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A COMPARISON OF FIVE SITE-PREPARATION METHODS IN CENTRAL ONTARIO

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Abstract

FERIC undertook a comparison of five site-preparation methods (scalping with a bulldozer, scalping with an excavator, windrowing, mulching of the full site, and strip mulching) in central Ontario. The study was designed to measure equipment productivity, assess the results in terms of microsite quality, and calculate the costs of the various operations. The results suggested that each treatment could be effective under certain conditions. The choice of an optimal treatment within the study conditions should be facilitated by biological follow-ups that will be carried out by the Ontario Forest Research Institute over the next few years.

Introduction

The site conditions in central Ontario often present particular constraints for site preparation. This is especially evident in tolerant mixedwood stands, where site preparation equipment must be able to maneuver efficiently around the residual trees left behind after clearcuts (e.g., unmerchantable trees) or in partial cuts (e.g., future crop trees). At the same time, the equipment must be able to produce plantable microsites despite interference from hardwood tops on the ground (Figure 1).

Figure 1. Site conditions after clearcutting a mixedwood stand with many unmerchantable trees.

In this context, FERIC undertook a comparative study of five site-preparation methods after clearcutting in a mixedwood stand near South River (Ontario) in cooperation with the Ontario Ministry of Natural Resources' (OMNR) Bracebridge area office and the Ontario Forest Research Institute (OFRI). The study area, known as the Management Impact Assessments

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(MIA) Project, has two main objectives: to assess the ecological effects of alternative site-preparation techniques, and to develop cost-effective, ecologically sustainable forest management practices for rehabilitating coniferous Great Lakes–St. Lawrence forest ecosystems.

To prepare the site for planting while addressing the project objectives, researchers chose site-preparation equipment that would produce a range of site disturbance conditions after treatment. Traditionally, these cutovers are cleared after harvesting by using a rake attachment on a bulldozer to remove the litter and humus layers and expose the mineral soil. This practice, although quite effective at controlling vegetation, may be detrimental to long-term site productivity. To address this issue, four additional treatments were compared with the traditional bulldozer approach:

- mulching of the full site with the Meri Crusher MJ-2.3,
- strip mulching with the Meri Crusher MJ-0.8,
- a light raking with the bulldozer-mounted rake (with minimal disturbance of the humus layer), and
- scalping with an excavator-mounted rake.

The Meri Crushers differ from the other treatments in that the machines mulch the humus and the upper mineral-soil horizons rather than removing them; as such, they represent an interesting alternative because of the possibility of maintaining site productivity.

After treatment, the site was planted with two size classes of both white spruce and white pine to study the effects of plant size on survival and growth in relation to the site-preparation treatments that were employed. OFRI researchers are also monitoring the site to observe the impacts on artificial and natural regeneration, seedling ecophysiology, microclimate, plant diversity, site productivity, vegetation management and *Armillaria* infections (Paterson et al. 1997).

FERIC's contribution to the project was to measure equipment productivity, describe the results in terms of microsite quality, and calculate the costs of the various options. This report describes the equipment used, its economics, and its effectiveness in creating acceptable planting sites.

Description of the Equipment and Treatments

Meri Crusher MJ-2.3 Mounted on a Tractor (full mulching)

The Meri Crusher MJ-2.3 is a mulching implement composed of a 2.3-m-wide horizontal drum that is 36 cm in diameter and is equipped with 85 mining bits. For this trial, the Meri Crusher was mounted on the three-point hitch of a 63-kW John Deere 6400 tractor (Figure 2). The device was powered by the tractor's 1000-rpm power take-off. The tractor was also equipped with a front-end loader that was used to windrow slash prior to treatment with the implement. The mulching action of this machine produced a relatively uniform mixing of mineral and organic horizons over the entire treatment plot except the windrows.

Figure 2. Mulching with the Meri Crusher MJ-2.3 mounted on a John Deere 6400 tractor.

Meri Crusher MJ-0.8 Mounted on a Skid-steer Loader (strip mulching)

A Meri Crusher MJ-0.8 was mounted on the front of a 46-kW Thomas HD233 skid-steer loader (Figure 3). The crusher was powered by an auxiliary variable-displacement hydraulic pump that drove the drum at about 500 rpm. The 0.8-m-wide drum was equipped with 52 mining bits and had a diameter of 36 cm. Hunt (1995) provides additional information on the implement and its prime mover. The plots treated by the Meri Crusher MJ-0.8 were first windrowed by a bulldozer equipped with a rake (see the next section for details). Mulching was done in 0.8-m-wide strips spaced at 2 m between the strip centers and ran either parallel or perpendicular to the windrows.

