameter	5	3	2
Average depth of the debris (cm)	3	4	13
Coverage of the ground by debris (%)	11	9	38
Number of stumps/ha	663	933	1066
Number of residual trees/ha	277	193	65
Stocking of softwood regeneration (%)	1	2	20
Stocking of all tree species (%)	91	25	72
Number of stems of softwood regeneration/ha	27	65	1246
Number of stems of all tree species/ha	33 095	6172	12 946
Cover of herbaceous vegetation and shrubs (%)	46	25	41
Mean humus thickness (cm)	10	23	12
% of soil deeper than16 cm	73	91	76
% of soil deeper than 30 cm	48	69	59
Stoniness of the soil (%)	23	25	30

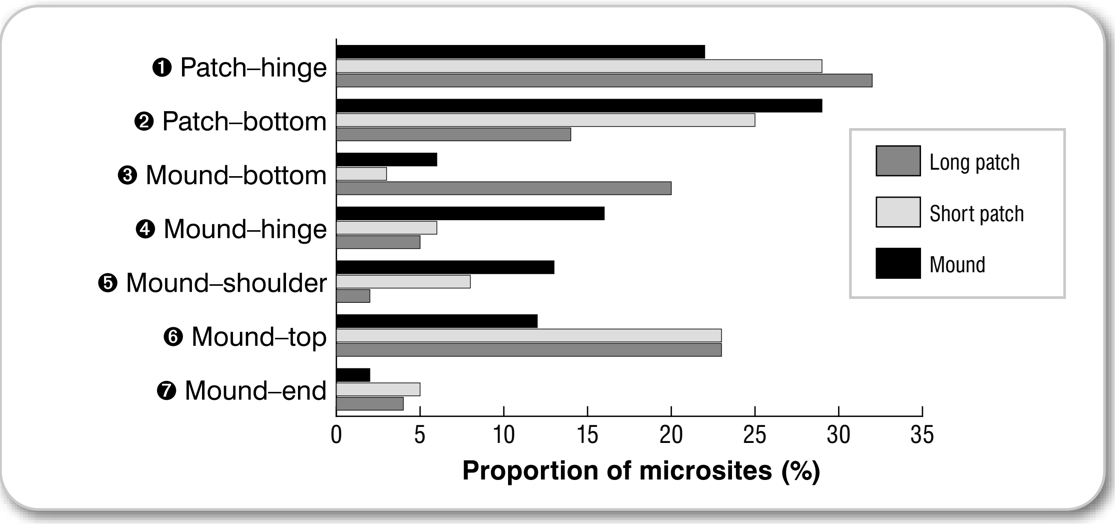
Table 3. Summary of the plantable microsites produced by the site preparation

Type of treatment	Area	Microsites/ha	
		Ideal	Marginal
Discs	Dobleau	1511	302
	Hertel	1776	47
	Philippe	844	316
	Average	**1377**	**222**
Mounds	Hertel	1625	26
	Philippe	791	60
	Average	**1208**	**43**
Short patches	Dobleau	1385	30
	Hertel	1748	87
	Philippe	1196	48
	Average	**1443**	**55**
Long patches	Hertel	1304	0
	Philippe	1123	27
	Average	**1213**	**13**

program (Table 3). Adding marginal microsites to the ideal microsites increased the number of microsites potentially suitable for planting by less than 5%. The total densities of plantable microsites (ideal and marginal) were 1251, 1498, and 1226 microsites/ha, respectively, for the *mound*, *short patch*, and *long patch* programs.

Distribution of the microsites produced by the Bräcke M36a

With all three programs, most of the ideal microsites were located in the patches, primarily at the bottom and hinge of the patch (Figure 6, Table 4). For the *mound* program, the ideal microsites on the mound were mostly located on the hinge, whereas for the *short patch* and *long patch* programs, they were mostly located on top of the mound.