Figure 3. Mulching with the Meri Crusher MJ-0.8 mounted on a Thomas HD233 skid-steer loader.

Rake Mounted on a Bulldozer (scalping and windrowing)

A 2.5-m-wide custom-made rake with nine teeth was mounted on a 61-kW Case 850D bulldozer (Figure 4). This implement was used to perform two types of treatment: scalping (windrowing of debris and removal of the entire organic layer) and windrowing of debris (leaving the organic layer intact). The bulldozer was also used to windrow sites before treatment with the Meri Crusher MJ-0.8.

Figure 4. Scalping with a custom-made rake mounted on a Case 850D bulldozer.

Rake Mounted on an Excavator (scalping)

A 2-m-wide custom-made rake was mounted on a 70-kW Hitachi EX150 excavator (Figure 5). The rake, which had six teeth, was mounted directly on the excavator's bucket. This machine was used to perform scalping (clearing of slash and removal of the organic layer), mostly by pushing the material away from the machine. The effective reach of the excavator with the rake was about 9 m.

Figure 5. Scalping with a custom-made rake mounted on a Hitachi EX150 excavator.

Description of the Study Areas

The five site-preparation treatments were performed after clearcutting of a tolerant hardwood mixedwood stand on a sandy site covered with a relatively thin (<6 cm) humus layer. The site was divided into three adjacent blocks (Table 1). In each block, each treatment was applied over an area of approximately 1 ha in accordance with OFRI's experimental layout, which had been designed to permit a biological follow-up after various site-preparation options.

Despite the clearcutting, many dead or unmerchantable residual trees remained standing in the three study blocks. The high slash volume in Block 3 was a result of numerous downed dead trees. However, the slash load (% coverage and height) was greatest in Block 2, where the presence of many hardwood tops increased the percentage of the area covered by slash and the slash height. Block 3 had more stumps than the other two blocks, but the average stump size was smaller. Stoniness ranged from moderate in Block 1 to negligible in Block 3 (Table 1).

Table 1. Site conditions during the study[a]

	Block		
	1	2	3
Slash			
Volume (m^3/ha)	69 x	71 x	131 y
Coverage (%)	15 xy	21 y	9 x
Height (cm)	20 x	38 y	22 xy
Residual trees			
Density (stems/ha)	180 x	213 x	160 x
Proportion of dead snags (%)	44 xy	37 y	77 x
Brush (stems/ha)	833 x	867 x	893 x
Stumps			
Density (number/ha)	280 x	293 x	480 y
Diameter (cm)	31 y	29 y	22 x
Height (cm)	41 x	35 x	32 x
Stoniness (%)	43 x	20 y	0 z
Humus depth (cm)	6 x	5 x	6 x

[a] Numbers in any row followed by different letters are significantly different based on a Tukey multiple-range test at a 95% confidence level.

Table 2. Summary of productivities

	Productivity (ha/PMH)		
	Block 1	Block 2	Block 3
Bulldozer			
Scalping	0.13	0.13	0.12
Windrowing	0.33	0.36	0.30
Excavator			
Scalping	0.16	0.13	0.12
Meri Crusher MJ-2.3			
Windrowing + mulching (full site)[a]	0.15	0.14	0.12
Windrowing alone	0.36	0.31	0.25
Mulching (full site) alone	0.26	0.25	0.22
Meri Crusher MJ-0.8			
Strip mulching	0.16[b]	0.18[c]	—

[a] Windrowing and mulching were part of the same operation, but were timed separately to permit separate productivity calculations.
[b] Mulching was done perpendicular to the windrows.
[c] Mulching was done perpendicular to the windrows in part of the block, and parallel to the windrows in the remainder of the block.

Results

Productivity

The productivities of the scalping treatments (bulldozer, excavator) and of the Meri Crusher MJ-2.3 treatment that combined windrowing with mulching of the full site ranged between 0.12 and 0.16 ha/PMH (Table 2). Windrowing by itself (using the bulldozer) was roughly three times faster (from 0.30 to 0.36 ha/PMH). In terms of mulching alone, the Meri Crusher MJ-0.8 (0.16 to 0.18 ha/PMH) was unable to work as fast as the Meri Crusher MJ-2.3 (0.22 to 0.26 ha/PMH), even though the smaller machine was only treating strips.

Of all the site conditions, the characteristics of the slash appeared to be the primary factor that affected productivity. The slash in Block 3 was composed mainly of short segments from dead trees that were more difficult to accumulate and to windrow than the hardwood tops and branches in Blocks 1 and 2.

Productivity also varied with respect to the treatment intensity. After an examination of the results of scalping with the excavator in Block 1, the operator was instructed to expose more mineral soil, and this significantly decreased productivity in the remaining two blocks. Similarly, the productivity of the Meri Crusher MJ-2.3 was related to the proportion of the site covered by the machine (74, 77 and 81% for Blocks 1, 2, and 3, respectively).

Strip mulching at a spacing of 2 m (center to center) was performed by the Meri Crusher MJ-0.8 in two blocks that had been previously windrowed with the bulldozer. In Block 1, mulching was done perpendicular to the windrows. In Block 2, the treatment was parallel to the windrows in part of the block and perpendicular in the remainder. Because the depth of the block was far larger than the distance between the windrows, the parallel treatment involved less turning time and thus improved productivity (0.20 ha/PMH) compared with the perpendicular treatment (0.15 ha/PMH).

Quality of Site-preparation

The nature and intensity of the soil disturbance varied greatly, depending on the treatment (Figure 6). Treatments of the full site actually only covered 73 to 96% of the area (including slash piles), and left 4 to 27% of the area in the form of untreated islands. Because of its nature, strip mulching covered only 44% of the site based on the total area (including the 19% of the site covered by slash piles).

After site preparation, piles of slash generally covered 16 to 19% of the area; however, in the excavator areas, slash covered 26% of the site. Scalping with the bulldozer and the excavator produced comparable results, with the high degree of mineral-soil exposure that the prescription required (around 50% of the total area), but windrowing by itself only exposed mineral soil in 11% of the area. Mulching with the Meri Crusher MJ-2.3 mixed the slash and the organic