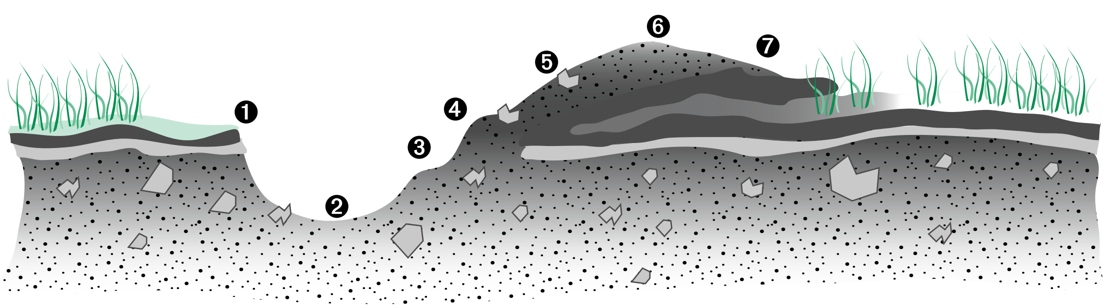


Figure 6. Positions of the ideal microsites produced by the Bräcke M36a scarifier using each of the three programs. Values are for all three study sites combined.

Table 4. Distribution of ideal microsites produced by the Bräcke M36a scarifier using each of the three programs. Values are for all three study sites combined

	Patch (% of total)		Mound (% of total)				
	Hinge (1)	Bottom (2)	Bottom (3)	Hinge (4)	Shoulder (5)	Top (6)	End (7)
Program							
Mound	22	29	6	16	13	12	2
Short patch	29	25	3	6	8	23	5
Long patch	32	14	20	5	2	23	4

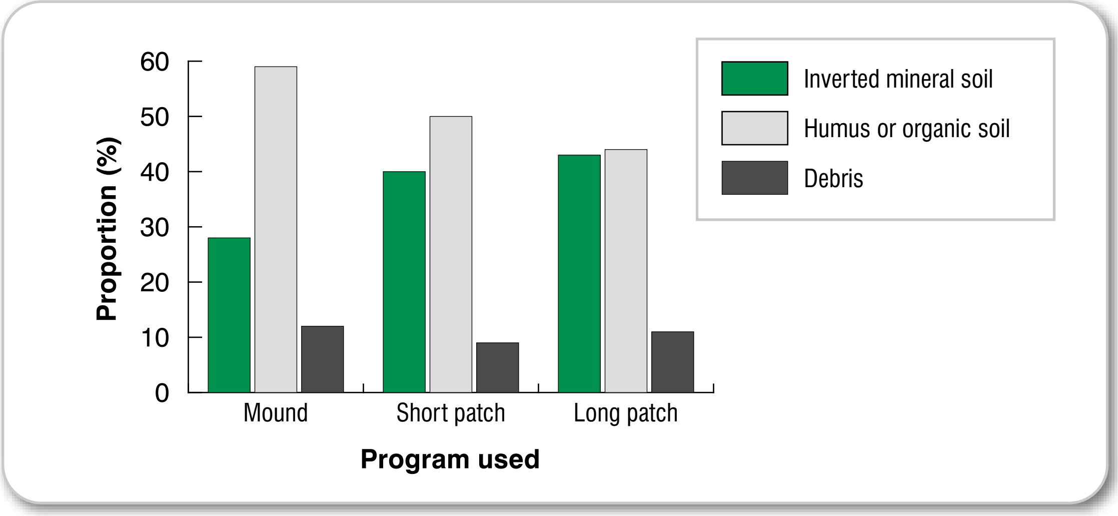


Figure 7. Composition of the mounds produced by the Bräcke M36a scarifier using each of the three programs, for all three study sites combined.

Proportion of mound types

The *short patch* and *long patch* programs produced different mounds (Figure 7). With all three programs, the mounds were composed primarily of humus or organic soil (from 44 to 59%) and of inverted mineral soil (from 28 to 43%). By excavating more mineral soil than with the *mound* program, the *short patch* and *long patch* programs created more mounds composed primarily of inverted mineral soil.

Productivity in the detailed study

Productivity using the *mound* program was 40% greater than that using the *short patch* program on sites with non-burned areas and 60% greater than on sites with burned areas. On the latter sites, productivity was similar for the *long patch* and *short patch* programs. However, productivity increased considerably when using the *long patch* program in non-burned areas. This can be explained by the fact that the *long patch* program produced fewer mounds per hectare; thus, the forwarder was probably slowed less by the drag created by the ripper teeth during penetration of the soil to create the patch from which soil was excavated to produce the mound.

Comparison between mounding and disc scarification

It is difficult to directly compare the two mounding and disc scarification treatments because of the different natures of the microsites that are created. Disc scarification creates microsites along more or less uniform furrows, whereas mounding creates a series of patches and mounds.

Compared with disc scarification, a larger number of factors affect the creation of potential microsites by mounding. With disc scarification, reforestation is possible in the same year, but with the M36a, it is preferable to wait until the following spring to give the mounds time to settle and become more stable. Our study demonstrated that during the year of the scarification, most of the mounds were unstable, particularly in areas with a large quantity of debris on the ground, high stoniness, or a high percentage of shallow soil (high boulder content in the first 16 cm of soil).

Using the *short patch* program, the M36a creates roughly the same number of potential microsites (ideal + marginal) as powered disc scarification, but the proportion of potential microsites is higher (Table 3). However, most of the microsites are not found on the mound, which is the desirable microsite expected with this type of site preparation.

For both types of scarification, it was difficult to establish significant relationships between the pretreatment site conditions and the quality of the site preparation. This can probably be explained by two factors: too many interactions between the site conditions and the work quality, and the low amount of variation in site conditions between the study sites. The main factors that influenced both the disc scarification and the mounding were the stoniness, soil depth, and coverage of the site by shrubs.

Long-term study

Productivity observed throughout the operating season

The estimated long-term productivity does not account for the influence of the different programs. The mean productivity for a standardized spacing of 6 m between passes was 1.11 ha/PMH, and the actual observed values ranged between 0.48 and 1.59 ha/PMH, for an annual average of 1.02 ha/PMH. For the whole operating season, the effective work time accounted for 90% of productive time; operational delays of less than 15 minutes accounted for the remaining 10%.

Given the pass spacing of 6 m, the expected productivity of the M36a should be significantly greater than that of a disc trencher, which uses a 4-m pass spacing. The productivity of the M36a was only about 14% greater than the average for disc scarifiers working in Quebec (Gingras and Cormier 2009). No increase in productivity was observed after adding the push bar to the front of the forwarder.

Treatment costs

Our analysis of the costs per microsite accounts for both the utilization cost and the treatment quality. In this analysis, it is necessary to first determine the operating costs per PMH of the machine–scarifier combination. The cost per hectare can then be estimated based on a standardized productivity based on the spacing between passes. The observed plantability at each site can then be used to calculate a cost per microsite for each machine.

The hourly cost of the Bräcke M36a was higher than that of the Bräcke T26a because of the former implement's higher purchase and operating costs. Despite the use of wider passes thanks to the M36a's three-row configuration, the productivity increase did not reach the targeted levels, and therefore did not compensate for the higher operating costs (Table 5).

Table 5. The costs of the scarifiers used in Feric's study

Scarifier	Cost ($/PMH)[a]	Cost ($/ha)	Cost ($/microsite)[b]
Bräcke M36a	337	302	0.20
Bräcke T26a	214	224	0.14

[a] Calculated based on a mean utilization rate of 69.3% for the machines (Gingras and Cormier 2009).

[b] For the M36a, the calculations were based on the potential microsites obtained during the study using the *short patch* program (Table 4).