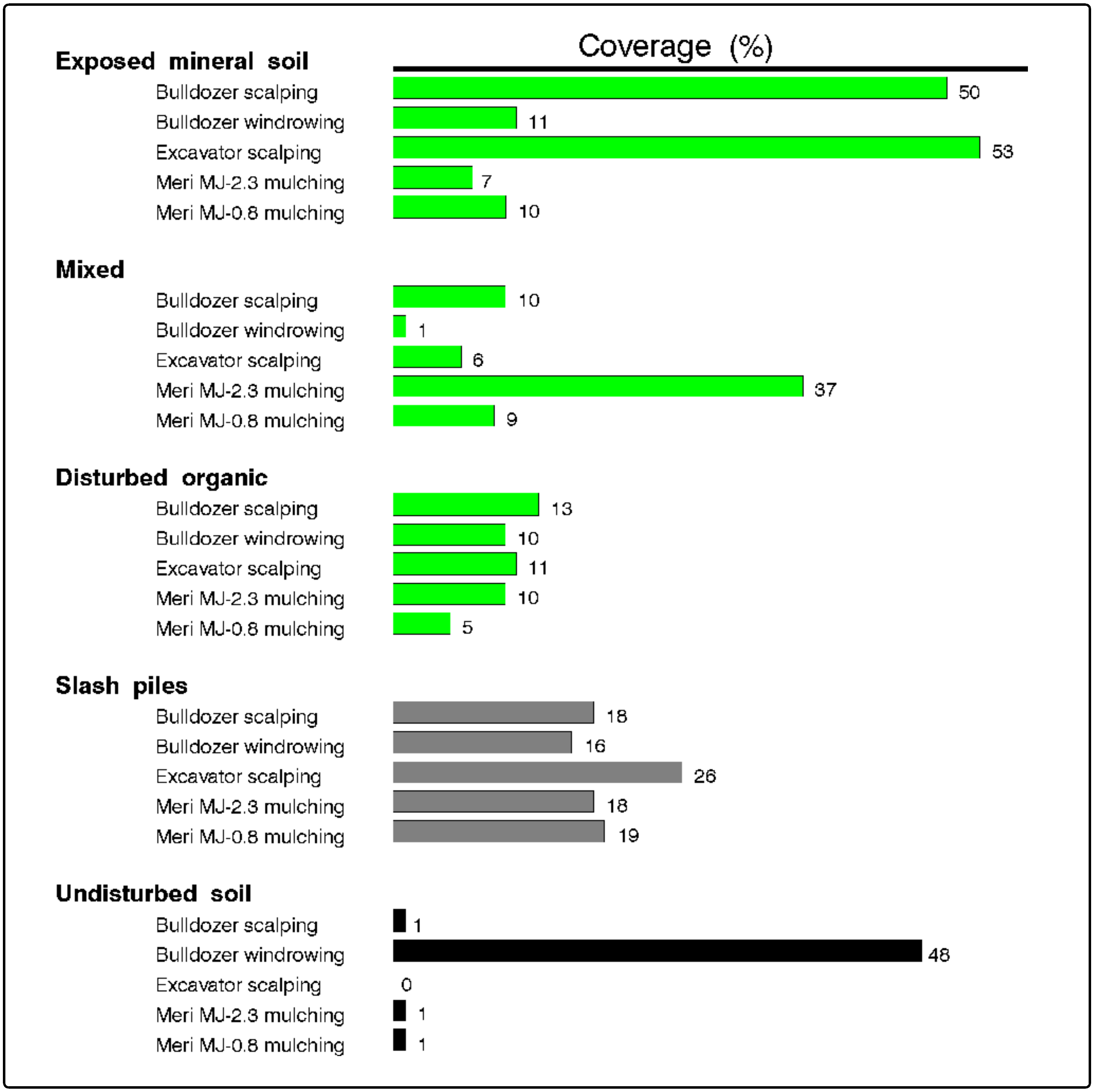

Figure 6. Soil disturbance results.

horizons with the mineral horizons in 37% of the area; in contrast, the Meri Crusher MJ-0.8 produced strips that covered only 25% of the area and created mixed soil in only 9% of the area. The Meri implements tend to expel part of the mulched material towards the rear of the machine, and this creates microsites that are enriched in mineral soil at the end of each pass; this increases the relative proportion of exposed mineral soil where the operator performs short passes, as was the case with the Meri Crusher MJ-0.8 working perpendicular to the windrows.

Microsite plantability was judged to be acceptable if the microsite was composed of exposed mineral soil, a thin humus layer (less than 5 cm), or a mixture of organic and mineral material (Figure 7). The composition of the best available microsite was also noted for all acceptable microsites (bottom half of Figure 7). Plantability was considered marginal if planters would require a minor additional effort to render the microsite acceptable. All other microsites were considered unacceptable.

All five treatments produced plantability levels of 95 to 99% (including marginal and acceptable planting spots) between windrows. The highest level of acceptable plantability was obtained with scalping; the bulldozer and the excavator both produced more than 90% acceptable microsites (mostly mineral-soil exposure) in the areas between windrows. Mulching with the Meri Crushers produced a lower level of acceptable microsites (65 to 79%), but produced a higher proportion of mixed-soil microsites (33 to 72%). Windrowing produced the least soil disturbance and often left an overly thick humus layer that resulted in a higher proportion of microsites with marginal plantability.

Discussion

FERIC's standard costing method (based on Rickards and Savage 1983) was used to compare the five treatments (Table 3). Comparisons were based on the price of new machines, equal salaries for the operator of each machine, and a 15% profit margin. Float costs for the machines are not included in the comparison. Because scalping with a bulldozer is the traditional form of site preparation in this region, it served as the basis for comparison.

The least expensive treatment ($235/ha) was windrowing with the bulldozer. However, local OMNR personnel report that this treatment encourages the growth of competing vegetation and thus increases the risk of growth reductions and decreased survival rates of the planted trees; as a result, it will lead to substantially higher tending costs than with the other treatments.

Table 3. Estimated operating costs of the treatments

	Operating cost ($/ha)
Bulldozer scalping	600
Bulldozer windrowing	235
Excavator scalping	680
Windrowing (tractor) + mulching (Meri Crusher MJ-2.3)	660
Windrowing (bulldozer) + mulching (Meri Crusher MJ-0.8)	600

The scalping treatments cost $600/ha with a bulldozer and $680/ha with an excavator. The excavator treated a larger proportion of the area, but also left a larger area occupied by windrows. Scalping with an excavator is not commonly used after clearcutting and would be easier to justify in the context of site preparation after partial cutting (Bulley and Cormier 1995; Cormier 1996).

Strip mulching with the Meri Crusher MJ-0.8 was carried out at a cost ($600/ha) comparable to that of scalping with a bulldozer. The treatment only affected a portion of the site, and left the remainder of the site in the same condition as after windrowing with the bulldozer, which may lead to higher future tending costs. However, the improved microsite quality in the strips could improve plantation growth and decrease the amount of competing vegetation near the seedlings.

The costs of mulching the entire site with the Meri Crusher MJ-2.3 ($660/ha) were calculated based on the approach used in this study (i.e., with windrowing performed by the tractor). The use of a bulldozer for the windrowing phase could reduce the cost of this treatment by about $50/ha, and this would lead to a cost comparable to scalping with a bulldozer. Given the quality of the microsites produced by the Crusher as a result of incorporating the humus layer, it represents an interesting alternative to traditional scalping with a bulldozer.

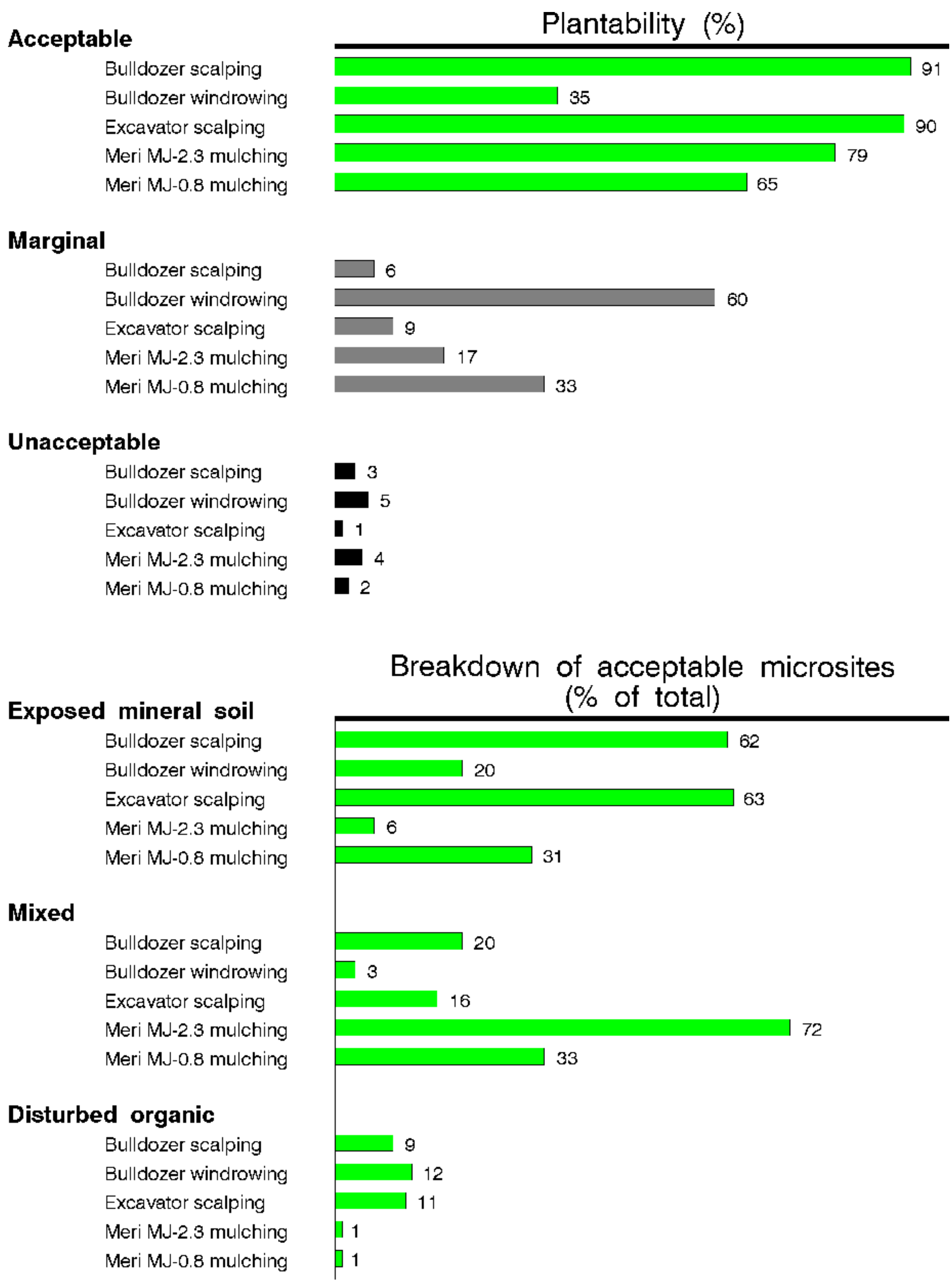

Figure 7. Plantability levels between windrows and the breakdown of acceptable microsites.

Conclusions

Compared with the traditional method used in central Ontario (scalping with a bulldozer), scalping with an excavator, windrowing, and mulching all represent interesting alternatives under certain circumstances. Windrowing provides significant short-term cost advantages, but could pose long-term problems in terms of plantation establishment and tending. Despite having a higher cost under the study conditions, the excavator could be used effectively in partial cutting. Mulching seems to provide an interesting option because its cost is comparable to that of scalping, yet the treatment has the potential to create superior microsites.

However, determining the most appropriate treatment under the study conditions will require a longer-term assessment of plantation development. To this end, the follow-up being conducted by OFRI will determine the biological benefit of the five site-preparation methods tested. OFRI's study will also determine the time and intensity of any subsequent tending that will be required to ensure optimal growth.

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Disclaimer

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