Implementation

Silvicultural prescription

The silvicultural prescription plays an important role in the success of the site preparation. Interest in the Bräcke M36a arises from its ability to produce a range of microsite types that may be better adapted to site conditions than the microsites created by the scarifiers that have traditionally been used in Quebec. However, as is the case with the other scarifiers, the quality of the results depends on the site conditions. To facilitate implementation of the prescription, it's therefore important to better understand how site can influence the quality of the implement's work as a function of the types of microsites that are desired (mounds or patches). The results of the present study provide some insights, but it will be necessary to continue these studies to better define the niche for this new scarifier and develop a flowchart to guide its use.

In addition, the size and configuration of the blocks should be considered when the Bräcke M36a is used with a forwarder because this equipment combination requires more time and space to turn around at the ends of blocks than a skidder with a conventional disc trencher. The selection of operating blocks that permit long passes by the scarifier would decrease the likelihood of non-productive delays caused by such maneuvers.

Planning and supervision of the work

Planning and supervision of the work are crucial with the Bräcke M36a, since the machine has a high hourly cost that can potentially be offset by the possibility of using a large number of different programs to account for the different site preparation needs that arise from the range of conditions present on the cutover. Allocation of blocks based on using the right tool in the right place is also important. The operator should be trained well to understand the program options that are most suitable for the specific conditions in each block.

The choice of programs is even more important because it affects both the implement's productivity and its work quality. Poor utilization can increase operating costs or decrease scarification quality. Operators and their supervisors must understand how the Bräcke M36a works and how to use the onboard computer to adjust the scarification program in response to the site conditions, thereby optimizing the scarifier's work.

Performance of the work

The operator is the most important person who determines the success or failure of scarification with a Bräcke M36a. They must have sufficient experience operating a forwarder, since adding the Bräcke M36a to the forwarder makes it more difficult to maneuver. With this type of scarifier, it is also necessary for the operator to master the onboard computer because operation of the implement is controlled by that computer's software. The operator must receive adequate training on how to use this computer so they can troubleshoot any common problems that may arise without requiring additional assistance. In addition, operators must be able to respond rapidly to switch programs when changing site conditions make this necessary. Operators must understand the delay time before the Bräcke M36a can change between programs and must be able to identify and rapidly appraise the site conditions for which each program can be used at the right moment and at the desired location.

Conclusion

Because the Bräcke M36a permits a unique type of scarification, it has a niche in Quebec's fleet of scarification equipment. Biological follow-ups will be required to confirm whether the microsites the scarifier creates can improve the growth of planted seedlings. Despite its three-row configuration, the machine was not able to attain the 50% productivity improvement that is theoretically possible compared with a conventional two-row powered disc trencher. However, it must be noted that the new scarifier was evaluated while it was still being broken in during its first season of operation. The treatment quality and productivity of the Bräcke M36a will likely improve as operators gain more experience and learn how to better plan their work throughout the operating season.

The Bräcke M36 produced at least as many microsites suitable for planting as the powered disc trenchers. However, most of the suitable microsites were produced in the patch rather than on the mound. It was not able to create the quantity of mounds required to attain the number of plants per hectare required by Quebec's Ministère des Ressources Naturelles et de la Faune at any of the study sites. The expected number of plants per hectare could, however, be attained if the microsites created in the patches are included. The primary deficiency of the mounds was their instability; however, because our surveys were performed shortly after the treatment, it's likely that the mounds will settle and become more stable by the following spring and that the quantity of suitable microsites per hectare on the mounds will be greater than the values measured in the present study. Rain and snow should help to compact the mounds and eliminate air pockets, thereby increasing the number of mounds that are suitable for planting.

The scarification quality provided by the Bräcke M36a is affected by many site factors. However, it was difficult to precisely define the relationship between site conditions and the scarification quality because of the specific impact of each site characteristic on the quality of the patches and mounds. During the study, the soil depth, cover of Kalmia and Labrador tea, stoniness of the soil, humus thickness, and quantity of debris with a diameter larger than 5.0 cm were the factors that most strongly influenced the scarification quality achieved by the Bräcke M36a.

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- Société Sylvicole Chambord Ltée.

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